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Integrating Suitable Planting Time and Bio-rational Pesticides to Suppress the Pest Complex of Soybean in Northeast India

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ABSTRACT

A series of experiments was conducted to identify the suitable planting time and eco-friendly approaches to minimize the pest damage in soybean during 2012-2014. The experiments were conducted in randomized block design and each treatment was replicated thrice. Stem fly (*Ophiomyia phaseoli*) damage was significantly reduced in seed treatment with imidachloprid as well as in foliar spraying with imidachloprid and also when soybean crop planted after the end of June. Population of blister beetles (*Mylabris* spp.) was almost nil in soybean planted in mid July. Foliar spraying of *Beauveria bassiana* and N.S.K.E. 5% two times during flowering was very effective against foliage and flower feeding insects. On the basis of prior experiments, three pest management modules were formulated and evaluated for yield potential. Overall results indicate that, the soybean seeds may best be planted during mid July and the soybean crop could be sprayed alternatively with N.S.K.E and *B. bassiana* during flowering to suppress the damage caused by major pests of soybean. Foliar spray of imidachlorpid may be given only if the stem fly damage exceeds economic threshold level.

1. Introduction

Soybean is one of the most important oilseed legumes in the world, with a great economic value due to its high protein and oil content. Soybean cultivation was in practice in the Himalayan States, including the north-eastern region of India from ancient time. In India, soybean crop was grown in the 122 million hectare area; which produced about 120 Million tonnes during 2013-14 (Anonymous 2014). The northeastern region of India is one of the promising soybean growing belts, where the crop is cultivated on slopes, *jhum* lands, terraces and plains (Bhattacharjee et al. 2013). Insect pests cause enormous losses in soybean yield throughout the country. Owing to distinct climatic conditions, north-eastern hill region of India is highly diverse in terms of flora and fauna and therefore pest complex of many crops, including soybean is relatively different in northeast India than other parts of the country (Azad Thakur et al. 2012; Firake et al. 2013, 2016b; Lytan and Firake 2012). In northeast India, the soybean crop is damaged by several pests at different growth stages (Sachan and Gangwar 1980; Azad Thakur 1985; Azad Thakur et al. 2012). Amongst, leaf folders (*Omiodes indicate* (*Nacoleia vulgalis* Guenee) and *Omiodes diemenalis*), stem fly (*Ophiomyia phaseoli*), leaf beetles (*Monolepta signata* and *M. quadriguttata*), blister beetles (*M. pustulata*, *M. cichorii* and *Epicauta* spp.) and leaf eating caterpillar (*Spodoptera litura*) mainly infests soybean crop. Soybean aphid, *Aphis glycines* (Plate 1) and stink bug, *Nazara viridula* (Plate 2) sucks the sap from the tender shoots and leaves, especially during August-September, but occasionally cause major damage. The spotted dove, *Spilopelia chinensis* and feral pigeon, *Columba livia* (Columbiformes: Columbidae) also damage the soybean seeds during sprouting stage and cause huge losses (Firake et al. 2016a). The caterpillars of leaf folder damage the crop either by folding the leaves or webbing together many leaves and skeletonise them completely (Plate 3).

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Leaf folders can cause up to 9.3% yield loss in soybean crop in the Meghalaya state of northeast India (Azad Thakur 1985). The leaf eating caterpillar, *S. litura* is a polyphagous pest, known to feed on a variety of crops and cause heavy losses in commercially important crops (Chaudhari et al. 2015). Leaf eating caterpillars voraciously feed on soybean leaves (Plate 4) and completely skeletonize the plants and in later stages, caterpillars attack pods and feed on grains. However, due to rapid vegetative growth of soybean plants during *kharif* season, the plants normally overcome some damage caused by leaf defoliators (Personal observations, D M Firake unpublished). Stem flies infest the soybean crop mainly during the seedling stage (Plate 5) and cause 15.41 % yield loss in the Meghalaya state of India (Shylesha et al. 2006).

Synthetic chemical pesticides are very effective against several pests of soybean; nevertheless in consequence of ecosystem disruption and health related hazards, their use is restricted. Therefore, eco-friendly approaches based on bio-pesticides are gaining popularity for pest management programmes. Seed treatment with neonicotinoid pesticides like imidachloprid and thiamethoxam is, however, suggested as an effective method for the management of stem flies in soybean (Jayappa 2000; Kamala 2000; Kumar et al. 2009). Moreover, exploitation of systemic pesticides for seed treatment is believed to be a less hazardous to non-target fauna than foliar spraying and soil application. Entomopathogenic fungi, *Beauveria bassiana* and *Metarhizium anisopliae* are reported as potential bio-agents against a variety of insects, especially under humid climate (Thakur and Sandhu 2010; Sandhu et al. 2012). Neem based pesticides are also reported to be effective against several insects, including soybean defoliators (Biswas & Islam 2012)

Identification of suitable planting date is of prime importance of developing a package of practices. Normally, insect population fluctuates throughout the cropping season and their activities are mainly confined for a specific period, where they cause significant losses to the crop plants. Consequently, evaluating their damage at different planting dates would help in desynchronizing their emergence with vulnerable/critical stages of the crop growth. Soybean is one of the important oilseed legumes in northeast India, but there is a lack of information on effective pest management modules. Considering these facts, present experiment was planned to develop operative management strategies against major pests of soybean for better yield.

2. Materials and Methods

A series of experiments was conducted using soybean variety 'Bragg' at Entomology farm, Division of Crop Protection, ICAR Research Complex for NEH Region, Umiam, Meghalaya (India) during 2012-2014. Recommended practices were followed for raising a healthy crop with a planting distance of 45cm 'row to row' and 15cm 'plant to plant'. The experimental plots were made up at 3x3 m^2 area and the plots were separated by 30cm distance.

2.1 Effect of different insecticides on stem fly damage

The experiment was conducted in randomized block design (RBD) during 2012 and 2013. The soybean crop was planted during the first week of June to get maximum stem fly damage. Two pesticides *viz*. imidachloprid 17.8 SL and chlorpyriphos 20 EC were used for seed treatment @ 3ml each/kg seed. Another treatment was a foliar spray of imidachloprid 17.8 SL @ 1ml/litre water at 25 days after planting. Each treatment was replicated three times. The number of stem fly affected plants (wilted plants) was counted in each replication and per cent stem fly damage was determined.

2.2 Effect of planting dates on major soybean pests

The experiment was conducted during 2012 and 2013 in RBD. Soybean crop was planted in four sowing dates at 15 days interval starting from 1st June to 15th July. Each treatment was replicated three times. Recommended agronomic practices were followed for raising healthy soybean crop. Stem fly damage was calculated as explained in the above section. Observations on number of blister beetles and *S. litura* larvae per plant was recorded from 10 randomly selected plants in a plot/replication at weekly interval during flowering period.

2.3 Evaluation of bio-pesticides against major pests of soybean

The experiment was conducted during 2012 and 2013 in RBD. The soybean crop was planted during the first week of June to get maximum pest damage. Four bio-pesticides *viz*., *B. bassiana* ($1x10^9$cfu/ml) @ 6ml/l, *M. Anisopliae* ($1x10^9$cfu/ml) @ 6ml/l, N.S.K.E. 5% @ 3ml/l and karanjin 2EC @ 2ml/l and one chemical pesticide, chlorpyriphos 20 EC @ 1ml/l was sprayed twice at 15 days interval during the flowering stage. After 7 days of each spraying, the observations on pest population/damage were recorded as explained in the above section. After maturity, yield per plant (in kg) was calculated from ten randomly selected plants per replication and converted into per hectare basis.

Plate 1. Soybean aphid (*Aphis glycines*)

Plate 2. Green stink bug (*Nazara viridula*)

Plate 3. Leaf folder, *Omiodes* (=*Nacoleia*) spp. damage

Plate 4. Leaf eating caterpillar (*Spodoptera litura*)

Plate 5. Stem fly (*Ophiomyia phaseoli*) damage

Plate 6. Blister beetle (*Mylabris* spp.)

Plate 7. Blister beetle (*Epicauta tibialis*)

Plate 8. White spotted leaf beetle, (*Monolepta* spp.)

2.4 Evaluation of different pest management modules on soybean yield

On the basis of prior experiments, three modules were formulated and evaluated for their yield potential during 2014. In all the modules, the crop was planted in mid July and foliar sprays of different bio-pesticides were applied during the flowering stage. In module I and II, the crop was sprayed twice with N.S.K.E. 5% @ 3ml/l and *B. bassiana* ($1x10^9$cfu/ml) @ 6ml/l, respectively at 15 days interval. In module III, the crop was sprayed alternatively by N.S.K.E. 5% @ 3ml/l and *B. bassiana* ($1x10^9$cfu/ml) @ 6ml/l at 15 days interval. Recommended agronomic practices were followed for raising a healthy crop. After maturity, yield per plant (in kg) was calculated from randomly selected 10 plants per replication and converted into per hectare basis.

2.5 Statistical analysis

Data obtained during different experiments were analyzed using one way analysis of variance (ANOVA) at a significance level of 0.05. Before conducting 'F' test, the homogeneity of variances among different treatments was tested (Levene 1960).

3. Results and Discussion

3.1 Effect of different insecticides on stem fly damage

All three treatments were found superior over control. Stem fly damage was significantly reduced in seed treatment and a foliar spray of imidachloprid (4.33% and 6.33%, respectively) (Figure 1). Stem fly adults lay eggs inside the stem, newly hatched maggots bore the stem, make the tunnels and eventually kill the plants. Stem fly incidence is generally higher during the seedling stage. In northeast India, the soybean is usually planted during mid June to mid July and the period from June to August receives maximum rainfall in the year. Although contact pesticides may have the ability to kill the adult flies, foliar application of contact pesticides is unable to provide enough control of stem flies and is mainly due to the frequent washing of plant parts under heavy rain. A neonicotinoid group of pesticides is generally systemic in nature and thus widely used in the seed treatments. These pesticides are the competitive modulators of the nicotinic acetylcholine receptors (nAChR) and hence have quick and selective action against the target pests. Furthermore, neonicotinoid insecticides are highly water soluble, and plants can absorb them and move systemically in different plant parts. Consequently, in the present study, systemic action of imidachloprid might be responsible for less stem fly damage in soybean. Several workers recommended neoinicotinoid pesticides for seed treatments against stem flies in soybean (Jayappa 2000; Kamala 2000; Kumar et al. 2009)

3.2 Effect of planting time on major soybean pests

Significant variation was found in pest damage and yield of soybean planted at different dates. Stem fly damage was considerably reduced in soybean crop planted after the end of June. A similar trend was observed in populations of blister beetle and it was found to be almost nil in soybean crop planted in mid July (Table 1). However, population of tobacco caterpillar and leaf folders were almost comparable in a soybean sown in different planting dates. Mid June to mid July is recommended sowing time of soybean in northeast India (Singh et al. 2010). The less population of stem flies in crop planted after June end might be due to the direct impact of heavy rainfall during July-August on pest activity. Heavy rainfall is usually associated with decline in insect population (Delobel & Lubega 1984; Weisser et al. 1997). The stem fly damage was minimum in crop planted in mid July and this little damage can also be compensated by adopting slight high seed rate during sowing; which may eventually avoid the use of pesticides for seed treatment. Blister beetles are polypagous pest, which emerges out of soil for certain periods during the adult stage. Blister beetles of genus *Mylabris* (Plate 6) feed on flowers/blooms of soybean; while the other species, *Epicauta tibialis* (Plate 7) are rarely found in soybean and feed on foliage. Less damage of blister beetles in late sown crop is mainly attributed to desynchronization of pest emergence with flowering period. Peak adult emergence period of blister beetles in Meghalaya is July-September (Firake, unpublished) and thus late sown soybean crop normally escapes the severe damage. A planting of the soybean crop during mid July also helps to reduce the bird damage to sprouting soybean seeds during germination (Firake et al. 2016a).

3.3 Evaluation of some bio-pesticides on major pests of soybean

Among bio-pesticides, significant reduction in folded leaves was observed in NSKE treatment; while *S. litura* population was drastically reduced in NSKE, *B. bassiana* and karanjin treated plots. Mean per cent folded leaves and *S. litura* population was found to be 6.80% folded leaves per plant and 0.6 larvae/plant, respectively in chlorpyriphos treated plots during mid flowering stage (Table 2). Among bio-pesticides, *B. bassiana* and NSKE treatments produced a maximum yield

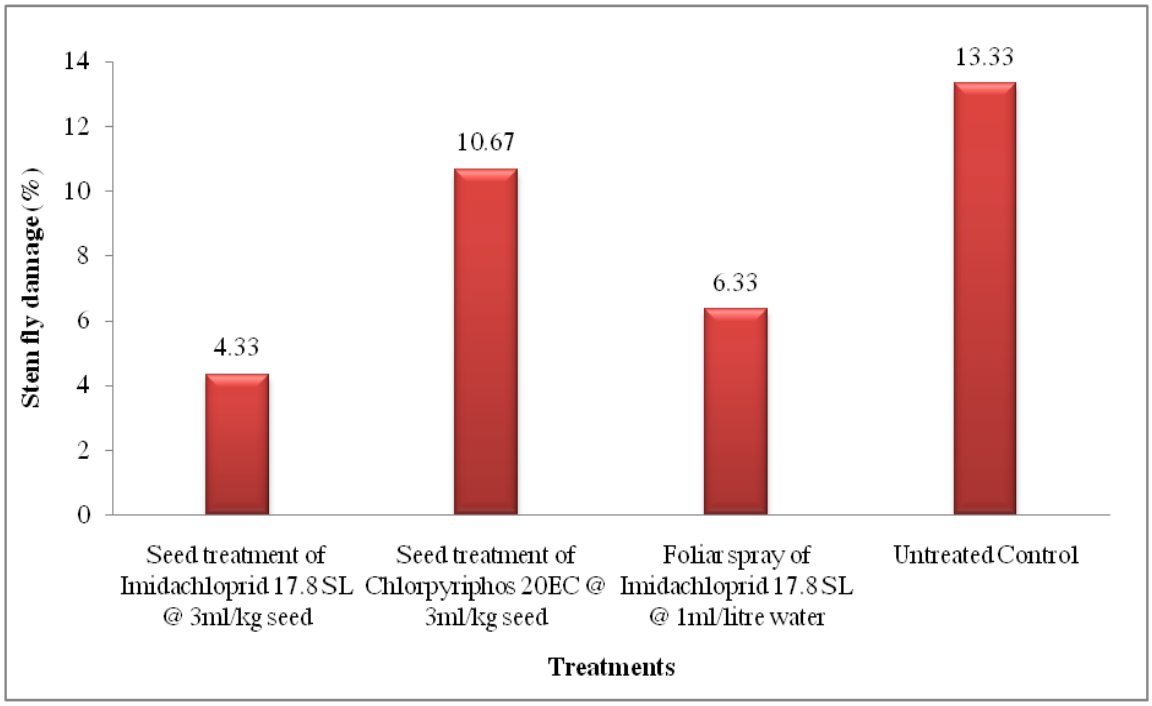

Figure 1. Effect of different pesticides on stem fly damage in soybean (year 2012-2013)

Table 1. Effect of planting time on incidence of major pests of soybean (year 2012-2013)

Planting time	Mean stem fly damage (%) at seedling stage	Mean % folded leaves/plant at 50% flowering stage	Average *S. litura* larvae /plant at 50% flowering stage	Average blister beetles/plant at 50% flowering stage
Early June	13.33[a]	12.50[b]	1.67[a]	2.00[a]
Mid June	12.0[a]	13.17[ab]	1.33[a]	2.33[a]
End June	8.67[bc]	13.33[ab]	1.50[a]	0.33[b]
Mid July	7.67[bc]	14.50[a]	1.83[a]	0.0[b]
CD at 5%	2.28	1.67	1.06	1.20

Note: Different small letters after mean values indicate significant differences among treatments

of soybean. Higher yield in these treatments could be due to their effect on other important pests *viz*. flower feeding blister beetles, *Mylabris* spp. and white spotted leaf beetles, *Monolepta* spp. (Plate 8). The latter species attack leaves and flowers, high populations shred leaves and denude flowers; while the former species feed on flowers and buds during the adult stage. Soybean plant normally sets more flowers than it can fill and due to the small size of numerous flowers, the feeding damage of blister beetles and leaf beetles cannot be correctly determined. However, because of its long flowering period, the soybean plant usually compensates some for losses. Azadirachtin has multiple modes of actions, including repellent, ovi-position deterrent, anti-feedant, growth regulator and sterilent. NSKE 5% crude extract is reported to be effective against several leaf and flower feeders (Rathikannu 2005; Ramprasadet al. 1998; Soejinto 1992). Fungus, *B. bassiana* is known to attack lepidopteran and coleopteran insects, including blister beetles (Miranpuri & Khachatourians 2009) and significantly reduces their damage in Meghalaya (Shylesha et al. 2006). Sufficient humidity and optimum temperature during August-September (flowering period) might be attributed to better activity of *B. bassiana* in Meghalaya. These reports support our findings.

3.4 Evaluation of different pest management modules on soybean yield

Among the three pest management modules evaluated in soybean, module III produced maximum yield, which consists of crop sowing during mid July + two alternate sprays of NSKE 5% @ 3ml/litre and *B. bassiana* ($1x10^9$cfu/ml) @ 6ml/litre at 15 days interval. This could be due to less stem fly damage in crop sown during mid July and direct action of foliar sprays of neem and *Beauveria* on leaf defoliators and blister beetles.

Conclusion

The present study concludes that the soybean seeds may be planted during mid July in northeast India and the soybean crop could be sprayed alternatively with N.S.K.E and *B. bassiana* during flowering to suppress the pest damage in soybean. Foliar spray of imidachlorpid may be given only if the stem fly damage exceeds economic threshold level.

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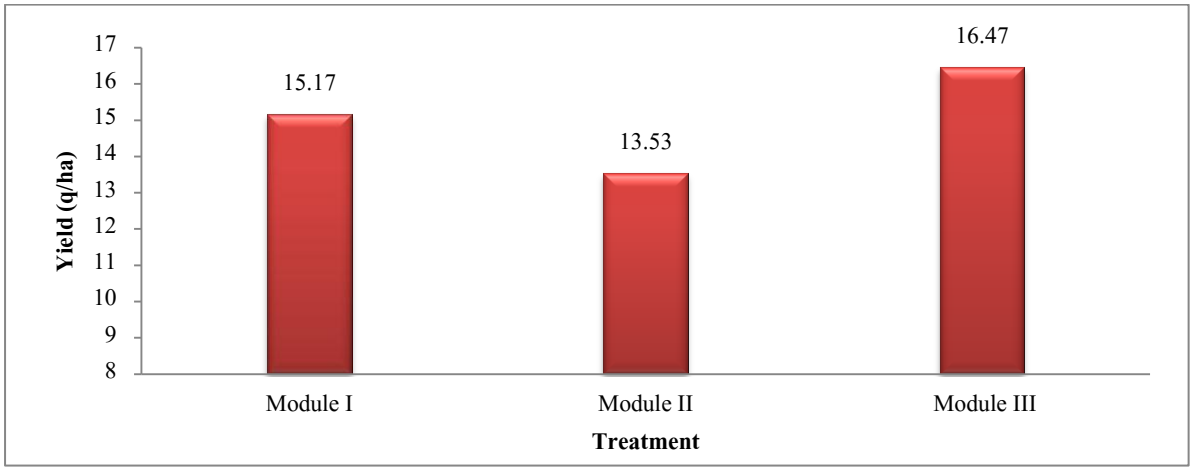

Figure 2. Evaluation of different pest management modules in soybean (year 2014)

Table 2. Effect of different biopesticides on major soybean pests during flowering (year 2012-2013)

Treatment	Dose	Mean % folded leaves/plant at 50% flowering stage	Average *S. litura* larvae/plant at 50% flowering stage	Yield (q/ha)
B. bassiana ($1x10^9$cfu/ml)	6ml/lit of water	11.17^{bc}	0.70^{bc}	13.77^{ab}
M. anisopliae ($1x10^9$cfu/ml)	6ml/lit of water	11.83^{ab}	1.03^{bc}	11.57^{c}
N.S.K.E. 5%	3ml/lit of water	9.50^{c}	0.65^{bc}	12.47^{bc}
Karanjin 2EC	2 ml/lit of water	13.83^{a}	0.75^{bc}	11.60^{c}
Chlorpyriphos 20EC	1 ml/lit of water	6.80^{d}	0.60^{bc}	14.90^{a}
Control	Water	14.85^{a}	1.70^{a}	11.18^{c}
CD at 5%		2.08	0.58	1.55

Note: Different small letters after mean values indicate significant differences among treatments

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