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Indigenous approaches for the management of termite and white grub in upland rice

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ABSTRACT

Termites and white grubs are of regional importance in upland rain fed rice. Major insect pests in upland rice are stem borers, gundhi bug, mealy bug, root aphids, white grubs, and termites (*Odontotermes obesus* and *Microtermes obesi*). The management of the subterranean pests *viz.*, termites and white grubs is challenging in the recent past. In spite of the integrated approach with feasible management options with chemical, biological and cultural methods, both termites and white grubs are posing serious threat to rice in particular upland and rainfed system. The present paper reviews and focus on the indigenous approaches for termite and white grub management, which can find a place in integrated management strategies to curb these soil insect-pest problem.

KEY WORDS: Occurrence, termites, white grubs, Upland rice

A study carried out by Rockfeller foundation (Herdt, 1991) reveals that seven out of 20 major challenges in rice production are insect-pests and diseases. Apropos another analysis of ecology-wise key pests of rice in India (www.rkmp.co.in), the major insect pests include stem borers, leaf folder, brown plant hopper, gundhi bug, mealy bug, white grubs, termites and root aphids. Amongst the soil-insect pests, termites are recognised as pest of regional importance in upland rainfed rice (DPPQR&S, 2001). In India 6.5 m ha area is under rain fed upland rice, out of which 5.2 m ha is in the Eastern India only (Maiti *et al.*, 2007). The average yield was estimated to be 1.3 t/ha and of total area, 5.0 m ha is plain area upland and 1.0 – 1.5 m ha is high altitude upland. The white/root grub has been reported as the important biotic stress in hill upland rice (Krishnaiah and Varma, 2009). In this paper, the occurrence of the termites and white grubs in upland rice will be presented with more focus on indigenous management approaches for the both that alleviate the biotic stress.

Termites

Termites (*Odontotermes obesus* and *Microtermes obesi*) are the most important species in red-light textured soil with low water holding capacity under prolonged drought conditions. Although, termites are typical problem in upland rice, infestations can also be there in light-textured low moisture content soils in rainfed wetland areas as well. No doubt, termites are one major biotic stress in upland rice, in irrigated rice-wheat system of Indo-Gangetic plain also termites are found as pests. In dealing with termites in rice, the following headings are detailed for a common understanding.

Habit and habitat

Termites are xylophagus, principal food is cellulose. The workers feed on decaying wood, paper, fabrics and other fibre plants or the plant materials such as humus, grass, fungi, etc. The termites obtain nourishment from a cellulose diet because of presence of certain protozoa in their digestive tract, which possess enzymes capable of digesting cellulose. Termites usually avoid direct light. They make an irregular network of large interconnected galleries through which they travel from their nests to the food source. Oviposition by the primary queen will be low at first, but in due course of time she assumes massive morph measuring 2-4 inches and may give rise to a colony consisting of over a million termites. The individuals produced in a colony in the early stages are all sterile caste. The alate reproductives develop later on. When the colony becomes big enough the king and the queen, among higher termites, remain in a royal cell lodged deep in the termite mound (=termitarium).

Pest status in rice

Termites are polyphagous, and infest a wide range of host plants. Usually termites infest upland paddy but it also attack in lowland where there is no assured irrigation/ water stagnation. Termite colony attacks on germinating seed or growing root causing complete drying of crop. The damaged plant can easily be pulled out by hand. Even though they are permanent residents of non-flooded environment, termites may attack rice but can readily be controlled with insecticides. Termites attack living rice plants when dead plant material is not available and generally late in the crop growth stage. They attack drought-stressed crops and prefer older plants having greater cellulose content. They tunnel through the plant stem and eat the roots. The attacked plants become stunted and then wilt. Termite attack also predisposes plants to further damage by ground-dwelling pests such as rodents, ants, saprophytic fungi and bacteria. Yield losses ranging from 50 to 100% have been reported (UNEP, 2000).

Termites in paddy can also occur in light-textured soils in rain fed wetland areas. Infestations are severe on light textured soils with low moisture content. Some grassland termites make nests composed of many tunnels deep in the soil. They attack living rice plants only when dead plant material is not available. They attack a drought-stressed crop, but prefer older plants having greater cellulose content. They tunnel through plant stems and eat roots. The plants become stunted and then wilt. Damaged plants can easily be pulled by hand. Termites are more serious in Latin America and Africa than in Asia. The common Asian species that attack rice plants are *Macrotermes gilvus*, *Heterotermes philippinensis,* and *Coptotermes formusanus*. In Africa, *Microtermes* and *Macrotermes* termites have been reported as pests of rainfed upland rice (Pathak and Khan, 1994). In India, termite species recorded in rice are *Odontotermes* and *Microtermes* spp.

In wheat-rice irrigated agro-ecosystem particularly in northern India, termites can be a problem. Actually termites are of serious concern in wheat. However, careful handling with water management can be helpful in tackling the termites. Soil treatment, seed treatment and spot applications are taken on need-basis.

Causes of termite outbreaks

- Presence of termite nests/mounds around the paddy field or farm.
- Warm and dry climatic conditions (i.e. lack of rainfall) – uneven rainfall due to climate change.
- Introduction of exotic crop species. Indigenous crop species capable of coping with termite infestation as they have evolved some level of resistance
- Presence of unhealthy crop species that have been subjected to biotic and abiotic stresses such as drought, weeds, diseases, etc.
- Lack of effective termite control measures and lack of suitable integration of termite control tactics.

Some grassland termites make permanent nests composed of many tunnels deep in the soil. Other species make nests as mounds above the ground. The tunnels are lined with body waste to seal the walls so that high humidity can be maintained.

Nature of damage

Most grassland termites lack symbiotic protozoa to digest cellulose. Instead they culture fungi in underground fungal combs. Fungal gardens (=combs) are made by termite workers of partly digested plant material. This plant material becomes inoculated with the fungi and the termites later feed on the combs. Workers constantly construct and eat the fungal combs in their nests.

Termites prefer dead to living plants but when their preferred food is gone, they feed on living roots. After land preparation, the termite workers feed on living plants. They tunnel through plant stems and eat roots, causing the plants to become stunted. Damaged plants can easily be pulled by hand. When rice is not vigorously growing, drought encourages termites to attack a standing crop.

Management of termites

Broad-spectrum and organo-chlorine insecticides have been largely relied upon for termite control (Mahapatro, 2011; Mahapatro *et al.*, 2011). The limitations associated with the application and efficacy of these chemicals such as the destruction of non-target insects, high cost of the chemical insecticides, accidental poisoning and environmental pollution emphasizes the need for alternative methods. Other non-chemical control measures such as biological control, cultural control, use of plant extracts and host plant resistance are being relied upon to control termite infestation. Because of the unique advantages of host plant resistance, it is believed to be a durable strategy in pest management in developing countries. Unfortunately practically no work has been done in this regard in India.

Cultural control

- Termite mounds in and near the paddy field to be located and exterminated by manual digging and dequeening.
- To take advantage of termites perference for dead plant material, farmers can divert the pest from the growingcrop by putting crop residuein the field at planting.
- Deep ploughing with chisel plough is helpful in reducing termite infestation.
- Populations of soil-dwelling pests of dry land rice (such as white grubs, mole crickets, termites, ants, and root bugs) can be reduced by increasing the number of tillage operations.

Biological control

Termites have a wide variety of predators, both opportunist and specialist, but ants are the greatest enemies of termites in all regions of the world. Although ants limit termite numbers under natural conditions, their suitability for use as biological control agents for target termite management has yet to be ascertained. Naturally termites are predated upon by various animals – frogs & toads, lizards, snakes etc.

Microbials against termites - Termites nesting in soil environments are in constant contact with entomopathogens but have evolved a range of defence mechanisms, resulting in individual and social immunity that reduce the chance for epizootics in the colony. Recently it was reported that the faecal nest supports the growth of Actinobacteria which provide another level of protection to the termite *Coptotermes formosanus* against entomopathogens (Chouvenc *et al.*, 2013). A *Streptomyces* species with *in vivo* antimicrobial activity against fungal entomopathogens was isolated from the nest material of multiple termite colonies. Termite groups were exposed to *Metarhizium anisopliae*, a fungal entomopathogen, during their foraging activity and the presence of *Streptomyces* within the nest structure provided significant survival benefit to the termites. Fifty years of analysis on attempted biological control of termites implicated the practical failure (Chouvenc *et al*., 2011). Therefore, it is advocated that use of bio-control agents may be discouraged in the affected upland rice. Of course further research is most welcome.

Termite control with non-chemical methods:

1. Locating mounds/ termitarium and destruction of the same.
2. Flooding/water stagnation avoids termite infestation.
3. To control termite in the field some farmers cut approximately 5 kg each of *Calotropis* and Kheemp (*Leptadenia pyrotechnica*) twigs into small pieces and put them in an earthen pot. Then add 1 kg salt and 10 L water/cow/human urine. The pot is kept in a pit for 15-20 days. The suspension is filtered through cotton cloth and filtrate is applied as an insecticide @ 10 L/ha in irrigation channel (Source: *Integrated Disease Pest Management in Sri Paddy. SRI Secretariat (SDTT), Bhubaneswar, 24p*.).
4. Biopesticides such as neem seed oil (22 L of neem seed oil concentrate in 220 L of water/ha) and neem powder (800 kg/ha) may be used.
5. The entomopathogenic fungus, *Metarrhizium anisopliae* is used as
6. biological control strategy (2 grams spore powder of *Metarrhizium* mixed with 60 cm^3 of wood powder/saw dust. Put mixture in a hole of 3 cm depth and cover with a small quantity of saw dust to protect spores against sunlight).
7. Application of red palm oil mixed with pawpaw (=papaya) is an indigenous biological control practice. The mixture attracts soldier ants that attack and drive away the termites.
8. Use of resistant/tolerant rice varieties such as LAC 23, NERICA1, 2, 5, 14 and others (for African nations)(# 2-5: source: www.rkmp.co.in)
9. Extracts of juice of immature papaya fruits controls termites (CTDT, 2008).

Elimination of the termite mound

Mounds are permanent abodes of termite where they multiply and become a continuous source of termite attack. Thus, it becomes necessary to destroy these termite mounds as a first step to check the termite attack. The generally accepted chemical method of termite control over the years has been liquid insecticides. However chemicals can be expensive and have many harmful effects to environment. One should know which mound is active and needs control. After the rainfall in its season, the fresh mound growth can well be marked on the mounds.

Quick and complete extermination of the mound-colony at low cost can be achieved by treating the mounds by pouring in, through a funnel, water suspension of insecticides, through two or three holes in the mound. The minimum rate is 9 litre of liquid per 10 cu. ft. (2.8 cu.m) of mound volume. For sub-cylindrical mounds, as in *O. obesus* following height-liquid ratio may is maintained (Table 1). Chlorpyriphos 20%EC (2-3 ml/L water) and imidacloprid 17.8%SL (1 ml/L water) is the liquid solution to be poured into the mounds (Mahapatro, 2013).

Height of mound	***Dosage of liquid insecticide***
*1 - 2 foot	2 - 4 litres
3 foot	4 - 5 litre
4 foot	20 - 25 litre
5 foot	45 - 50 litre
6 foot	80 - 85 litre

Normally these are new colony growths which can be dug out easily.

The control of termitarium without use of harmful liquid chemicals

(a) The regular disturbance through cracking prevents termites from building extensive mounds. Manual and explosive destruction of nests followed by the removal of the queen is also effective.

(b) Manual digging, collecting queen(s) and killing.

(c) Smoking the mound is a traditional method of termitarium control.

Some indigenous methods used to eliminate the termite mounds in India and African region (Source: various: NF Project works)

S. N.	Indigenous Materials	Methods of application used by farmers	*Implementable status
	African ITK's		
01	Human urine	Mixed fermented urine (stored for 1 to 2 weeks) with carbon and used to spray or pour directly into the mounds. Sometimes, only matured urine is used for this purpose. It is claimed to have killing (toxic) and repellent effect on the termites.	++
02	Toads, Intestines of Rat or fish, dead animals or shell/ scallop of tortoise	Killed toads inserted directly into the mounds. Intestines of rat or other dead animals and the shell / scallop of tortoise can also be used in the same way. These have repellent effects on termites which will leave the mounds some days after the application.	-- (wild species of toads, snakes are supposed to be protected)
03	Water in which fresh fish is dissected	Water in which fresh fish is washed or dissected is poured directly into the mound by breaking the top of the mound. After at least one week of this application, termites will leave the mound. After this, destroy the mound.	+
05	Wood ash	Wood ash is used to control termites by putting it inside the mounds or sprinkling around it.	++
06	Sand	Pouring the sand inside the initial new mound, termites will immediately abandon the mound.	++
07	Dry cell	10 used dry cells material (flashlight batteries), mix with 10 litres of water and pour into mound through a hole made on the top.	+
08	Fire	Dig hole on top of mound, insert wood and grass and set fire to it, then seal to confine the smoke and heat. OR fill hole with dry cow dung, set it on fire and leave to burn slowly.	++
09	Trenching around mound	Dig trench about 2 ft deep around mound.	++
10	Opium or tobacco	When alates emerge, blow smoke of opium or tobacco into the mound through the alates exit holes. A lot of alates come out and the remaining castes (queen, workers and soldiers) all die.	++

11	Snake	Insert dead snake into mound through a vent and seal the vent.	_
12	Cow dung	Dig hole on top of mound, put in 1 basin of cow dung and pour 20 litres of boiling water through the same hole.	++
13	Used engine oil	Dig hole on top of mound and pour 0.5 litre of oil into mound. Do not seal hole.	+ (may not be economical)
Indian ITK's			
14	Salt, juice of lemon and castor cake	Salt, juice of lemon and castor cake added to hot water is poured into termite mound after digging them up to some depth.	+
15	Wild animals	Presence of termitaria, offer shelter to venomous snakes. In many areas of Chhattisgarh wild bear (Bhalu) is a big problem and termites are favourite food for them. According to them, the presence of termite mounds around the fields force the bear to visit the area and after eating termites, they attack on crops also. So, farmers prefer to destroy the mounds.	_
16	Fire	Smoking termitaria to suffocate and kill the colony. Lighting a fire after queen removal is also known by few farmers.	
17	Mechanical/ organic practice	Cow dung cakes are effectively put inside the termitaria for control.	+
18	Phyto-chemical (repellent)	*Aloe vera* planted at termitaria can repel the termite population (noted in Jharkhand state).	-- Not applicable in Delhi, proved scientifically.

* Implementation feasibility is decided based on the wisdom, scientific arguments and past experiences.
-- Not recommended
\+ Scientific but needs validation
++ Scientific and based on validation/past experience.

In some cases, an expert opinion may be necessary to do this.

Research gaps

Persual of literature reveals that the seed treatment for rice recommendation varies widely. *Total Seed Treatment Campaign* of Govt of India recommends chlorpyriphos 3 ml/kg rice seed, and another paper from CRRI (Cuttack) i.e., Rath and Dani (2009) cited need based protection (seed-treatment with chlorpyriphos 20EC @ 3.75 lit per 100 kg Seed). The last mentioned seed treatment dosage for chlorpyriphos works out to be 37.5 ml/kg rice seed. This seems too high, and toxic to seeds. Field trials must be done only after conducting laboratory tests for toxicity (germination test) following standard protocols. Seed treatment of rice may be a viable option in termite management in an ecofriendly way.

However, concerted research efforts are to be directed in this line.

White grubs

The white grubs are the major biotic stress of several commercial crops in many parts of India. These beetles belong to subfamilies, Melolonthinae and Rutelinae of Family Scarabaeidae under Order Coleoptera, which comprises of large number of species that are devastating pests of several commercial crops. The commercially cultivated crops like sugarcane, groundnut, cereals, millets, pulses, vegetables and plantation crops are attacked by white grubs (David and Ananthanarayan, 1986) besides attack on plantation crops and turf grasses. Several species have been observed to cause serious damage throughout the country right from Himalaya to Kerala and Gujarat to North eastern regions (Chandla *et al.*, 1988; Misra, 1992). The immature stages of these beetles feed on the roots and rootlets of the crop and results in huge yield losses.

Among the estimated 2000 species of Scarabaeidae found in India, 932 species belong to the subfamily Melolonthinae and 400 species belong to Rutelinae. The white grub complex is characterized by species richness and studies on the species taxonomy, larval identities, detailed life histories, food preferences and reproductive behaviour are scarce and sparse or incomplete and inaccurate.

Habit and Habitat

The adults live in the soil during day time and emerge out during dusk to the nearby avenue trees like neem, ber, guava, jamun, moringa, etc. and feed on the leaves. The first adult emergence of these beetles will be maximum after monsoon showers during June – July, hence called as June beetles. The adults lay their eggs in the moistened soil and in about week to fifteen days depending upon the species, the neonates hatch out and start feeding on the rootlets of the young plants. The larva has three instars and spends longer period usually three to six months (in annual or biannual grubs) or twelve to eighteen months (in biennial grubs feeding on the roots of the plants. Later pupation takes place in the soil and adults emerge out after one month or so and dwells in the soil until the monsoon showers are received.

Nature of damage

The grubs are subterranean and attack a wide range of wild plants and crops. The immature stages *viz.,* larvae appropriately called grubs feed on the roots and rootlets of the plants thereby affecting the water and nutrient flow to the aerial parts of the plant. As a result of which the plant slowly dries and eventually dies leading to huge economic losses in commercial crops. The white grub infestation results in 10 to 90% economic loss depending upon the crop and season. Thamarai Chelvi (2011) reported that white grub species, *Holotrichia serrata* caused 80-100% damage in sugarcane in Tamilnadu, India. Incidence of scarab beetle, *Schizonycha ruficollis* in teak (*Tectona grandis*) at Ramdongari, Nagpur during 2002 to 2005 lead to 14-52% of damage to seedlings in the nursery beds (Kulkarni *et al.*, 2007).

Pest status in upland rice

White grubs are the problematic pests of upland rice in many parts of the World especially in Phillipines. Five species of white grubs *viz., Leucopholis irrorata* (Chevrolat), *Holotrichia mindanaoana* Brenske, and *H. flachi* Brenske being biennial with *Adoretus luridus* Blanchard and *Anomala humeralis* Burmeister being annual species were found associated with upland rice in Claveria, Northern Mindanao, Philippines (Litsinger *et al.*, 2002). International Rice

Research Institute (IRRI) reported that white grub is a problem in upland rice of Laos in 2009. White grub species, *Leucopholis irrorata* (Chevrolat) feeds on the roots of many crops grown in well-drained soil and it damages upland rice in the Philippines (Capule and Herdt, 1983), Indonesia and Latin America (Hoque *et al.*, 1981). Farmers consider *Leucopholis irrorata* (Chevrolat) to be the principal insect pest of rice and maize in upland areas of Batangas Province, Luzon, Philippines (Apostol and Litsinger, 1976).

All India Network Project on White grubs in India (2002-2007) reported many species of white grubs i.e. *Holotrichia consanguinea, H. coriacae, Leucopholis lepidophora, Lepidiota stigma, Leucopholis burmeisteri, L. coneophora, Anomala rufiventris, H. longipennis, H. serrata and H. reynaudi* causing severe damage during 2002-2006 in states like Rajasthan, Himachal Pradesh, Karnataka Uttaranchal and Assam. The report reveals the extent of loss ranging 50 to 90% in various kharif crops namely millets, upland rice, soybean and off season vegetables grown under rainfed conditions in both the Kumaon and Garhwal regions of Uttaranchal (www.icar.org.in).

The white or root grubs resulted in a moderate infestation assuming the important status in upland rice of Odisha during 2006-2009 in rice ecosystem, however they were not a problem in Bihar, Uttar Pradesh, Haryana, Punjab and West Bengal from 2000 to 2009 (Krishnaiah and Varma, 2009).

Management of white grubs

Several management options are integrated in bringing down the white grub population. The trees, where adults feed upon are targeted for insecticidal sprays to control the adult beetles. Soil application and seed treatment with insecticide is followed. Later treatments with bioagents like microbials, entomophilic nematodes are used. The pheromone, which effectively works for *Holotrichia consanguinea* Blanchard are also used as location specific treatment. Besides, the mechanical collection and destruction of the adults and grubs is also followed in endemic areas.

Indigenous approaches for the management of white grubs

Owing to the polyphagous nature, subterranean habit, high species richness and diverse feeding habits of immature and adult stages, management of white grubs is a hard task. The integrated management strategies that include seed treatment, soil application, foliar application of chemical insecticides, entomopathogens and entomophillic nematodes (EPNs) widely followed to lessen the white grub menace becomes futile at times in severe cases.

The indigenous technologies involving the cultural practices like deep ploughing to expose the grubs and pupae for predation to birds and use of cover crops may help to the greater extent at times in lowering the pest load. The deep ploughing after the harvest of crop and removing the stubbles that often harbours the pupating grubs and destruction of the same will alleviate the pest problem to certain extent.

Since the white grub infestation is more pronounced in high altitude upland rice which has lesser land holdings, poor resource-based farmers; thus ideally the eco-friendly indigenous approaches like cover crops may be followed to contain the pest. There are certain cover crops used in rice ecosystems, which can bring down the white grub population considerably.

Rabary *et al.* (2011) reported a number of cover crops exert pest suppressing activity against white grubs in upland rice cropping system. It is presumed that the toxicity of these cover crops alters the composition of soil inhabiting macrofauna. The cover crops used for white grub control were hairy vetch (*Vicia villosa*), fodder radish (*Raphanus sativus*), *Brachiaria ruziziensis* x *B. brizantha* (var. mulato), *Crotalaria grahamiana*, *Cleome hirta*, *Tagetes minuta* and *Cosmos caudatus* of which radish was found effective in controlling white grub larvae.

In a study by CIRAD to see the effects of plant diversification on pests population, allelopathic effects of cover crops was observed in relation to white grubs in upland rice in Madagascar. In an effort to elaborate novel cropping systems that are resilient to pests and diseases, based on the introduction of Specific plant diversity (SPD) in agrosystems, the beneficial effects of fodder radish, *Raphanus sativus* was identified against white grubs in mulch-base rice crop. The service plant exerts antibacterial effects suppressing the incidence of white grubs (Ratnadass and Avelino, 2013).

White grub prone areas were recommended three bullocks driven ploughing in three consecutive days and if the soil is dry one or more irrigation prior to ploughing is suggested. 70% of the white grubs' population can be controlled before they go for pupation by this method.

Climate change and soil insect-pests

Pests have been associated with crops since times immemorial. But under changing environment their number has increased and the minor pests now become the major one causing greater damage to the crop. This is evident from the fact that rice crop had 3 major pests in 1965 which has increased to more than 15 in 2005. The greater incidence of disease/pest leads to greater chemical application resulting in higher input cost and agro-ecological imbalance.

Causal relationship exists between climatic conditions and the swarming and colony founding behaviour in termite species. Swarming is meant for the purpose of dispersal and the colony founding. This results in the perpetuation of the species. It seems probable then that the flights must be scheduled in response to some common signal in the environment, such as change in temperature, atmospheric pressure or light intensity. However it would not be surprising to find that certain temperature and moisture conditions are prerequisite for the operation of these cues. Sangamma and Chimkod (2012) concluded that the main stimulus factor for the swarming cues in the termite species (*Odontotermes wallonensis* and *O. brunneus*) depends upon the pre-monsoon rains, temperature and humidity of the climatic conditions.

Climate change that brings uneven rainfall pattern may greatly influence the termite and white grub infestation in rice. As mostly short duration varieties are used in upland, shifts in rainfall or monsoon drastically changes the coincidence of termite peak infestation period with the crop phenology. Location specific researches are needed to verify these facts in rice.

Points to ponder for management

- Effective traditional practices against termites include: smoking the termite nest, use of salt, and flooding of termite nests with water.
- The application of red palm oil mixed with papaya is an indigenous biological control practice. The mixture attracts soldier ants that attack and drive away the termites.
- Research needs for seed treatment must be given due importance for termites and white grubs.
- Suitability of various local cover crops may be tried for grub management vis-à-vis climate change.
- Research must be directed in bait-technology, push-pull-strategy for termites and appropriate bio-control agents for white grubs.

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