Effect of imidacloprid seed treatment on growth, yield, seedling vigor and biophysical parameters in cotton (*Gossypium* spp.) genotypes

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ABSTRACT

A field experiment was conducted under rainfed condition at ARS Dharwad Karnataka to test the effect of imidacloprid seed treatment (10g/kg seeds) on seedling vigor, growth, physiological and biophysical parameters in three cotton genotypes (DHH-11an intrahirsutum hybrid, DHB-105 an interspecific hybrid and Sahana a hirsutum variety). Seed treatment increased the seedling vigor, leaf area, specific leaf weight, leaf nitrate reductase activity, leaf chlorophyll content, rate of photosynthesis, stomatal conductance, rate of transpiration and seed cotton yield compared to untreated treatments. Seed treatment also helped in controlling sucking pests up to 45 days after sowing compared to the untreated control. Among the genotypes, maximum increase in seedling vigor, rate of photosynthesis, stomatal conductance, rate of transpiration was found in DHH-11, followed by DHB-105 and least in Sahana. It is inferred that imidacloprid treatment was efficient in increasing the seedling vigor and growth and controlled the incidence of early sucking pests, which improved the physiological and biophysical parameters as compared to untreated treatments. The practice of imidacloprid seed treatment was highly cost effective.

Introduction

Intensive cotton production in India requires 10-12 sprayings of pesticides, depending on the duration of the genotypes. Three to four sprays are required to control sucking pests alone. Jassids are regular, serious and most important sucking pests of cotton causing leaf damage, reddening, stunted growth, delayed maturity, lowered productivity and loss in yield. Spider mites feeding on leaf tissues and injecting phytollekins on host plants are ranked sometimes next to *Helicoverpa* in USA and within first five or six in India. These pests occur in dry weather causing yellowing and reddening of leaves, premature abscission, affecting yield and quality directly (Balasubramanian, 1980). Aphids and thrips are important sucking pests and often assume serious proportions all over India.

Imidacloprid 70 WS is a seed dressing formulation of an insecticide used for the management of sucking pests. This insecticide belongs to chloro-chotinyl group and controls sucking pests of cotton *viz*., thrips, aphids and jassids of cotton up to 45 days after sowing. With this background, studies were undertaken to evaluate imidacloprid for control of sucking pests in both hybrids and variety and to assess the effect of the chemical on some aspects of crop physiology.

Experimental procedure

A field experiment was conducted during monsoon 2001-02 at Agricultural Research Station, Dharwad, Karnataka, India. Three cotton genotypes having different morphological characters were sown as main plots and seed treatment [with or without imidacloprid] as subplots, with four replications.

Seedling vigor index was determined following the method of Abdul Baki and Anderson (1973). Leaf area per plant was determined by the formula suggested by Ashley *et al*. (1963). The specific leaf weight or the leaf thickness was determined as leaf dry weight/leaf area and expressed as mg dm^{-2}. Measurement of rate of photosynthesis, transpiration and stomatal conductance were made on the top fully expanded leaf, using portable photosynthesis system (LI-COR 6400). These measurements were made between 10.00 am to 12.00 noon. Leaf chlorophyll content and nitrate reductase activity *in vitro* was assayed in leaves following Hiscox and Israeltam (1979) and Saradhamabal *et al*. (1978) respectively. Sucking pests and beneficial insect counts were made on twenty-five randomly selected plants in each plot. The number of fully opened bolls and damaged open bolls were counted in five tagged plants of each treatment. Seed cotton yield/ha was determined from the net plot from several pickings.

Results and Discussion

The data on seedling vigor index (SVI), leaf area and specific leaf weight (SLW) in response to seed treatment and untreated control are presented in Table 1. SVI differed significantly among genotypes, treatments and their interaction. Irrespective of treatments, DHH-11 gave significantly higher seedling vigor index (1002) over other genotypes. SVI was lowest in Sahana (840.5). Imidacloprid seed treatment increased the seedling vigor index significantly (954.7) compared to the untreated control (896.3). The interaction effect of genotypes and treatments indicated that DHH-11 recorded highest SVI with treated seed (1021) and Sahana recorded the lowest under untreated control (802).

Significant differences occurred for leaf area among genotypes, treatments and their interaction. DHH-11 produced a significantly higher leaf area (17.39 dm^2/pl.) over other genotypes. DHH-11 recorded highest leaf area with treated seed (18.46 dm^2) and the lowest value was recorded by Sahana with untreated seed (13.49 dm^2). Leaf area indicates the size of the assimilatory portion of a plant. In the early stage the sucking pests are low in seed treated plots and by this the leaf growth was good as compared to untreated. Seed treatment had a significant effect on SLW in all the genotypes. DHB-105 produced a significantly higher SLW (1072.8 mg/dm^2) over other genotypes and the lowest SLW was recorded in Sahana (930

mg/dm^2). SLW increased significantly from 956.7 mg/dm^2 in untreated plants to 1059.9 mg/dm^2 in treated plants. DHB-105 produced its highest SLW with treated seed (1041.7 mg/dm^2) and Sahana recorded the lowest with untreated seed (879.8 mg/dm^2). SLW is considered as a measure of leaf thickness and are more sensitive to environmental changes (Hunt, 1982). Increase in leaf thickness and the area of mesophyll cells available for gas exchange have been proposed as mechanisms by which plants adapt to salinity changes (Longstrength and Nobel, 1979).

Biophysical parameters

The data on biophysical parameters *viz*., the rate of photosynthesis, stomatal conductance and transpiration are presented in Table 2. A significant difference was observed in photosynthesis among genotypes, treatments and their interaction. Irrespective of treatments, significantly higher rates of photosynthesis (25.59 m mol/m^2/s) were recorded on DHH 11 over other genotypes. The lowest rate of photosynthesis was recorded in DHB-105 (22.62 m mol/m^2/s). Seed treatment had a significant effect on photosynthesis. It increased the rate of photosynthesis from 21.03 mol/m^2/s in untreated plants to 26.84 mol/m^2/s in plants treated with imidacloprid. The enhancement in the rate of photosynthesis would have been due to increase seedling vigor and less damage due to sucking pest. Changes in stomatal conductance followed the trend of rate of photosynthesis. Among the genotypes, stomatal conductance was the maximum in DHH-11 (0.15 mmol/m^2/s) followed by DHB-105 and Sahana. Seed treatment enhanced the stomatal conductance significantly, in all the genotypes. The stomatal conductance was more in treated plants (0.12 mmol/m^2/s) compared to untreated ones (0.06 mmol/m^2/s). The reduction in photosynthesis is attributed to reduction in stomatal conductance (Brungnoti and Lauteri, 1991). The rate of transpiration was highest in DHH-11 (3.88 mmol/m^2/s) and was least in DHB-105 (1.81 mmol/m^2/s). Irrespective of genotypes imidacloprid seed treatment increased the rate of transpiration (3.00 mmol/m^2/s) significantly compared to untreated plants (2.12 mmol/m^2/s). The lower rate of biophysical parameters in untreated plants may be due to the damage caused by the sucking pest.

Chlorophyll content

Significant differences were observed in total chlorophyll content, (Chlorophyll-a and Chlorophyll-b) among the genotypes, seed treatment and their interaction (Table 3). DHH-11 had the highest total chlorophyll content, while Sahana had the lowest. Irrespective of genotype, imidacloprid seed treatment increased the total chlorophyll content (1.20 m/g/fresh weight) compared to untreated plants (1.10 m/g/fresh weight). Chlorophyll-a and -b followed the trend of total chlorophyll content. The chlorophyll content is known to influence the rate of photosynthesis and in turn influence growth and development of cotton (Karasichdova *et al.,* 1989). Bharadwaj *et al.* (1988) reported that cotton genotypes with higher specific leaf weight had higher chlorophyll content.

Nitrate reductase activity

The data on NR activity is presented in Table 4. Significant differences were observed in NR activity for genotypes, treatments and their interaction. NR activity was highest in DHH-11 (79.68 mg NO_2/g fresh weight) over other genotypes. Lowest NR activity was recorded in Sahana (70.19 mg NO_2/g fresh weight). Imidaclorprid seed treatment had a significant effect on NR activity. In treated plants the activity was 76.30 mg NO_2/g fresh weight. While untreated plants showed 73.47 m g NO_2/g fresh weight. NR activity was highest in treated DHH 11 plants (80.98 mg NO_2/g fresh weight) and the lowest in untreated plants of Sahana (68.97 mg NO_2/g fresh weight). Nitrate reductase is the first and most important enzymes in the nitrogen metabolism of the plant. In the leaves nitrate reduction is closely associated with photosynthesis. It is believed that the reduction of nitrite to nitrate by nitrate reductase activity is the rate limiting process to the utilization of nitrogen in the form of nitrate. The present study revealed that because of non-occurrence of sucking pests in early stages, leaves are maintained healthy and the nitrate reductase activity was high.

Number of beneficial insects/plant.

The data on beneficial insects is presented in Table 4. Due to non availability of host insects (aphids) in the treated plots the build up of coccinellids population was considerably reduced. However their were no change in number of *Chrysopa* per plant, since it is a general predator which is not only dependent on aphids but also on jassids, eggs and larval population of boll worm.

Sucking pests

The data on number of thrips, aphids and jassids per leaf recorded at 40 days are presented in Table 5. The population of these insects was low in seed treated genotypes as compared to untreated genotypes.

Yield and yield components

The data on yield, properly opened bolls and poorly opened bolls are presented in Table 6. Sahana produced a significantly higher yield (8.29 q/ha) than the other genotypes. The lowest yield was produced by DHB-105 (6.91 q/ha). Imidacloprid increases the yield significantly (8.32 g/ha) compared to untreated plot (6.98 g/ha). The interaction effect of genotypes and treatments indicated that Sahana produced the highest yield when seed was treated with imidacloprid (9.08 q/ha) and the lowest yield was produced by DHB-105 grown from untreated seed (6.24 q/ha). Significant differences were observed in the number of fully opened bolls among genotypes, treatments and genotypes x treatment interaction. Irrespective of treatments, there were significantly higher properly opened bolls in DHB

105 (12.62 q/ha) compared to other genotypes. The lowest number of properly opened bolls was recorded in Sahana (8.48 q/ha). The imidacloprid treatment decreased the number of poorly opened bolls/ plant (1.24) compared to untreated (1.63). The interaction effect of genotypes and treatments indicated that DHH-11 plants grown from treated seed gave the greatest number of properly opened bolls (12.96 q/ha). There were more poorly opened bolls on plants of DHB-105 (1.68) than on other genotypes. Imidacloprid treatment decreased the mean number of poorly opened bolls (1.24) compared to untreated (1.63) for all genotypes, seed treatment with imidacloprid increased seed cotton yield. In the present study it is concluded that attack of sucking pest in the early stages of crop growth reduced the photosynthesis, conductance, seedling vigor, chlorophyll and nitrate reductase activity resulting in decreased yield. By treating cotton seeds with imidacloprid (10 g/kg seeds) we can control sucking pests up to 45 days and obtain higher yield.

References

- Abdul-Baki, A.A. and Anderson, J.D. (1973). Vigour determination in soybean seeds by multiple criteria. *Crop Sciences,* **13**: 630-633.
- Ashley, D.M., Doss, D.B. and Bennett, O.L. (1963). A method of determining leaf area in cotton. *Agronomy Journal,* **55**: 584-585.
- Balasubramanian, V. and Sarin, M.N. (1980). Effect of growth retardants onyield of wheat grown in saline soil. *Indian Journal of Plant Physiology,* **17**: 36-38.
- Bharadwaj, S.N. (1988). Basis for higher productivity in upland cotton under north Indian agro-climatic conditions. *In* Proceedings International Congress Plant Physiology. I: (Ed.) Sinha, S. K., Sane, P. V. Bhargava and Agarwal, P.K. pp. 480-486.
- Brugnoli, E. and Lauteri, M. (1991). Effects of salinity on stomatal conductance, photosynthetic capacity and carbon isotopoe discrimination of salt tolerant (*Gossypium hirsutum*) and salt-sensitive (*Plaseolus vulgaris* L.) C_3 non-halophytes. *Plant Physiology,* **95**: 628-635.
- Hiscox, J. D. and Israelstam, G.F. (1979). A method for extraction of chlorophyll from leaf tissue without maceration. *Canadian Journal of Botany*, **57**: 1332-1334.
- Hunt, R. (1982). Plant growth curves: an introduction to functional approach to plant growth analysis Edward Arnold, London, pp.14-46.
- Krasichkova, G.V., Asoeva, L.M., Giller, YU, E. and Singinov, B.S. (1989). Photosynthetic system of G. barbadense at the early stages of development. Doklady Vsesovuznoi ordena Trudovogo Krasnogo Znameni Akademii Sel' Skokhozya istvennykh Nauk Imen V.I. Lenina, No. 12, 9-11. Institute Fiziologii i Biofiziki Rastenil, An Tadazh SR, Dushanbe, Tadzhik SSR.
- Longstrength, D. and Nobel, P.S. (1979). Salinity effects on leaf anatomy. *Plant Physiology,* **63**: 700-703.
- Saradhambal, K.V., Singh, S.P., Prakash, S. and Naik, M.S. (1978). Effect of bacterial blight on the activities of nitrate reductase and peroxidase in rice plants. *Indian Journal of Biochemistry and Biophysics,* **15**: 105-107.
- Wullschleger, S.D. and Dosterhuis, D.M. (1991). Photosynthesis, transpiration and water use efficiency of cotton leaves and fruits. *Photosynthetica,* **25**: 505 - 515.

Table 1. *Effect of imidachloprid seed treatment on seedling vigor, leaf area and specific leaf weight in cotton genotypes.*

Genotypes	Seedling vigour index			Leaf area (dm^2/ plant)			Specific leaf weight (mg / dm2)		
	Treated	Untreated	Mean	Treated	Untreated	Mean	Treated	Untreated	Mean
DHH-11	1021	983	1002	18.46	16.32	17.39	1058	986	1022
DHB-105	964	904	934	16.12	15.86	15.99	1142	1004	1073
SAHANA	879	802	840	14.18	13.49	13.84	980	880	930
Mean	954	896	925	16.25	15.22	15.74	1060	957	1008
For comparing		SEM±	CD 5%		SEM±	CD 5%		SEM±	CD 5%
Treatments (T)		13.2	40.0		0.26	0.81		25.7	78.1
Genotypes (G)		18.8	57.3		0.43	1.32		14.9	45.2
Interaction (TXG)		35.6	108.1		0.83	2.50		36.3	110.0

Table 2. *Effect of imidacloprid seed treatment on rate of photosynthesis, conductance and transpiration in cotton genotypes at 90 DAS.*

Genotypes	Photosynthesis (µ mol/m2/s)			Conductance (µ mol/m2/s)			Transpiration (m mol/m2/s)		
	Treated	Untreated	Mean	Treated	Untreated	Mean	Treated	Untreated	Mean
DHH-11	28.12	23.05	25.59	0.194	0.093	0.144	4.36	2.99	3.68
DHB-105	26.29	18.94	22.62	0.105	0.045	0.075	2.39	1.23	1.81
SAHANA	26.11	21.11	23.61	0.053	0.027	0.040	2.26	2.14	2.20
Mean	26.84	21.03	23.94	0.117	0.055	0.086	3.00	2.12	2.56
For comparing		SEM±	CD 5%		SEM±	CD 5%		SEM±	CD 5%
Treatments (T)		1.02	3.10		0.013	0.042		0.198	0.61
Genotypes (G)		0.30	0.91		0.198	0.063		0.13	0.42
Interaction (TXG)		1.39	4.20		0.056	NS		0.83	NS

Table 3. *Effect of imidacloprid seed treatment on chlorophyll 'a', chlorophyll 'b', total chlorophyll and nitrate reductase activity in cotton genotypes.*

Genotypes	Chlorophyll a (mg /g fresh weight.)			Chlorophyll b (mg /g fresh weight.)			Total Chlorophyll (mg /g fresh weight.)			Nitrate reductase activity		
	Treated	Untreated	Mean	Treated	Untreated	Mean	Treated	Untreated	Mean	Treated	Untreated	Mean
DHH-11	0.929	0.883	0.906	0.370	0.321	0.346	1.299	1.204	1.252	80.98	78.24	79.61
DHB-105	0.906	0.834	0.870	0.332	0.287	0.310	1.238	1.121	1.180	76.52	73.21	74.86
SAHANA	0.794	0.752	0.773	0.259	0.231	0.245	1.053	0.983	1.018	71.42	68.97	70.19
Mean	0.876	0.823	0.850	0.320	0.280	0.300	1.197	1.103	1.150	76.30	73.47	74.89
For comparing		SEM±	CD 5%		SEM±	CD 5%		SEM±	CD 5%		SEM±	CD 5%
Treatments (T)		0.014	0.410		0.010	0.031		0.023	0.071		0.74	2.43
Genotypes (G)		0.297	0.091		0.021	0.065		0.039	0.120		1.35	4.12
Interaction (TXG)		0.073	NS		0.46	NS		0.149	NS		2.05	6.24

Table 4. *Effect of imidacloprid seed treatment on number of Coccinellids/plant and* Chrysopa/plant.

Genotypes	Coccinellids /plant			Chrysopa/plant		
	Treated	Untreated	Mean	Treated	Untreated	Mean
DHH-11	0.08	0.40	0.24	0.32	0.26	0.29
DHB-105	0.28	0.29	0.29	0.34	0.37	0.36
SAHANA	0.08	0.68	0.38	0.24	0.26	0.26
Mean	0.15	0.46	0.30	0.30	0.30	0.30

Table 5. *Effect of imidacloprid seed treatment on number of thrips/leaf, aphids/leaf and jassids/leaf in cotton genotypes.*

Genotypes	Thrips/leaf			Aphids / leaf			Jassids / leaf		
	Treated	Untreated	Mean	Treated	Untreated	Mean	Treated	Untreated	Mean
DHH-11	7.79	11.76	9.78	7.85	9.10	9.10	1.19	1.52	1.36
DHB-105	14.78	19.63	17.21	13.50	17.50	17.50	1.99	2.80	2.40
SAHANA	7.19	15.54	11.37	8.80	11.68	11.68	1.21	1.52	1.37
Mean	9.92	15.64	12.78	10.05	12.76	11.41	1.46	1.95	1.75

Table 6. *Effect of imidacloprid seed treatment on number of properly opened bolls, poorly opened bolls and seed cotton yield (q/ha) in cotton genotypes.*

Genotypes	Properly opened bolls/plant			Poorly opened bolls/plant			Yield (Q/ha.)		
	Treated	Untreated	Mean	Treated	Untreated	Mean	Treated	Untreated	Mean
DHH-11	12.96	10.20	11.58	1.16	1.68	1.42	8.31	7.21	7.76
DHB-105	12.88	12.36	12.62	1.44	1.92	1.68	7.57	6.24	6.91
SAHANA	8.56	8.40	8.48	1.12	1.28	1.20	9.08	7.50	8.29
Mean	11.47	10.32	10.89	1.24	1.63	1.43	8.32	6.98	7.65
For comparing		SEM±	CD 5%		SEM±	CD 5%		SEM±	CD 5%
Treatments (T)		0.27	0.82		0.153	0.311		0.26	0.80
Genotypes (G)		0.76	2.30		0.119	0.360		0.17	0.50
Interaction (TXG)		1.02	3.10		0.162	0.487		0.36	1.10