

Field Evaluation of Imidacloprid as an Insecticidal Seed Treatment of Cotton Cultivar with Particular References to Sucking Pest, Predator and Yield

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Abstract

Imidacloprid is a neonicotinoid insecticide that has been used for controlling sucking pests of cotton. This study showed the efficacy of the imidacloprid insecticide, Gaucho 70 WS as seed dresser against aphids, whiteflies and thrips incidences on CB3 cotton cultivar. At the same time, inhabitants of the predators (ladybird beetles, lacewings, syrphids and spiders) and yield of the crop were evaluated. Fuzzy and delinted cotton seeds treated with imidacloprid reduced pest population compared to untreated control or foliar spray of monocrotophos 40 WSC at 1120 ml ha⁻¹, and being the highest efficacy at 5.5 g kg⁻¹ fuzzy seed. Cotton plants grown with imidacloprid treated seeds have abundances of ladybird beetles, lacewings, syrphids and spiders. The cotton cultivar produced significantly higher yield when seeds were treated with imidacloprid at 5.5 g kg⁻¹ fuzzy seed. Therefore, use of imidacloprid, Gaucho 70 WS as a seed dresser may be an option for controlling sucking pests of cotton under field conditions.

Key words: Cotton, imidacloprid, seed treatment, pest, predator, yield.

Introduction

Cotton is the most highly valued cash crop in Bangladesh, but it appears major polluter crop because of heavy and indiscriminate pesticide use especially insecticides for controlling sucking and chewing insects. In Bangladesh, CB3 is an extensively cultivated cotton variety which has been released by the Cotton Development Board (CDB) of the country. The CB3 is a short height (88.3 cm) and smooth variety (Amin *et al.*, 2008; Amin *et al.*, 2011) and is infested by a number of sucking insects of

which aphid *Aphis gossypii* Clover, whitefly *Bemisia tabaci* Gennadius and thrips *Thrips tabaci* Lindeman are the major destructive pests (Amin *et al.*, 2008).

The sucking insects ingest phloem sap from the plants thus the plants reduce vigor; severe infestations destroy terminal buds and infested plants produce excessive branching (Bohmfalk *et al.*, 1996). The aphid and whitefly secrete honeydew on cotton lint which creates problem during lint processing at textile mills (Bellows *et al.*,

1994; Bohmfalk *et al.*, 1996; Bi *et al.*, 2001). Moreover, the deposition of honeydew droplets on leaves provide a suitable substrate for sooty mold development, which inhibits foliar photosynthesis and reduces yield and quality (Bohmfalk *et al.*, 1996; Bi *et al.*, 2001). The predators associated with cotton pests include beetles, true bugs, lacewings, flies, midges, spiders, wasps, and predatory mites (Hoffmann and Frodsahm, 1993). The most abundant predatory inhabitants in the cotton field of Bangladesh are ladybird beetles, syrphids, lacewings and spiders (Azad *et al.*, 2010).

Proper variety selection and protection of crops from pests and diseases are important prerequisites for higher yield and quality of cotton. Cotton growers of Bangladesh spray insecticides throughout the season to protect their crops. Foliar applications of insecticides create complications in the ecosystem and reduce predator and insect pollinator species (Moser and Obrycki, 2009). The residues of the foliar applications of imidacloprid killed foraging predators and parasitoids (Boyd and Boethel, 1998; Sclar *et al.*, 1998). On the contrary, seed treatment with systemic insecticide is a less pollution, environment friendly, cost-cutting, selective and least interference to natural equilibrium in integrated pest management programmes (Taylor *et al.*, 2001; Nault *et al.*, 2004).

Imidacloprid is a neonicotinoid insecticide in the chloronicotinylnitroguanidine chemical family. This chemical is most promising, low cost, selective and less polluting and has been widely used as seed dresser for management of cotton pests (Udikeri *et al.*, 2007).

Vastrad (2003) reported that imidacloprid insecticide as seed dresser has proved effective against pest abundance. Imidacloprid has appeared the best seed dresser in cotton and has been found to be promising against cotton sucking pests (Patil *et al.*, 1999; Dandale *et al.*, 2001; Vadodaria *et al.*, 2001; Dhawan and Simwat, 2002; Patil *et al.*, 2004). This compound keeps cotton crop free from infestation of sucking pests for at least 45 days after sowing and also comparatively safe to natural enemies (Udikeri *et al.*, 2007).

Imidacloprid as seed treatment agent moves systemically within the plant and provide protection against piercing-sucking insects (Zhang *et al.*, 2011). Now-a-days, the cotton growers of Bangladesh are showing interest on seed dressing for protecting their crops from pest attack (Amin *et al.*, 2009). The effectiveness of imidacloprid treated cotton seeds relation with the population density of sucking pests, predators and yield under Bangladesh condition are unknown. In the present study imidacloprid insecticide, Gaucho 70 WS was used as seed dresser of CB3 cotton cultivar and investigation was done to know its effect on the abundance of sucking pests, predators and yield under field condition.

Materials and methods

Seed delinting

CB3 cotton seeds were delinted by a delinting machine (Bajaj Steel Industries Ltd., Nagpur, Maharashtra, India). Seeds were fed into the stainless steel container of the machine and the agitator of the machine was then rotated and commercial sulphuric

acid was poured slowly into the container at 100 ml kg⁻¹ seed having the cotton seeds through its periphery. Due to the churning action, the fuzz was uniformly subjected to the acid reaction. At the end of 90 seconds, the acid treated seeds were washed with water. The process of washing with water was repeated three times and then the seeds were collected and dried.

Seed treatment

Fuzzy and delinted seeds were separately soaked in water for half an hour and then put on sieves to dry. Therefore, imidacloprid (Gaucho 70 WS powder) and seeds were poured into different bowls following 1.5, 2.5, 3.5, 4.5 or 5.5 g kg⁻¹ seed and stirred for 10-15 minutes for complete adherence of the chemical to the individual seed coat. Then the seeds were put on papers and dried in the sun for 30-40 minutes, therefore, stored in brown paper bags until sowing.

Cultivation of crops

The crops were cultivated during three consecutive seasons of 2008, 2009 and 2010 at the Regional Cotton Research Station, Dinajpur (25°13'N, 88°23'E) in Bangladesh. The experiments were conducted with fuzzy and delinted seeds of CB3 cotton cultivar and treatments consisted of untreated controls and seeds treated with imidacloprid insecticide Gaucho 70 WS at 1.5, 2.5, 3.5, 4.5 or 5.5 g kg⁻¹ seed. An additional treatment was made with foliar spray of monocrotophos 40 WSC at 1120 ml ha⁻¹ for four times, which is widely used by the cotton growers of Bangladesh. The experimental design was a randomized complete block with three replications. The plot size was 5.4 m × 5.0 m and the spacing

between block to block and plot to plot was 1.5 m and 1.0 m, respectively. Seeds were sown in rows with 45 cm apart and row to row distance was 90 cm. Fertilization and intercultural operations were maintained according to the recommendations of the Cotton Development Board of Bangladesh.

Observation of sucking pests and predator populations

After emergence of seedlings, field inspection was done fortnightly intervals up to 70 days for observation of the population of sucking pests, viz. aphid (*A. gossypii*), whitefly (*B. tabaci*) and thrips (*T. tabaci*). Every inspection, five plants were randomly selected from each plot and the number of sucking pests on the top, middle and bottom leaf were counted. Similarly, adult predators viz. ladybird beetle *Coccinella septempunctata* L. and *Menochilus sexmaculatus* Fabricius, lacewing *Chrysoperla carnea* Stephens, syrphid *Syrphus opinator* Sacken and spider *Chiracanthium inclusum* Hentz and *Lycosa pseudoannulata* Bosenberg and Strand populations were recorded.

Measurement of cotton yield

Open bolls (seed cotton) in each plot were handpicked and obtained seed cotton yield of each treatment was converted into ton ha⁻¹.

Data analysis

The data on mean population of sucking pests, predators, and seed cotton yield of the year 2008, 2009 and 2010 were calculated and subjected to statistical analyses using analysis of variance (ANOVA), and the mean comparisons were made by Duncan's Multiple Range Test (DMRT).

Results

The efficacy of imidacloprid seed treatment against sucking pest incidence on CB3 cotton cultivar under field condition is presented in table 1. The imidacloprid seed treatments showed significantly lower incidence of aphid on treatment groups than those on the untreated control ($F_{11, 96} = 29.3$, $p < 0.001$). The efficacy of the seed treatments showed that aphid incidence on CB3 decreased from 5.1 to 0.8 and seed treatment was most effective against aphid when imidacloprid was applied at 5.5 g kg⁻¹ fuzzy seed.

Table 1 shows that the whitefly population on CB3 cultivar varied from 1.8 to 9.3 and the results showed that whitefly population on the treatment groups were significantly lower than those on the untreated control ($F_{11, 96} = 11.5$, $p < 0.001$). The cultivar exerted significantly lowest incidence of whitefly when seed treatment was done with Gaucho 70 WS at 5.5 g kg⁻¹ fuzzy seed. The incidence of thrips on cotton cultivar was found significantly lower in the treatments than those on the untreated control ($F_{11, 96} = 34.9$, $p < 0.001$). The number of thrips on cotton cultivar ranged from 2.2 to 10.9 and the plants showed significantly lowest incidence in the treatment imidacloprid at 5.5 g kg⁻¹ fuzzy seed.

The ladybird beetle, lacewing, syrphid and spider populations associated with CB3 cultivar are presented in table 2. Imidacloprid seed treatments significantly reduced lady beetles population on treatment groups compared to control ($F_{11, 96} = 77.7$, $p < 0.001$). Lady beetles population on studied cotton cultivar was found lowest (2.1 leaf⁻¹) when seed treatment was done

with Gaucho 70 WS at 5.5 g kg⁻¹ fuzzy seed. The lacewing inhabitants on CB3 cotton cultivar varied from 1.6 to 5.9 leaf⁻¹ and the results differed significantly ($F_{11, 96} = 56.5$, $p < 0.001$). The treatment Gaucho 70 WS at 5.5 g kg⁻¹ fuzzy seed revealed the lowest abundance of lacewing on the cultivar. The syrphid population on CB3 was observed 1.5 to 5.2 leaf⁻¹, and there were significant differences among the treatments ($F_{11, 96} = 53.8$, $p < 0.001$). Imidacloprid seed treatments significantly suppressed spider population on CB3 cotton cultivar ($F_{11, 96} = 41.5$, $p < 0.001$) and spider population on the cultivar ranged from 1.4 to 5.6 leaf⁻¹. The treatment Gaucho 70 WS at 5.5 g kg⁻¹ fuzzy seed showed the lowest abundance of syrphid and spider on the cultivar.

Table 3 shows that seed yield of CB3 cultivar varied from 0.40 to 1.43 t ha⁻¹ and the results differed to a significant level ($F_{11, 96} = 170.4$, $p < 0.001$). Among the treatments, Gaucho 70 WS at 5.5 g kg⁻¹ fuzzy seed revealed the highest seed yield (Table 3).

Discussion

Seed treatment is a highly progressive and demandable technology for management of various crop pests (Taylor *et al.*, 2001; Magalhaes *et al.*, 2009). This study showed that imidacloprid seed treatments effectively reduced aphid, whitefly and thrips inhabitants in the cotton field of Bangladesh. Both fuzzy and delinted seeds exhibited higher efficacy against the sucking pests in the field conditions. This was consistent with Zhang *et al.* (2011), who reported that imidacloprid seed treatments were effective in suppressing the whitefly population in cotton fields. Our

Table 1. Incidence of sucking pests on CB3 cotton cultivar as influenced by seed treatment with imidacloprid Gaucho 70WS

| Treatments | Number of pests (mean \pm SD)/plant | | |
|---|---------------------------------------|------------------|------------------|
| | Aphid | Whitefly | Thrips |
| Gaicho 1.5 g kg ⁻¹ fuzzy seed | 1.6 \pm 0.2 b | 4.3 \pm 2.0 b | 4.7 \pm 1.1 bc |
| Gaicho 2.5 g kg ⁻¹ fuzzy seed | 1.4 \pm 0.3 bd | 3.5 \pm 1.7 bd | 4.1 \pm 1.0 bd |
| Gaicho 3.5 g kg ⁻¹ fuzzy seed | 1.2 \pm 0.3 bd | 3.1 \pm 1.7 bd | 3.4 \pm 0.8 dg |
| Gaicho 4.5 g kg ⁻¹ fuzzy seed | 1.0 \pm 0.3 bd | 2.4 \pm 1.2 bd | 2.8 \pm 0.7 eg |
| Gaicho 5.5 g kg ⁻¹ fuzzy seed | 0.8 \pm 0.3 d | 1.8 \pm 0.9 d | 2.2 \pm 0.7 g |
| Gaicho 1.5 g kg ⁻¹ delinted seed | 1.7 \pm 0.2 b | 4.1 \pm 1.7 b | 5.2 \pm 1.5 b |
| Gaicho 2.5 g kg ⁻¹ delinted seed | 1.5 \pm 0.3 bd | 3.2 \pm 1.5 bd | 4.5 \pm 1.3 bd |
| Gaicho 3.5 g kg ⁻¹ delinted seed | 1.3 \pm 0.3 bd | 2.8 \pm 1.3 bd | 3.9 \pm 1.1 ce |
| Gaicho 4.5 g kg ⁻¹ delinted seed | 1.2 \pm 0.4 bd | 2.2 \pm 1.0 cd | 3.5 \pm 1.4cf |
| Gaicho 5.5 g kg ⁻¹ delinted seed | 0.9 \pm 0.3 cd | 2.1 \pm 0.7 cd | 2.6 \pm 0.8 fg |
| Monocrotophos 1120 ml ha ⁻¹ | 1.5 \pm 0.2 bc | 3.9 \pm 2.2 bc | 4.5 \pm 1.3 bd |
| Control (fuzzy seed) | 5.3 \pm 1.9 a | 9.3 \pm 3.4 a | 11.1 \pm 0.9 a |

Means within a column followed by same letter(s) are not significantly different (DMRT, $p \leq 0.05$)

Table 2. Abundance of major predators on CB3 cotton cultivars as influenced by seed treatment with imidacloprid Gaucho 70WS

| Treatments | Number of predators (mean \pm SD)/plant | | | |
|---|---|------------------|------------------|------------------|
| | Ladybird beetle | Lacewing | Syrphid | Spider |
| Gaicho 1.5 g kg ⁻¹ fuzzy seed | 4.5 \pm 0.4 c | 3.8 \pm 0.5 c | 3.6 \pm 0.4 f | 3.6 \pm 0.3 bc |
| Gaicho 2.5 g kg ⁻¹ fuzzy seed | 3.9 \pm 0.4 d | 3.1 \pm 0.5d e | 2.9 \pm 0.4 d | 2.9 \pm 0.3 de |
| Gaicho 3.5 g kg ⁻¹ fuzzy seed | 3.1 \pm 0.4 ef | 2.6 \pm 0.3 fg | 2.5 \pm 0.5 ef | 2.4 \pm 0.1 fg |
| Gaicho 4.5 g kg ⁻¹ fuzzy seed | 2.6 \pm 0.3 g | 2.3 \pm 0.4 g | 2.0 \pm 0.3 g | 1.9 \pm 0.3 g |
| Gaicho 5.5 g kg ⁻¹ fuzzy seed | 2.1 \pm 0.3 h | 1.6 \pm 0.3 h | 1.5 \pm 0.3 h | 1.4 \pm 0.3 h |
| Gaicho 1.5 g kg ⁻¹ delinted seed | 5.2 \pm 0.3 b | 4.6 \pm 0.5 b | 4.2 \pm 0.3 b | 4.0 \pm 1.0 bc |
| Gaicho 2.5 g kg ⁻¹ delinted seed | 4.8 \pm 0.6 c | 3.9 \pm 0.6 c | 3.6 \pm 0.5 c | 3.6 \pm 0.4 bc |
| Gaicho 3.5 g kg ⁻¹ delinted seed | 3.9 \pm 0.4 d | 3.5 \pm 0.5 cd | 3.1 \pm 0.2 d | 3.1 \pm 0.1 cd |
| Gaicho 4.5 g kg ⁻¹ delinted seed | 3.5 \pm 0.4 e | 3.1 \pm 0.2 de | 2.9 \pm 0.3 de | 2.8 \pm 0.2 df |
| Gaicho 5.5 g kg ⁻¹ delinted seed | 2.9 \pm 0.3f g | 2.7 \pm 0.2 eg | 2.4 \pm 0.2 f | 2.4 \pm 0.4 ef |
| Monocrotophos 1120 ml ha ⁻¹ | 3.1 \pm 0.3 ef | 2.9 \pm 0.4 ef | 2.8 \pm 0.4 df | 2.9 \pm 0.4 de |
| Control (fuzzy seed) | 6.5 \pm 0.8 a | 5.9 \pm 0.8 a | 5.2 \pm 0.8 a | 5.6 \pm 0.9 a |

Means within a column followed by same letter(s) are not significantly different (DMRT, $p \leq 0.05$)

Table 3. Yield (seed cotton) of CB3 cotton cultivar as influenced by seed treatment with imidacloprid Gaucho 70WS

| Treatment | Yield (t/ha) |
|--|--------------------|
| Gaicho 1.5 g kg ⁻¹ fuzzy seed | 0.84 \pm 0.04 fg |
| Gaicho 2.5 g kg ⁻¹ fuzzy seed | 0.94 \pm 0.07 e |

| | |
|---|--------------|
| Gaicho 3.5 g kg ⁻¹ fuzzy seed | 1.10±0.05 d |
| Gaicho 4.5 g kg ⁻¹ fuzzy seed | 1.27±0.05 b |
| Gaicho 5.5 g kg ⁻¹ fuzzy seed | 1.43±0.11 a |
| Gaicho 1.5 g kg ⁻¹ delinted seed | 0.78±0.04 g |
| Gaicho 2.5 g kg ⁻¹ delinted seed | 0.88±0.06 ef |
| Gaicho 3.5 g kg ⁻¹ delinted seed | 0.88±0.06 ef |
| Gaicho 4.5 g kg ⁻¹ delinted seed | 1.20±0.07 c |
| Gaicho 5.5 g kg ⁻¹ delinted seed | 1.27±0.05 b |
| Monocrotophos 1120 ml ha ⁻¹ | 0.94±0.06 e |
| Control (fuzzy seed) | 0.40±0.07 h |

Means followed by same letter(s) are not significantly different (DMRT, $p \leq 0.05$)

findings also agree with the results of Mote *et al.* (1995) and Patil *et al.* (2003), who observed that seed treatment with imidacloprid reduced the sucking pest population below the economic threshold level up to 40 days after sowing. There is report that seed treatment of cotton with imidacloprid was effective against leafhopper population up to 61 days after germination (Dandale *et al.*, 2001; Murugan *et al.*, 2003).

This study showed that imidacloprid seed treatments had proved better performances compared to control as well as traditional pest control method (foliar application of monocrotophos at 1120 ml ha⁻¹). This study also showed that sucking pest population on CB3 cultivar differed regarding to the dosages of seed treatment. The cultivar showed lower pest incidence when the fuzzy and delinted seeds were treated with imidacloprid at 5.5 g kg⁻¹ seed. Our results also showed that pest incidence decreased with increasing doses of Gaicho 70 WS.

Imidacloprid is a broad-spectrum insecticide that kills most insect species (Lind *et al.*, 1998a; 1998b). Our study showed that imidacloprid seed treatments

were safer for CB3 cultivar but reduced predator population in the field. It is revealed that ladybird beetles, lacewings, syrphids and spiders were abundant on CB3 cotton plants that were grown from the seeds treated with imidacloprid. Imidacloprid seed treatments in higher concentration exhibit translocation to flowers and reduce survivorship and alter behavior of pink ladybird beetle, *Coleomegilla maculate* DeGeer and green lacewing, *Chrysoperla carnea* Stephens (Rogers *et al.*, 2007). The present study showed that predator abundances on the cultivar were positively correlated with the abundances of prey. Zhang *et al.* (2011) reported that all leaves of the cotton plants at 40 day after germination contained low concentrations of the active ingredients of the imidacloprid insecticides. Early research also showed that concentrations of imidacloprid in plants gradually reduced from bottom to top leaves and most of the translocated imidacloprid exist in the cotyledon (Tröltzsch *et al.*, 1994).

Mote *et al.* (1995) reported that imidacloprid seed treatment increased nitrogen and chlorophyll content in cotton plants thus the plants enhance vigor and

growth. This study shows that imidacloprid treatment kept the cotton plants free from severe insect infestation, thus normal vigor of the plants were not hampered and produced higher yield compared to untreated control. This finding shows concur with Udikeri *et al.* (2007), who obtained higher seed yield of cotton by protecting the crop from early sucking pest infestation by treating the seeds with Chlothianidin 600 FS (Poncho) at 9.0 ml kg⁻¹ seed. Dobbs *et al.* (2006) reported that imidacloprid (Gaucho) seed treatments produced significantly higher lint yield of cotton than untreated control.

Integrated pest management (IPM) programmes include biological control, biorational insecticides and conventional insecticides for controlling pests, and cultivation of resistant varieties. Imidacloprid is effective for controlling sucking and piercing insects of cotton, in addition, there have been anecdotal reports of yield and growth enhancement after multiple foliar applications (Gonias *et al.* 2003). Under African condition, seed treatment with this chemical was proved significant effective against sucking pests (Salmon, 2003). Imidacloprid as seed treatment agent move systemically within the plant and provide protection against pests. This chemical has been used successfully for the control of early pest complex in sugar beet, maize, vegetables and other crops (Altmann, 1991; Elbert *et al.* 2008; Taylor *et al.* 2001). The present investigation clearly suggest that imidacloprid seed dresser offers promising protection against aphid, whitefly and thrips on CB3 cotton cultivar without disrupting natural enemy complex which suppressed

subsequent resurgence and secondary pest outbreak. Thus seed treatment of CB3 cotton cultivar with imidacloprid can be an ideal strategy for IPM in the cotton field of Bangladesh.

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