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Insect pest constrains of jute and its control by biological agents under modern Eco-Friendly sustainable production system

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Abstract
India is one of the world's largest jute producing country. Insect pests are one of the main constrains for underscoring jute production. To ensure and to stabilize production, farmers generally apply huge amount of insecticides of different newer brands. Toxic chemicals not only not only underscore the environmental health but also impart long, persistent and perennial effect on the farmer's health. Further, insect pest population evolved resistance to chemical pesticides due to producing large number of offspring with highest degree of mutation, variation, co-evolution and natural selection. Therefore emphasize on biological control in modern IPM practice to control insect pest population, by their natural enemy, predator and parasitoids is a time-needed programme. In biological control the 'agents' are targets on specific insect pest and control them without affecting other organisms and environment. The current review is an gross view on the processes of effective management of major insect pest of jute by biological agents under modern IPM Practices which broadly covers different scientific publication in different journals and contemporary works of the scientists.

Keywords: Biological control, major jute pest, parasitoid, pesticide resistance, natural enemy, yield loss.

1. Introduction

Resistance to pesticide results in the decrease in efficacy of pesticide for a given pest population that was previously effective to control the pest. Long exposure to pesticide causes pesticide 'treadmill effect' and consequently results in the resistance of pests due to 'natural selection' which is established by three factors. Firstly, insects produce large number of offspring with great degree of mutation, hybridization and genetic variation. Secondly, pest evolved and exists in nature earlier then human evolution. Insect pest coevolved with their host plants, as they produces phytotoxins and insects detoxify or to create poisons [Ferro, 1999; Bishop *et al.* 1996].Thirdly, humans often rely almost exclusively on insecticides for pest control. Comparatively more resistant organisms with more chances of survival value and fitness pass their genetic message to their off spring and accordingly get selected [PBS, 2001]. Further, pesticides that fail to breakdown quickly and remain in the area contribute to selection for resistant organisms even they are no longer being applied [Daly *et al.* 1998]. Rachel Carson (1962) in her book "*Silent Spring*" proclaim the devastating effect of pesticide and advocate to more reliable and eco-friendly approach to control the pest population and to ensure a good health quality of the farmers and the common people. [PBS, 2001].

The people of India traditionally used jute to make rope, sacks, paper, and coarse hand woven fabrics for matting and bedding. English traders saw the potential of jute as a substitute for hemp and flax as early as 1793, and eventually a consignment found its way to Dundee in Scotland. The flax spinners there learned how to spin jute yarn by batching fibres with whale oil and water and modifying power-driven flax machinery (NJB, 2014).

Before long they were producing jute goods in substantial quantities. Jute thrives best under warm and humid climate. It is a crop of around four months grown in rain-fed situation during summer to early rainy season (mid March to end of July). Weeding and retting (microbial decomposition in high volume of water) are two major field operations in jute cultivation. It is an under-mechanized crop (BBC, 2013).

Sustainable Agriculture:

Environmental issue is not just a physical phenomenon. It is multidimensional and muti-facet, physical, biological and soicio-economical global issues. Sustainable agriculture is the way by which agricultural products are growing or raising in an ecologically and ethical manner (Gold, 2009). It include agricultural practices that do not harm the environment, that provide fair treatment to workers and that supports and sustain local communities (RSGA, 2002). Sustainable crop production in contrast to conventional culture practice it includes minimum use of chemical pesticides and fertilizers, maximum use of organic manure and natural enemies of pest to get higher yield over time with less need of expensive and environmentally damaging inputs [Miguel, 1995]. Sustainable development strategy establishes harmony between growth process and protection of nature by striking off a balance between socio-economic and environmental need of present and future generation. This means that fulfillment of twin objective of accelerated growth of income couple will enhance employment opportunity, utilizing maximum local renewable resources by adapting modern and advance technology to achieve higher productivity (Robert, 1993).

Jute: The Golden Fiber:

Jute is an agricultural rapid growing crop and renewable source of biomass. Jute and Allied Fibers (JAF) are mainly cultivated in the equatorial, the topical and sub-topical zones and has similar pattern of geographical distribution as they are related phylo-genetically and their origin in Egypt and Indo-china. Jute is a long, soft, shiny vegetable fiber that can be spun into coarse, strong threads. It is produced from plants in the genus *Corchorus* (Family: malvaceae). It is lingo-cellulosic bast- fiber. Traditionally are being used as a raw material for packaging materials. It is a versatile fiber having the properties of soft and hard fiber both traditional and diversified products are biodegradable, photo-degradable, thermal degradable, non-toxic, non-plastic, hydrophilic, anionic, less extensible, high water and UV absorbing capacity, visco-elastic, reusable, easily disposable.

Sustainable Jute Production:

The economy of India is basically depends on agriculture. Jute is a commercial fibre crop, which plays a significant role in the economy of a number of Asian countries like, India, Bangladesh, Nepal, Thailand, China and Myanmar **(Fig.1)**. Fiber crop production and export has been given priority at commercial level to ensure better Indian national income (NJB, 2014).Production of jute in India is outstanding with an average low export of 162,000 tones of raw jute [IJSG, 2014]. Jute is the most affordable natural fibers and only second to the cotton in amount produced. In India, jute is predominantly cultivated by the marginal (65%) and small (25%) farmers of West Bengal contributing about 80 per cent national jute production (Chapke *et. al*. 2006).

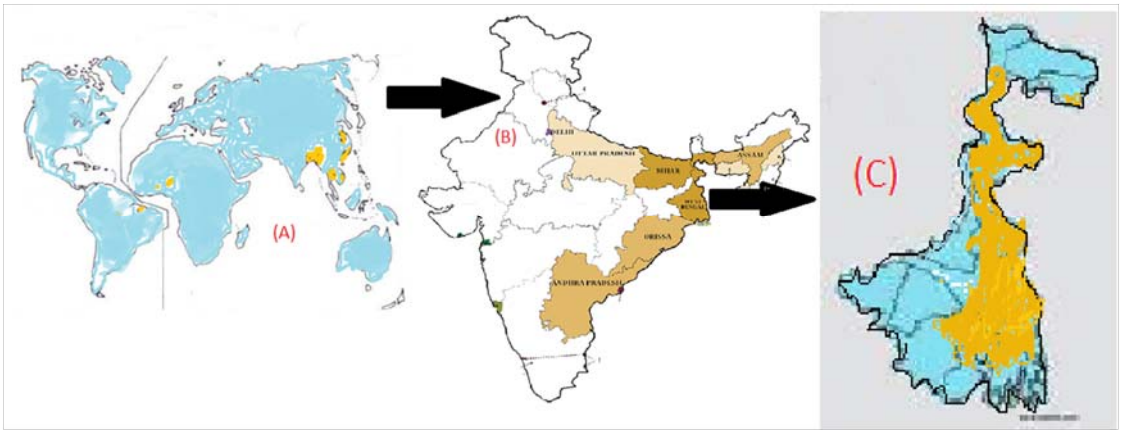

Fig 1. Jute Production in (A) World (B) India (C) West Bengal

In present-day sustainable jute production attracts for higher production with minimal health hazard. In the context of global awareness for environmental concerns, and allied fibres, as eco-friendly packaging materials are again in the centre stage as against synthetic fibres, which are pollutant by nature as claimed by the environmentalists (Sen *et al.* 2008). Food and Agriculture Organization (FAO) has declared year 2009 as the *International Year for Natural Fibres* considering, particularly, their environmental significance.

The Jute Cultivars and Production Scenario:

Out of the top ten jute producing countries, Bangladesh and India hold first two positions [FAO, 2014]. The jute producing countries are -India, Bangladesh, China, Uzbekistan, Nepal, Vietnam, Zimbabwe, Thailand and Egypt **(Table 1)**. These countries together cover an area of 1.7 million has in world which covers the total jute producing land [FAO, 2014].

Table 1: Major Three Jute Producing Countries

Country	Jute cultivating land(lakh ha)		Production (Tones)	
	Total area	Percentage	Total area	Percentage
Bangladesh	3.84	32.79	1,924,326	55.25
India	7.25	61.92	1,523,315	43.63
China	0.62	5.29	43,500	1.12

In India jutes are cultivated mostly in the states of the northern part of the country **(Fig. 1)**. These states are West Bengal, Bihar, Assam, Orissa, Tripura and Andhra Pradesh. Out of this West Bengal, Bihar and Assam share in about 80% of the production. West Bengal tops the list in respect of both the area (73.5%) and production (82.26%) of jute in

the country. Jute producing area in the state West Bengal is conventionally sub divided into 3 regions –southern Bengal, semi northern part of Bengal and northern parts of Bengal. Mursidabad, Hooghly, Nadia, Howrah, 24 Pargana (North and South) and Medinipur districts are the important producer district out of the total state territory. Among these both North and South Dinajpur district jointly covers 31,973 ha land for jute cultivation [Raja, 2012].

Among the various varieties of jute, two species *C,Capsularis* and *C,Olitorius* are widely and commercially grown particularly in Bangladesh and India. They technically are called white and *tossa* respectively. Previously white variety was the most widely used but now changes to *tossa*.

Constrains of Jute Production:

There are several factors responsible for the low jute productivity, of which the loss due to insect pest is one of the major concern. In the quest for increasing fibre production to meet the ever-increasing demand, fertilizers generally have played a crucial role. But, in recent years, fertilizer cost and concern for sustainable soil productivity and ecological stability in relation to pesticides and effective farm management use have emerged as important issues (Aulakh *et al*. 2000). Improper fertilizer management and unscientific adoption of pesticides of different newer brands underscore not only the soil health for time but also the insect pest incidence (RPMN, 2007).

Farmer of West Bengal apply high doses of inorganic fertilizer and different types of toxic and hazardous type of newer insecticides in high quantum without any concern to the environment [Das *et al*. 1986].Farmer being used these chemicals extensively in the growing tract of West Bengal, pests developed resistance due to long time exposure and thus necessitates the newer formulation of chemical molecule [Sadat *et al*. 2009]. New chemical molecules that are introduced create two prime problems. Primarily, chemicals of same group and in higher concentration affect other crop field and nearby crop ecosystem and it will make unquestionably more resistant pest in future because of the applied higher concentration. Secondly, several new chemicals with novel mode of action are available in market, but it may not be suitable unless their field efficiency and baseline data for toxicity at regional level is generated [RPMN, 2007].Further, use of synthetic chemical insecticides although successfully control the pest(s), it destroy predator, parasitoids and beneficial microbes causing imbalance in the ecosystem.

Major Insect Pests of Jute and Extent of Damage:

As jute is grown during the summer season, a number of insect pests infest throughout the crop cycle **(Table 2)**. Rahman *et al*. (2006) in West Bengal, India has estimated at about 31–34% fibre loss due to multiple insect pest attack. Das *et al*. (1986) and Rahaman *et al*. (2012) had enlisted a profile of insect pests in relation to the growth stage of the jute plant damaging jute crop. In general 40 species of insects and mites attack jute in Bangladesh as reported by Kabir, (1966). Out of this, jute hairy caterpillar *Spilarctia (=Spilosoma) obliqua* (Walker) is of prime importance (Kabir *et al*. 1968). Apart from jute hairy caterpillar, jute semilooper (*Anomis sabulifera* Guen.) (FIG 2), Bihar hairy caterpillar (*Spilarctia obliqua* Wlk.), indigo caterpillar (*Spodoptera exigua* Hubner), stem girdler (*Nupserha bicolor* Dutt), stem weevil (*Apion corchori* Marshall), grey weevil (Myllocerus *discolor* Bohemus), yellow mite (*Polyphagotarsonemus latus* Banks) and red mite (*Oligonychus coffeae* Nietner) are considered as the other major pests (Das *et al*. 1977) in India.

Fig 2: (A) Jute Field (B) Jute Pest [Jute Semilooper] (C) Damaged Jute Leaf.

The jute semilooper, a cosmopolitan pest, is reported from the entire jute growing region all over the world and has estimated to damage up to 90% of the leaves of jute plant in some cases [Tripathi *et al*. 1964]. Damage to jute foliage results in poor plant growth and ultimately low fiber quantity [Tripathi *et al*, 1964; Sing *et al*. 1979; Das *et al*. 1976; Das *et al*. 1995].In general the pest of second generation is comparatively more destructive to the fiber crop [Sing *et al*. 1979]. Dutta, (1958) had recorded that in 81% cases the 7-9 leaves of upper part of the standing crop are damaged.In some cases the extent of damage may extend up to 91% covering 9th position of the leaf of the tiller. Pre monsoon rains followed by drought condition are congenial for the outbreak of semilooper and may lead up to 50% loss of crop as reported by Dutta (1958).

Both the nymph and adult of Jute mealy bug, *Phenacoccurs hirsutus* attack jute plant.Nymphs and female adult feed on the apical parts of the plant and result in stunted and bushy-top symptoms of the plant. The petiole of the fiber crop becomes shortened, the lamina crumples and inter-nodal length reduced which ultimately results in the deterioration of the fiber and reduction of the yield. [Das *et al*. 1976]. Beet

Armyworm, *Spodoptera exigua* though earlier was considered as minor pest, but it had changed its status to major accounting yearly 20% yield loss of jute fiber. [Dutta, 1958]. Plants planted at early season are more prone to damage by this pest. Mostly, *S. exigua* feeds on jute plant that are less them two months of age [http://nac./ac.in/eagri-50/ENTO331/Lecture-14/Jute-002].

Apion corchori preferably fed on *C.olitorius* than on *C.capsularis.* Damage to the quality of fiber is mainly caused due to the 'ovipositiion holes' caused by the weevils. Female make a number of such holes in stem before egg laying and accordingly damager numerous stems. Effective control of the pest is very crucial as because the insect passes there most of the life inside the stew and thus escapes from the direct contact of the applied pesticides [Das *et al.* 1986].

Jute stew girdle *Nupserah bicolor* and hairy caterpillar *Spilosoma oblique*a though once was considered as a sporadic pest on jute [Dutta, 1958], but become a major threat to jute plant and gain the status of major pest from last two decades [http://nac./ac.in/eagri-50/ENTO331/Lecture-14/Jute-002].

Yellow Mite, *Polyphagotarsonemus latus* is destructive for jute production [Das *et al.* 1979]. They sucks sap from younger leaves results in foliage discoloration; natural green colour of leaves turn into brown with change of shape due to curling [Das *et al*. 1985]. Loss of nutrition in young plant due to sucking, height of the plant becomes stunted and significant yield loss occurs [Nair, 1986, Pradhan *et al*. 1997].

Table 2: Major insect pests of jute, food habit, distribution and degree of damage.

Major insect pests	Food habit(monophagus/ polyphagus) and succession through time	Degree of Destruction*	Distribution
Anowis sabulifera	Monophagus	+++	Jute tracts of India, Bangladesh, china, Myanmar, srilanka, part of Africa.
Spodoptera exigua	Once it was mayor pest of indigo. Now minor pest of chilies, onion, brinjal, sweet pepper, gram, lentil, linseed, cabbage, maize, Catton, sufflower, sun flower etc.	+++	India and other countries of orient, Africa, Europe, south Africa, America.
Nupserha bicolor	Polyphagus. Jute, Mestas, dhaincha it becomes mayor pest of jute in the past two decades.	++	Jute tracts of India & Bangladesh.
Apion corchori	Polyphagus it has a number of alternate host plants but most preferred *capsularis* varieties.	++	Jute tracts of India & Bangladesh.
Phenacoccus Hirsutus	Polyphagus jute and Roselle fiber crop	++	Jute tracts of India
Spilosoma oblique	Polyphagus jute, tomato, brinjal, potato, sugar beet and solanaceous weeds	++	India Bangladesh, China.
Polyphagotarsonemus latus	Polyphagus jute,tea,grapes,apple, castor, chilli, coffee, cotton, potato, Mango, papaya etc.	++	India, Bangladesh, China, Srilanka and other past of south East East Africa, Europe, North &south America & Pacific island.

*Degree of destruction: +++ High, ++ Moderate, + Low

Application of Biological Agents for Pest Control:

The jute agro-ecosystem supports large number of natural enemies (Rahman *et al*. 2009) and their importance in integrated approach for management of pests of jute has been developed (Rahman *et al*. 2010).

Mechanical method, trap method, seasonal culture method and biological method are considered as the constituent in integrated pest management (Srivastaava, 2004). Out of this, control of pest by biological means is given prominence control because of its utility and effectiveness (Waterhouse, 1998 Srivastava, 2004).

In any biological control program it is essential that appropriate procedures are adopted in relation to the selection of suitability host-specific natural authorities and shape procedure for eliminating unwanted fellow travelers.

Predators: *Scymnus pallidicollis* (Coccinellidae) is the most efficient predator and feed vigorously on the egg, nymphs and adult females of jute mealy-bug, *Phenacocus hirsutus* [http://nac./ac.in/eagri-50/ENTO331/Lecture-14/Jute-002].

Jute Stem-girdler, *Nupserha bicolor* attacked by *Neocatolaccus* sp and *Norbanus* sp (Chalicidde) in larval condition [http://nac./ac.in/eagri-50/ENTO331/Lecture-14/Jute-002]. In India, during the serious outbreak of *Anomies* in Hydrabad, large number of common Mynah was reported to eat the larva (Khan, 1956).

Parasites: *Beuveria bassiana*, a fungal antagonist and entomopathogen could be ntroduced into jute as a endophyte through seed treatment. Colonization of entomopathogen in leaf, stem and pod was confirmed through culturing of plant tissues on selective medium. Under field condition the spore suspension of *B.bassiana* considerably reduces the damage caused by Bihar hairy caterpeller and semilooper, and performed better than the commercial formulation [Hong, 2003].

Many commercial insectaries rare & market a variety of natural enemies' including predaceous mites, lady beetles, lacewings, praying mantids & several species of parasitoids. Success with such releases requires appropriate timing (the host must be present or the natural enemies will simply die or leave the area) & release of the correct number of natural enemies per unit area [Hoffmann *et al*. 1993].

Parasitoids: *Tricogramma* sp. and *Podisus* sp. from USA was introduced in China for control of *Anomies* sp [Wang *et al*. 1987]. In Mysore 70% of *Anomies* sp in cotton field were parasitized with *Apantenes spp* and tachnid flies. In laboratory condition eggs and pupae of *Anomies* sp were attacked by *Trichogramma minutus* and *Tetrastichus howardi* (Eulophidae) respectively [Maheswariah *et al*, 1956]. *Isyropa* sp and *Carcelia kockiana* (Diptera), *Apanteles* sp (Hymenoptera) from India [Maheswariah *et al*,

1956;Sohi, 1964;Thompson, 1953] and *Branchiomeria* spp (chalciddae) [He *et al*. 1993],*Apanteles anomidis* (Hmenoptera) [Xi *et al*. 1984] and *Eucanthecona Fercellata*(Hemiptera) [Wu *et al*. 1981] are reported as important parasitoid in China.

Conclusion:

Jute is a renewable source of bio-mass. Jute and jute products are bio-degradable, reusable, easily-disposable. Data and indicators generated and presented in this paper by both Life Cycle assessment and Emergy analysis reflected that jute and jute products from its plantation to disposal are ecologically compatible, environmentally acceptable and socially and economically sustainable. After green revolution due to use of vigorous fertilizer, pesticides and intensive crop pests are breakout around the country & damage our crop. Though we are using chemical insecticides; pest became more resistant to these. Also pesticides attack other animals and couses health hazards & habitat degradation. So, it is time to think about this serious problem & have to reduce use of those chemical. Therefore, biological pest control program introduced into IPM. The parasitoids are unlikely to be specific to *Anomis* sp, but also attack other lepidopteron larval feeds on same plants. Most of the other insect hosts are themselves larval feeds on same plants, whose abundance is also desirable to lower. Specifically in these circumstances is rather to lepidopteron larvae in a particular habitat & the parasitoids may thus be sufficiently restricted in their attack on non target species to be seriously considered as agents for classical biological control. Therefore through this modern IPM practices we can lead to the eco-friendly opportunity for a sustainable future of jute.

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