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# Potency of Swietenia Macrophylla King and Pachyrhizus Erosus (L.) Seed Powder and Extracts Against Tribolium Castaneum (Herbst)

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# POTENCY OF *SWIETENIA MACROPHYLLA* KING AND *PACHYRHIZUS EROSUS* (L.) SEED POWDER AND EXTRACTS AGAINST *TRIBOLIUM CASTANEUM* (HERBST)

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BY

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**BANGLADESH**

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# Dedication

To my

Grandmother

and

Parent

# DECLARATION

I hereby declare that the research reported in this thesis entitled "POTENCY OF *SWIETENIA MACROPHYLLA* KING AND *PACHYRHIZUS EROSUS* (L.) SEED POWDER AND EXTRACTS AGAINST *TRIBOLIUM CASTANEUM* (HERBST)" submitted to the Institute of Biological Sciences, University of Rajshahi, for the degree of DOCTOR OF PHILOSOPHY was carried out by me under the supervision of Dr Md Saiful Islam Faruki, Professor, Department of Zoology (Supervisor) and Dr KAM Shahadat Hossain Mondal, Professor, Institute of Biological Sciences, University of Rajshahi (Co-supervisor). The thesis has not been currently submitted elsewhere for any other degree.

30.06.13

**Md. Abul Hossain Mondal**

**University of Rajshahi**

# CERTIFICATE

This is to certify that Md. Abul Hossain Mondal carried out his research works under our supervision as a University Grand Commission (UGC) Ph D Research Fellow. We are pleased to forward his thesis entitled, "POTENCY OF *SWIETENIA MACROPHYLLA* KING AND *PACHYRHIZUS EROSUS* (L.) SEED POWDER AND EXTRACTS AGAINST *TRIBOLIUM CASTANEUM* (HERBST)" submitted for the degree of DOCTOR OF PHILOSOPHY. He carried out his research at the IPM and Toxicology Laboratory of the Institute of Biological Sciences, University of Rajshahi, Bangladesh, under our supervision. He has fulfilled all necessary requirements for submission of the thesis for the award of Ph D degree.

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The Author

male, female and unsexed adults of *T. castaneum* after exposure at 3, 5 and 7 days. Whereas the toxicity of methanol extracts of mahogany and kesur seeds were also evaluated against larvae and adults of the same stages after exposure at 5, 7 and 14 days. Both the plant seed extracts were effective in controlling both larvae and adults of *T. castaneum.*

The larvae and adults of *T. castaneum* were exposed to *S. macrophylla* and *P. erosus* seed powders treated food for detecting repellent effect. The 16 day old larvae were repelled significantly ($P<0.01$) after exposure to food treated with mahogany seed powder at 1 and 24h than 9 and 12 day old larvae. Similar repellent effect was also recorded on kesur seed powder. The highest repellency (93.30%) was recorded for 9 day old larvae exposed to mahogany seed powder treated food and 16 day old larvae for kesur seed powder treated food at 2% dose after 24h exposure. Both the plant powder had produced significant repellent effect on adults.

The chloroform seed extracts of mahogany showed significant ($P<0.05$) repellent effects on 9 and 12 days old larvae of *T. castaneum* after 1h exposure to treated filter paper. The methanol seed extracts had no repellent effects at any exposure periods and in any larval stages. The *S. macrophylla* seed extracts of chloroform and methanol similarly had no repellent effects on adults. The chloroform and methanol seed extracts of kesur had no significant repellent effects on larvae and adults of *T. castaneum* at any exposure periods.

The mahogany and kesur seed powders and extracts either alone or in combination on reproductive potential of *T. castaneum* were evaluated. The treatments significantly ($P<0.001$) reduced the number of eggs laid by females developed from treated foods and the fertility of the laid eggs.

The deformities in adults were noted from larvae after exposure to treated food, and from pupae after exposure to treated filter paper and treated food. All the treatments of mahogany and kesur seed powders and extracts either alone or in combinations significantly ($P<0.001$) produced adult deformities in *T. castaneum.*

The formation of larval, pupal and F1 adult progenies of *T. castaneum* were observed from adults released on treated food with different doses of mahogany and kesur seed powder separately. All the treatments of both plant seed powders significantly ($P<0.001$) suppressed the population. Similarly, the larval, pupal and adult populations of *T. castaneum* significantly ($P<0.001$) reduced by the effects of chloroform and methanol extracts of mahogany and kesur seeds. In the development of population, powder and extracts of kesur seeds were more effective than that of mahogany.

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# Chapter 1

# GENERAL INTRODUCTION

## Botanical Insecticides

Botanical insecticides are insect killing chemical substances obtained from plants. These chemicals include an array of glycosides, alkaloids, saponins, tannins, essential oils, cyanogens, phenolics, amino acid analogs, non protein amino acids, proteinase inhibitors, cardiac glycosides, and other organic compounds, whose metabolic functions are presently obscure (Youngken 1950).

## Prospect of the botanicals

Plants are considered to be the most potent to human beings not only because of their support for food and shelter, but also because they provide all the requirements for the survival of the civilization during the past few decades. The world advanced rapidly with remarkable development in pesticide technology and medicine, but there are still some problems especially for undesirable changes in gene pool for the presence of some mutagenic agents. So a question has arisen for sustainability and the survivability of the living beings on the planet with non-hazard environment. Hence, a worldwide interest has created in the revolution and use of age- old traditional botanical agents (Heyde *et al.* 1984).

Several insecticides have been tried to control the insect pests. Control by chemical insecticides are very effective, but indiscriminate use of chemical pesticides has given rise to many serious problems, including resistance by pest species, environmental pollution, threat to wild life, motivation by weather, hazards from handling etc, as mentioned earlier These hazards have created awareness to people and developed a worldwide interest for the use of botanical pest control agents as botanicals are comparatively safer to mammalian and higher animals (Feinstein, 1952).

In the rural areas of Bangladesh, farmers traditionally mixed leaves, bark, seeds, roots or oils of certain plants with stored grains to keep them free from insect attacks. Such techniques have been inherited as part of traditional culture (Saxena *et al.* 1989). Recently a number of investigators isolated, identified and screened chemical compounds from plants and reported the effective use of these materials as insecticides against stored grain pests (Ahmed *et al.* 1980, Khanom *et al.* 1990a,b; Khalequzzaman and Islam 1992a,b; Talukder and Howse 1994).

The plants synthesize and accumulate a complex array of extractable bioactive organic chemicals with specific stereochemistry called secondary metabolites (Balandrin and Klocke 1988, Harborne 1988), providing the richest source of economically important organic chemicals on earth (Grainge and Ahmed 1988) For example, a good secondary metabolite having a high degree of structural complexity is Azadirachtin. These economically important metabolites are normally obtained from plant materials by stem distillation or by extraction with organic or aqueous solvents (Balandrin and Klocke 1988). Secondary metabolites produced by the plants are used against insects, mites, pathogens and even weeds (Grainge and Ahmed 1988). Biochemists often refer to them as natural products (Geissman and Crout 1969) to distinguish them from synthetic products that are produced in the laboratory (Simmonds *et al.* 1992).

Extracts of plants have been used by humans for control of insects since before the time of the ancient Romans (Talukdar and Howse 1995). The interest in botanical pesticides revealed during the recent years because of some of the serious drawbacks of the synthetic insecticides including lack of selectively, impact on the environment and the emergence and spread of pesticides resistance (Grainge and Ahmed 1988, Su and Mulla 1998).

Botanicals are environmentally non pollutive, renewable, inexhaustible, indigenously available, easily acceptable, largely non phytotoxic, systemic epimeral, thus readily biodegradable, relatively cost effective and hence most suitable in the strategy of integrated pest management (Upadhyay *et al.*1996).

**Plants used in this study**
**Taxon: *Swietenia macrophylla* King**

Taxonomic Hierarchy

| | | |
|---|---|---|
| *Kingdom* | Plantae | –Plants |
| Subkingdom | Tracheobionta | –Vascular plants |
| Super division | Spermatophyta | –Seed plants |
| Division | Magnoliophyta | –Flowering plants |
| Class | Magnoliopsida | –Dicotyledons |
| Subclass | Rosidae | |
| Order | Sapindales | |
| Family | Meliaceae | -Mahogany family |
| Genus | *Swietenia* King | –Mahogany |
| Species | *Swietenia macrophylla* King | |

### Common names

| | | |
|---|---|---|
| Honduras mahogany | – | English |
| Mahogany | – | English |
| aguano | – | Portuguese (Brazil) |
| caóba | – | Portuguese (Brazil) |
| mogno | – | Portuguese (Brazil) |
| caoba | – | Spanish |

### Local name

- Bara Mahogini (Rahman 2009).

### Synonyms

- *Swietenia candolei* Pittier
- *Swietenia krukovii* Gleason
- *Swietenia belizensis* Lundell
- *Swietenia macrophylla* King var. *marabaensis* Ledoux et Lobato
- *Swietenia tessmanii* Harms

(NPGS-GRIN.Taxon; MMPND-Sorting *Swietenia* names; Agro Forestry Tree Database)

### Related species of interest

The genus consists of two other species, *S. mahagony* and *S. humilis.* The three species are poorly defined biologically, in part because they hybridize freely.

### Distribution and habitat

Humid zone species of the new world, widely distributed, natural as well as cultivated; native to Mexico (Yucatan), Central and northern South America (Amazon region). Extensively planted mainly in southern Asia and the Pacific; also introduced into West Africa. In Bangladesh, this species is planted throughout the country (Gullison *et al.* 1996, Rahman 2009).

### Uses

Mahogany is one of the most valuable furniture timbers in the world due to the decorative and attractive timber with good technical characteristics. It is widely planted in the tropics in reforestation and aforestation programmes. In agro forestry systems it is used for shade and fuel wood (Cottle 1959, Lyhr 1992, Soerianegara *et al.*1 993).

### Botanical description

Usually evergreen tree, 30-35m long. Bark grey and smooth when young, turning dark brown, ridged and flaky when old. Leaves up to 35-50 cm long, alternate, glabrous, paripinnate; 4-6 pairs of leaflets, each leaflet 9-18 cm long. Flowers small and white, 10-20cm long, branching panicles (Alvenga *et al.*1988).

### Fruit and seed description

**Fruit:** Dehiscent, usually 5-lobed capsule, erect, 12-5(-22)cm long, grayish brown, smooth or minutely verrucose. Outer valves woody, 5-7 mm thick, inner valves much thinner. In the centre is a woody, 5 angled columella extending to the apex. The fruits split open from apex or base when they are ripe and dry. Seeds are hanging from the columella by their wing, leaving conspicuous scars after their release. Usually 35-45 seeds per fruit.

**Seed:** brown, oblong, compressed, crested and extended into a wing at the attachment end, 7.5-15 cm long incl. wing with extensive air spaces. The seeds are dispersed by wind. There are1800-2500 seeds per kg (Nataniela *et al.* 1997).

### Flowering and fruiting habit

Flowers are unisexual and the tree monocious. The flowers are pollinated by insects. Hybridization is frequent, especially with *S. mahagoni* where the species grow together. Usually only one flower of the inflorescence develops into a fruit, the others are aborted. Development from flower to mature fruit takes 9-12 months.

Phenology data are summarized here:

| | Flowering | Fruiting |
|---|---|---|
| Central and northern S. America | April-June | Jan-March |
| Southern S. America | Sept-Oct | July-Aug |
| British Virgin Is. and Puerto Rico | May-June | Sept-Oct |
| Costa Rica | March-April | Dec-Jan |
| Solomon Islands | | June-Sept |
| Philippines | March-June | Dec-March |

(Pennington *et al.* 1992).

The long development time for the fruit makes crop assessment possible several months before harvest. Flowering usually takes place when trees are leafless or just coming into new leaf shortly before the rainy season.

### Harvest

The fruits are preferably collected from the trees just before they split open or from the ground immediately after seed fall. Seed production varies according to site and year. A crucial factor for seed production is pollination efficiency, which may be erratic especially outside the natural range of distribution. A mature tree of *S. macrophylla* can produce up to 200 mature fruits in a year or about 4.8 kg of seeds. However, usually the production is only 2.5-4 kg per tree for trees with fairly exposed crowns (Nataniela *et al.* 1997).

### Processing and handling

Mature dry fruits or dry seeds collected from the forest floor can be stored for some days in sacks without significant deterioration. However, in order to reduce bulk it is often preferable to initiate processing in the field. The fruits will split open when dried for 1-4 days, depending on maturity, after which the seeds are easily released by gentle shaking of the fruits. Fruit parts (valves and columella) are removed by hand. Further reduction of bulk by manual dewinging may be desired (Nataniela *et al.* 1997).

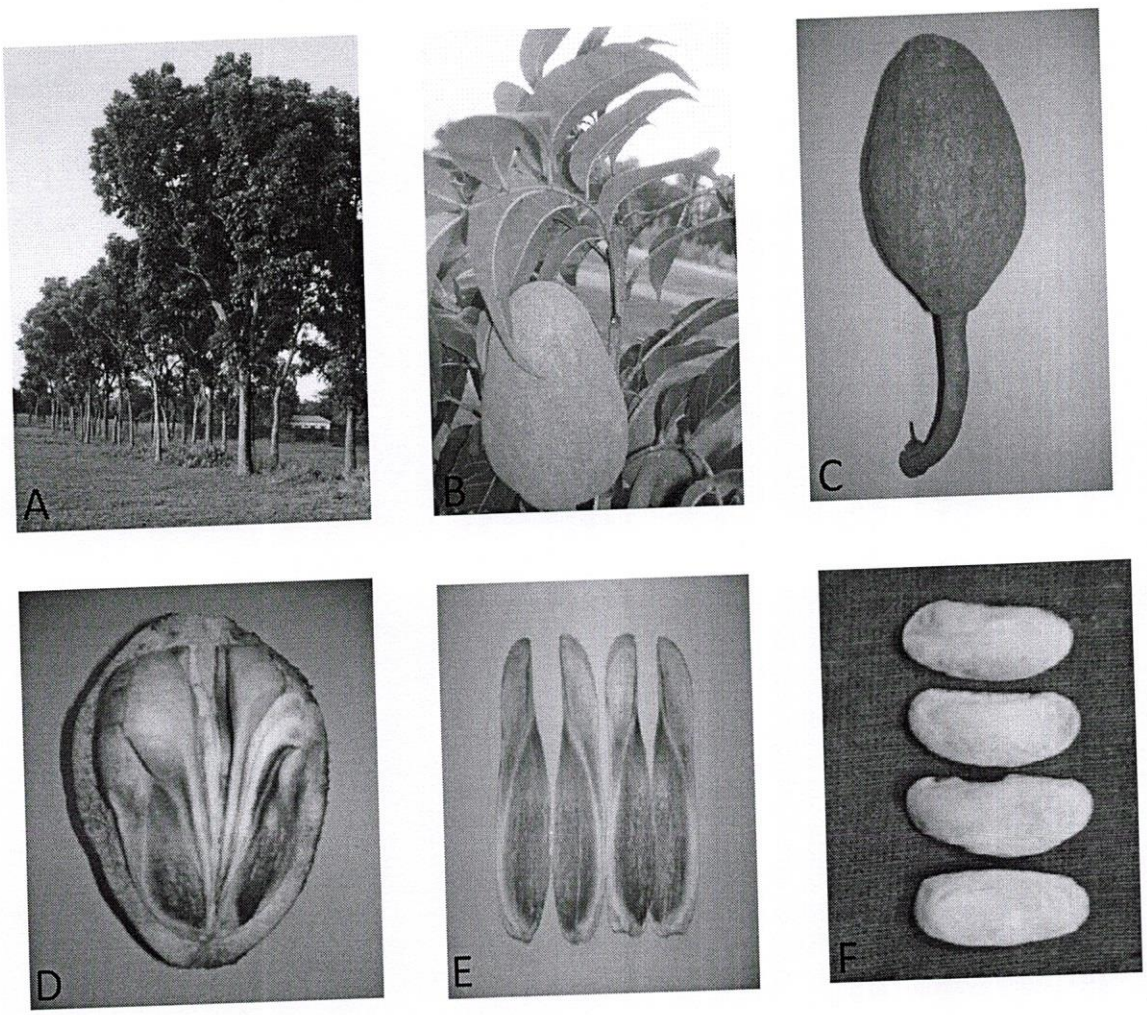


Plate 1. *S.macrophylla* tree with different parts; A-Mature trees, B-Branch with leaves and fruit, C-Fruit, D-Splited fruit, E-Winged seeds, F-seeds.

### Storage and viability

Seed is orthodox and if stored at 3-7% moisture content at low temperatures (1-5°C), it will retain high viability for several years. If the seed is stored in paper bags at room temperature, 7-8 months storage can be expected without loss in viability. Initial moisture content in mature seeds is 9-12%. Germination percentage of fresh seeds is 60-90% (Nataniela *et al.* 1997).

### Pretreatment

Pretreatment is generally not necessary but germination of seeds with low moisture content may be enhanced by soaking in water for 12 hours.

### Sowing and germination

Under test conditions seeds are germinated in sand at fluctuating 35-30°C or constant 30°C and 12/12 for 8/16 hours light /dark. In the nursery, seeds are sown in a bed of light sand in 3-7 cm deep furrows or holes or directly in containers. Germinating seeds should be kept moist and under shade. Seeds will germinate in 10-21 days. The seedlings are kept under shade until out planting, which can take place when they are about 50-100 cm tall (Nataniela *et al.*1997).

## Taxon: *Pachyrhizus erosus* (L.)

### Taxonomic Hierarchy

| | | |
|---|---|---|
| *Kingdom* | Plantae | –Plants |
| Subkingdom | Tracheobionta | –Vascular plants |
| Super division | Spermatophyta | –Seed plants |
| Division | Magnoliophyta | –Flowering plants |
| Class | Magnoliopsida | –Dicotyledons |
| Subclass | Rosidae | |
| Order | Fabales | |
| Family | Fabaceae | –Pea family |
| Genus | *Pachyrhizus* Rich. ex. DC. *pachyrhizus* | |
| Species | *Pachyrhizus erosus* (L.). Yam bean | |

### Common names

| | |
|---|---|
| Kesur | - Bengali |
| Yam bean | - English |
| patate cochon | - French |
| pois patate | - French |
| Yambohne | - German |
| mishrikand | - India |
| jícama | - Spanish |

### Local name

- Kesur, Shak-alu, Kesur-alu (Naderuzzaman 2009)

### Synonyms

- *Cacara erosa* (L.)Kuntze
- *Cacara palmatiloba* (DC.)Kuntze
- *Dolichos erosus* L.(basionym)
- *Dolichos palmatilobus DC.*

- *Pachyrhizus angulatus* Rich. ex DC.
  *Pachyrhizus bulbosus* Kurz
- *Pachyrhizus erosus var. palmatilobus* (Moc. & Sessé ex DC.)R. T. Clausen
- *Pachyrhizus palmatilobus* (DC.) ined.
- *Pachyrhizus strigosus* R.T.Clausen

**Botanical description**

A twining, climbing or trailing herb, with a large tuber, root simple or lobed, turnip shaped with light brown skin and white flesh. Stem with tony hair .Leaves trifoliate, alternate leaflets ovate rhomboid, coarsely dentate or 5-lobed, stipules linear lanceolate 5-10mm long, stipels linear. Flowers an axillary racemes, 1-5 flowers born in dense clusters or short pedicels at each node of peduncle. Calyx 4 lobed, unequal. Corolla violet or white. Stamens diadelphous, anthers uniform. Ovary sub sessile. Styles ciliate, recurved, stigmas subglobose. Fruit a pot, flattened, finely strigose, constricted, 4-12 seeded. Seeds almost square shaped, flattened, yellow, brown or red.

**Flowering and fruiting:** October – January.

**Chromosome number:** 2n =22 (Fedorov 1969)

**Habitat:** Plain dry lands, also cultivated.

**Distribution**

Originated in Mexico and Central America, now cultivated in tropics. In Bangladesh, it was recorded from Chittagong and Dhaka districts (Naderuzzaman 2009)

**Economic uses**

The tubers are mostly consumed fresh in salads or lightly fried .Tubers is also eaten raw.

**Ethno botanical information's**

Immature pods are used locally in south East Asia as a vegetable. The ground seeds are used as an insecticide or as fish poison.

**Propagation:** By seeds (Naderuzzaman 2009)

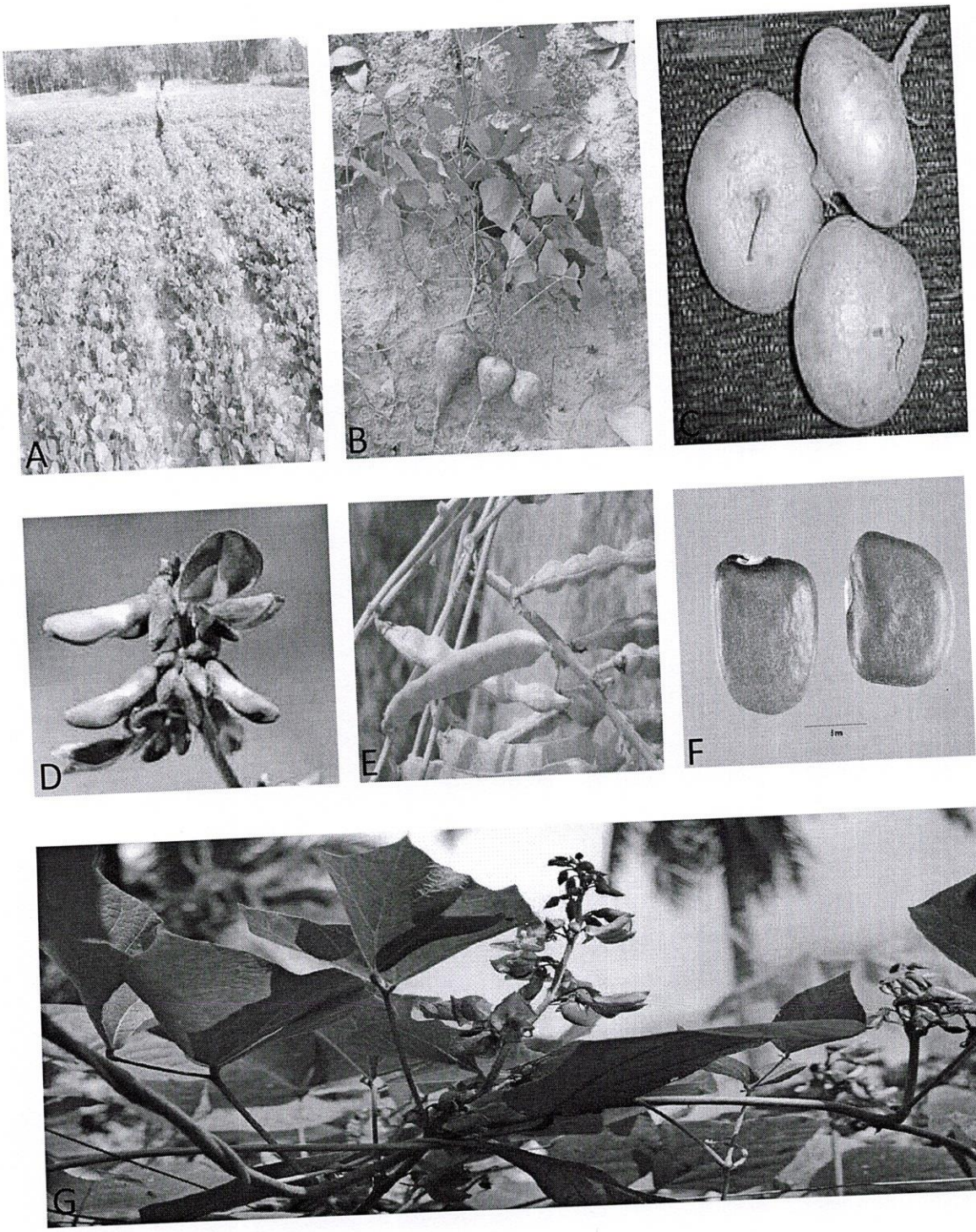


Plate 2.Cultivated field of *P. erosus* and its different parts; A-Cultivated field, B-Kesur-alu with stem, C-Kesur-alu, D-Flowers, E-Stem with bean, F-Seeds, G-Climbing stem with flowers.

## The insect used for this study

### Taxon: *Tribolium castaneum* (Herbst)

Taxonomic Hierarchy

| | |
|---|---|
| Kingdom | Animalia (animals) |
| Eumetazoa | (metazoans) |
| Bilateria | (bilaterally symmetrical animals) |
| Protostomia | (protostomes) |
| Ecdysozoa | |
| Phylum | Arthropoda (crustaceans, insects,spiders and relatives) |
| Uniramia | |
| Subphylum | Hexapoda |
| Class | Insecta (insects) |
| Subclass | Pterygota (winged insects) |
| Superorder | Neoptera |
| Holometabola | |
| Order | Coleoptera (beetles) |
| Suborder | Polyphaga |
| Superfamily | Tenebrionoidea |
| Family | Tenebrionidae |
| Genus | *Tribolium* |
| Species | *Tribolium castaneum* Herbst |

Synonyms

- *Colydium castaneum* Herbst
- *Dermestes navalis* Fabricius
- *Tenebrio castaneus* Schönhegr
- *Phaleria castanea* Gyllenhal
- *Uloma ferruginea* Dejann
- *Tribolium casteneum* MacLeay
- *Margus castaneus* Dejean
- *Stene ferruginea* Westwood
- *Tribolium ferrugineum* Wollaston

Common names

- Red flour beetle
- Rust red flour beetle
- Bran bugs

- Tribolium rouge de la farine, petit ver de la farine (France)
- Rotbraune reismehlkäfer (Germany)
- Tribolio castaneo, gorgojo castano de la harina (Spain)
- Chi Ni Gu Dao (China)

**_T. castaneum_ as a stored grain pest**

Rust-red flour beetle, *Tribolium castaneum* Herbst. (Coleoptera: Tenebrionidae) is a polyphagous and cosmopolitan pest. It is one of the most established insect pests of stored products. It is the most abundant and detrimental pest in flourmills, grain bulks, oilseeds and warehousing facilities (Zettler and Cuperus 1990, Zettler 1991). It feeds on those grains only, which have already been damaged by primary pests. Its presence in stored foods directly affects both the quantity and quality of the commodity (Mondal 19[illegible]). Insects may cause damage to the seed embryos, which results in decreased