

ALLELOPATHIC EFFECTS OF *Lantana camara* LEAF EXTRACT ON GERMINATION AND GROWTH BEHAVIOR OF SOME AGRICULTURAL AND FOREST CROPS IN BANGLADESH

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ABSTRACT

Lantana camara, an invasive weed in the secondary degraded and plantation forests of Bangladesh is becoming a problem not only competing with the crops but also releases allelochemicals to associated crops. The present study showed that water soluble allelochemicals of *L. camara* inhibit the germination and initial growth of both the selected agricultural (*Oryza sativa* L., *Triticum aestivum* L., *Vigna sinensis* (L.) Hassk., *Cucurbita pepo* L., *Abelmoschus esculentus* (L.) Moench, *Amaranthus tricolor* L.) and forest crops (*Acacia auriculiformis* A. Cunn. ex Benth. & Hook., *Paraserianthes falcataria* (L.) Nielson, *Albizia procera* (Roxb.) Benth.) in the laboratory conditions. The results revealed that different concentrations of *Lantana camara* leaf extracts caused significant inhibitory effect on germination, root and shoot elongation and development of lateral roots of the receptor crops. Bioassays also indicate that the inhibitory effect was proportional to the concentrations of the extracts and higher concentrations had the stronger inhibitory effect, whereas, the lower concentrations showed stimulatory effect in some cases.

Key words: *Lantana camara*, allelopathy, agricultural crops, forest crops, germination, growth inhibition.

INTRODUCTION

The term 'allelopathy' signifies the interactions between plants might lead to either stimulation or inhibition of growth. In addition to allelopathic effects, weeds also act as enemies to the crop plants and have harmful effects on agricultural crops due to several factors such as competition for space, light and nutrients. Organic chemicals released as leaf leachates, affect the desired crop plants. Weeds species are considered as rich source of secondary metabolites (allelochemicals) and these chemicals modify the environmental system on other plants growing in their vicinity and the phenomenon is known as allelopathy (Nandal *et al.*, 1994). Few researchers consider only the deleterious interactions as allelopathy, while, the latest thinking includes allelopathy to both harmful and beneficial

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interactions between the plants (Rizvi *et al.*, 1986). In agriculture, the inhibitory effect of weed species on germination and growth of crops has been attributed to phytotoxic chemicals released from the leaf litter and roots. Further, Rice (1974) observed that many species of weeds produce toxins that are inhibitory to other weeds and often to themselves. *Lantana camara*, one of the world's 10 worst weeds was introduced in the Indian subcontinent during the early part of the nineteenth century (Bansal, 1998). The weed is aggressively growing in forest, agriculture, tea garden and wastelands of all over the country (Ahmed, 1997). This obnoxious weed poses a serious problem to flora and fauna because of its toxic substance and it contains certain allelopathic compounds (Jain *et al.*, 1989). Although several researches have so far worked on the invasion and allelopathic effects of *Lantana* on various agricultural crops throughout the world (Bansal, 1998) however such scientific activities are scarce in the context of Bangladesh (Ahmed *et al.*, 2007). The present work was an attempt to explore the allelopathic effects of *L. camara* in the forest and agricultural crops commonly grown in Bangladesh.

MATERIALS AND METHODS

Receptor crops

The receptor agricultural crops used in this experiment were *Oryza sativa* L., *Triticum aestivum* L., *Vigna sinensis* (L.) Hassk., *Cucurbita pepo* L., *Abelmoschus esculentus* (L.) Moench. and *Amaranthus tricolor* L. The receptor forest crops were *Acacia auriculiformis* A. Cunn. ex Benth. & Hook., *Paraserianthes falcataria* (L.) Nielson and *Albizia procera* (Roxb.) Benth.

Donor plant and preparation of leaf extracts

In the present experiment, *L. camara* was used as the donor plant. Aqueous extract of *L. camara* leaves was prepared as under 200g of fresh *L. camara* leaves were soaked in 1000 ml distilled water and kept at a room temperature of 28-30°C. After 24 hour, the aqueous extract was filtered through the sieve and then some of the extracts was diluted to make the concentrations to 10, 25, 50 and 75 % (on the basis of volume) and stored for seed treatment experiments.

Treatments

Five treatments T₀, T₁, T₂, T₃, T₄ and T₅ were used during the experiment: T₀: Seeds of receptor plants grown in distilled water only (control) whereas T₁, T₂, T₃, T₄ and T₅: were Seeds of receptor plants grown in extracts of 10, 25, 50, 75 and 100% concentrations, respectively.

Germination and growth records

The germination test was carried out in the sterile Petri dishes (12cm dia) lined with filter paper Whatman No. 3. Each concentration

of the extract was added to each Petri dish of respective treatment daily in such an amount just to keep the seed moist enough to get favorable condition for germination and growth. The control treatment was treated with distilled water. Twenty seeds of each receptor species were placed in the petridish replicating five times. The Petri dishes were set in the analytical laboratory of the Institute Of Forestry and Environmental Sciences, Chittagong University, Bangladesh at room temperature ranging from 28-30°C. The experiment was extends over a period of seven days to allow the last seed germination A seed was considered as germinated, when radical emerged. The germination was recorded on daily basis. The results were determined by counting the number of germinated seeds, number of lateral roots and measuring the lengths of both primary and main shoot on seventh day (in case of agriculture crops) and twelfth day (in case of forest crops) of the experiment. The data were subjected to analysis of variance and Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Germination (%) of agricultural crops

The germination percentages of the 6-receptor plants are shown in Table-1. In most cases, variation of the germination percent varied evenly due to different concentrations. With the increase of concentration, the inhibitory effect was progressively increased. In all cases, the maximum inhibitory effect was found at T₅ treatment (100% concentration). The highest inhibitory effect (-35.08%) was found in *C. pepo* at T₅ treatment followed by -34.61% in *A. tricolor* in the same treatment.

Table-1. Germination percent of receptor agricultural crops to distilled water (T₀) and different concentration of *Lantana camara* leaf extracts (T₁-T₅).

Treatment	<i>O. sativa</i>	<i>T. aestivum</i>	<i>V. sinensis</i>	<i>C. pepo</i>	<i>A. esculantus</i>	<i>A. tricolor</i>
T ₀	96.67 a*	88.33 a	91.67 a	95.00 a	81.67 a	86.67 a
T ₁	88.33 ab (-8.63)	80.00 ab (-9.43)	88.33 ab (-3.64)	88.33 ab (-7.02)	78.33 a (-4.09)	81.67 a (-5.77)
T ₂	86.67 bc (-10.34)	78.33 b (-11.32)	83.33 ab (-9.09)	85.00 ab (-10.53)	80.00 a (-2.04)	75.00 ab (-13.46)
T ₃	80.00 bcd (-17.24)	73.33 bc (-16.98)	86.67 ab (-5.45)	80.00 bc (-15.79)	70.00 a (-14.29)	75.00 ab (-13.46)
T ₄	78.33 cd (-18.97)	68.33 cd (-22.64)	75.00 bc (-18.18)	70.00 cd (-26.32)	68.33 a (-16.33)	65.00 bc (-25.00)
T ₅	73.33 d (-24.14)	61.67 d (-30.18)	63.33 d (-30.92)	61.67 d (-35.08)	61.67 a (-24.49)	56.67 c (-34.61)

*- Values in the columns followed by the same letter (s) are not significantly different (p≤0.05) according to Duncan's Multiple Range Test (DMRT). Values in the parenthesis indicate the inhibitory (-) or stimulatory (+) effects in comparison to control (T₀) treatments.

The maximum relative germination ratio was found in *A. esculantus* (97.96%) at T₂ treatment while the minimum (64.92%) was occurred in *C. pepo* at T₂ treatment. Allelopathic effects of *Lantana camara* on germination and growth behavior of some agricultural crops was reported (Ahmed *et al.*, 2007). The researchers found that aqueous extracts of *L. camara* inhibited the seed germination of some agricultural crops. It was also observed that leaf extracts of *L. camara* significantly delayed the germination in all the receptor crops compared to the control treatment. The allelopathic effect of *Bambusa arundinacea* on *Arachis hypogaea* was also reported (Eyini *et al.*, 1989) to conclude that, aqueous extract of weeds inhibited the germination of selected crops.

Shoot elongation

The average shoot lengths (cm) of the germinated seedlings of agricultural crops in all the receptor crops are shown in Table-2. The study revealed that in some cases stimulatory effect was found at T₂ treatment in comparison to control and the inhibitory effect was progressively increased with the increase of concentration. Statistically significant effect was found at T₅ treatment followed by T₄ and T₃ treatments, respectively. Complete inhibition (-100%) occurred in *A. esculantus* at T₅ treatment. Among the survivors, the highest inhibitory effect was found on *V. sinensis* (-86.30%) at T₅ treatment and the lowest inhibitory effect was found on *C. pepo* (-0.21%) whereas the highest stimulating effect was found on *O. sativa* (+1.43%) at T₂ treatment. Maximum elongation of shoot (17.30cm) was observed in *V. sinensis* at T₀ treatment.

Table-2. Shoot elongation (cm) of receptor agricultural crops to distilled water (T₀) and different concentration of *Lantana camara* leaf extracts (T₁-T₅).

Treatment	<i>O. sativa</i>	<i>T. aestivum</i>	<i>V. sinensis</i>	<i>C. pepo</i>	<i>A. esculantus</i>	<i>A. tricolor</i>
T ₀	4.90 a*	11.62 a	17.30 a	14.30 a	8.03 a	5.47 a
T ₁	4.76 ab (-2.86)	6.43 b (-44.66)	15.87 b (-8.27)	14.27 a (-0.21)	5.29 b (-34.12)	4.32 b (-21.02)
T ₂	4.97 a (+1.43)	4.90 c (-57.83)	13.71 c (-20.75)	13.89 a (-2.87)	4.29 c (-46.58)	3.75 c (-31.44)
T ₃	4.56 b (-6.94)	4.52 c (-61.10)	9.62 d (-44.39)	14.24 a (-0.42)	4.11 cd (-48.82)	3.39 d (-38.03)
T ₄	4.23 c (-13.67)	3.29 d (-71.69)	4.22 e (-75.61)	5.18 b (-63.78)	3.58 d (-55.12)	3.26 d (-40.40)
T ₅	4.48 bc (-8.57)	1.95 c (-83.22)	2.37 f (-86.30)	3.45 c (-75.87)	0.00 e (-100)	2.72 e (-50.27)

*- Values in the columns followed by the same letter (s) are not significantly different (p≤0.05) according to Duncan's Multiple Range Test (DMRT). Values in the parenthesis indicate the inhibitory (-) or stimulatory (+) effects in comparison to control (T₀) treatments.

Root elongation

The root lengths of all the 6 bioassay species were found to be greatly inhibited with the increase of the extract concentration except for *O. sativa* and *A. tricolor*. In *O. sativa* and *A. tricolor* stimulating effect was observed and relative elongation ratio was found to be +8.01% and +4.43% at T₁ treatment respectively (Table-3). The inhibitory effect was much more pronounced at T₅ treatment followed by T₄, T₃ and T₂ treatments respectively. Complete inhibition was occurred in *A. esculantus* at T₅ treatment. Among the survivors, the highest inhibitory effect (-95.32%) was found on *C. pepo* at T₅ treatment followed by *V. sinensis* at T₅ treatment (-85.44%). Maximum elongation of root was observed in *C. pepo* (25.01cm) at T₀ followed by 22.48cm in T₂ treatment (Table-3).

Table-3. Root elongation (cm) of receptor agricultural crops to distilled water (T₀) and different concentration of *Lantana camara* leaf extracts (T₁-T₅).

Treatment	<i>O. sativa</i>	<i>T. aestivum</i>	<i>V. sinensis</i>	<i>C. pepo</i>	<i>A. esculantus</i>	<i>A. tricolor</i>
T ₀	6.24 ab*	10.63 a	10.92 a	25.01 a	6.98 a	4.51 b
T ₁	6.74 a (+8.01)	7.25 b (-31.79)	6.35 b (-41.85)	20.13 bc (-19.52)	5.20 b (-25.50)	4.71 a (-4.43)
T ₂	6.42 ab (+2.88)	6.56 c (-38.29)	5.61 c (-48.63)	22.48 b (-10.12)	4.58 c (-34.38)	3.84 c (-14.86)
T ₃	6.35 ab (+1.76)	6.45 c (-39.32)	4.61 d (-57.78)	18.39 c (-26.47)	4.62 c (-33.81)	3.39 d (-24.83)
T ₄	5.89 b (-5.61)	5.52 d (-48.07)	1.86 e (-82.97)	1.97 d (-92.12)	3.43 d (-50.86)	3.24 d (-28.16)
T ₅	5.34 c (-14.42)	3.23 e (-69.61)	1.59 f (-85.44)	1.17 d (-95.32)	0.00 e (-100)	2.58 e (-42.79)

* - Values in the columns followed by the same letter (s) are not significantly different ($p \leq 0.05$) according to Duncan's Multiple Range Test (DMRT). Values in the parenthesis indicate the inhibitory (-) or stimulatory (+) effects in comparison to control (T₀) treatments.

Number and Development of lateral roots

Considering the number of lateral root development, it was revealed that this phenomenon is significantly inhibited with the increasing concentration. In all cases most significant effects was found at T₅ treatment. Complete inhibition occurred at the same treatment (T₅) in case of both *A. esculentus* and *A. tricolor*. The effect was more or less evenly increased from 10% concentration to onward. In all cases control had the highest average lateral root number in comparison to other treatments except for that in *O. sativa* on which stimulating effect (+12.60%) was found at T₁ treatment.

Among the survivors, highest inhibitory effect (-96.96%) was found on *V. sinensis* at T₅ treatment and the lowest (-0.93%) was found on *O. sativa* at T₅ treatment whereas maximum number of lateral roots (96.89) were found in *C. pepo* followed by 91.34 both in same species in T₀ and T₂ treatment respectively (Table-4). Lateral

root development was completely inhibited in *A. esculantus* seedling at T₅ treatment. The survivors exhibited varying degree of necrosis and chlorosis, thin and grayish in color. Many seedlings lost their ability to develop normally as a result of reduced radical elongation and root necrosis. So, it can be concluded that the inhibitory effect of *Lantana* extract dependent very much on their concentration which was also reported by Daniel (1999).

Table-4. Number of lateral roots in receptor agricultural crops to distilled water (T₀) and different concentration of *Lantana camara* leaf extracts (T₁-T₅).

Treatment	<i>O. sativa</i>	<i>T. aestivum</i>	<i>V. sinensis</i>	<i>C. pepo</i>	<i>A. esculantus</i>	<i>A. tricolor</i>
T ₀	35.33 b*	16.11 a	31.22 a	96.89 a	17.56 a	4.67 a
T ₁	38.00 ab (+7.56)	11.22 b (-30.35)	18.78 b (-39.85)	77.00 c (-20.53)	7.78 b (-55.69)	3.44 b (-26.34)
T ₂	39.44 a (+11.63)	5.89 c (-63.44)	15.11 c (-51.60)	91.34 b (-5.73)	5.67 c (-67.71)	1.89 c (-59.53)
T ₃	39.78 a (+12.60)	2.67 d (-83.43)	11.33 d (-63.71)	77.11 c (-20.41)	3.00 d (-82.92)	1.11 d (-76.23)
T ₄	38.22 ab (+8.18)	1.78 de (-88.95)	07.45 e (-76.14)	11.55 d (-88.08)	2.00 e (-88.61)	0.56 e (-88.00)
T ₅	35.00 b (-0.93)	0.67 e (-95.84)	0.95 f (-96.96)	9.33 d (-90.37)	0.00 f (-100)	0.00 f (-100)

* - Values in the columns followed by the same letter (s) are not significantly different ($p \leq 0.05$) according to Duncan's Multiple Range Test (DMRT). Values in the parenthesis indicate the inhibitory (-) or stimulatory (+) effects in comparison to control (T₀) treatments.

Germination for forest crops

The germination percent of the 3-receptor forest crops is shown in Table-5. In most cases, variation of the germination varied evenly due to different concentrations. With the increase of concentration, the inhibitory effect was progressively increased.

Table-5. Germination percent of receptor Forest crops to distilled water (T₀) and different concentration of *Lantana camara* leaf extracts (T₁-T₅).

Treatment	<i>A. auriculiformis</i>	<i>P. falcata</i>	<i>A. procera</i>
T ₀	76.67 a*	85.00 a	78.33 a
T ₁	55.00 bc (-28.26)	73.33 b (-13.73)	55.00 b (-29.78)
T ₂	56.67 b (-26.09)	56.67 c (-33.33)	48.33 bc (-38.30)
T ₃	46.67 bcd (-39.13)	43.33 d (-49.02)	40.00 cd (-48.93)
T ₄	45.00 cd (-41.31)	53.33 cd (-37.26)	45.00 cd (-42.55)
T ₅	40.00 d (-47.83)	41.67 d (-50.98)	38.33 d (-51.07)

* - values in the columns followed by the same letter (s) are not significantly different ($p \leq 0.05$) according to Duncan's Multiple Range Test (DMRT). Values in the parenthesis indicate the inhibitory (-) or stimulatory (+) effects in comparison to control (T₀) treatments.

In all cases, the maximum inhibitory effect was found at T₅ treatment (100% concentration). The highest inhibitory effect (-51.07%) was found in *A. procera* at T₅ treatment followed by (-50.98%) in *P.*

falcataria at the same treatment. The maximum relative germination ratio was found in *P. falcataria* (86.27%) at T₀ treatment while the minimum was (48.93%) in *A. procera* at T₅ treatment. These results are more or less similar to the findings of Bora *et al.* (1999), who found the allelopathic effects of leaf extracts of *Acacia auriculiformis* on seed germination of some agricultural crops.

Shoot elongation

The average shoots length (cm) of the germinated seedlings of forest crops in all the receptor are shown in Table-6. The study revealed that in *P. falcataria*, stimulatory effect was found at T₅, T₃ and T₁ treatment in comparison to control and the inhibitory effect was progressively increased with the increase of concentrations. Statistically significant effect was found at T₄ treatment followed by T₃ and T₂ treatment respectively (Table-6). Complete inhibition (-100%) was occurred in *A. procera* at T₄ and T₅ treatment, though maximum elongation of shoot (8.43cm) was found in *A. procera* at T₀ treatment. Among the survivors the highest inhibitory effect was found on *A. auriculiformis* (-46.84%) at T₄ treatment and the lowest inhibitory effect was found on *A. auriculiformis* (-7.93%), whereas, the highest stimulating effect was found on *P. falcataria* (+8.05%) at T₅ treatment.

Table-6. Shoot elongation (cm) of receptor Forest crops to distilled water (T₀) and different concentration of *Lantana camara* leaf extracts (T₁-T₅).

Treatment	<i>A. auriculiformis</i>	<i>P. falcataria</i>	<i>A. procera</i>
T ₀	8.07 a*	6.83 b	8.43 a
T ₁	7.43 b (-7.93)	7.07 ab (+3.51)	6.41 b (-23.96)
T ₂	6.52 c (-19.21)	5.96 c (-12.74)	5.77 c (-31.55)
T ₃	4.98 e (-38.29)	7.28 a (+6.59)	5.09 d (-39.62)
T ₄	4.29 f (-46.84)	5.80 c (-15.08)	0.00 e (-100)
T ₅	5.49 d (-31.97)	7.38 a (+8.05)	0.00 e (-100)

* - values in the columns followed by the same letter (s) are not significantly different ($p \leq 0.05$) according to Duncan's Multiple Range Test (DMRT). Values in the parenthesis indicate the inhibitory (-) or stimulatory (+) effects in comparison to control (T₀) treatments.

Root elongation

The root length of all the 3 tree species were found to be significantly inhibited with the increase of the extract concentration, except in *P. falcataria* where stimulating effect was observed and relative elongation ratio was +27.38% and +6.53% at T₁ and T₅ treatment respectively (Table-7). The inhibitory effect was much more pronounced at T₃ treatment followed by T₂ and T₁ treatments respectively. Complete inhibition was occurred in *A. procera* at T₄ and T₅ treatment. Among the survivors, the highest inhibitory effect (-77.5%) was found on *A. procera* at T₃ treatment followed by *A. procera* at T₂

treatment (-70.92%). Maximum elongation of roots (5.49cm) was observed in T₁ of *P. falcataria* followed by 4.31cm in T₀ treatment (Table-7).

Table-7. Root elongation (cm) of receptor Forest crops to distilled water (T₀) and different concentration of *Lantana camara* leaf extracts (T₁-T₅).

Treatment	<i>A. auriculiformis</i>	<i>P. falcataria</i>	<i>A. procera</i>
T ₀	4.20 a*	4.31 ab	3.20 a
T ₁	3.83 b (-8.81)	5.49 a (+27.38)	1.14 b (-64.38)
T ₂	3.17 c (-24.52)	4.12 ab (-4.41)	0.93 bc (-70.94)
T ₃	2.77 d (-34.05)	3.53 bc (-18.10)	0.72 c (-77.5)
T ₄	2.00 f (-52.38)	2.62 c (-39.21)	0.00 d (-100)
T ₅	2.37 e (-43.57)	4.60 ab (+6.53)	0.00 d (-100)

* - Values in the columns followed by the same letter (s) are not significantly different ($p \leq 0.05$) according to Duncan's Multiple Range Test (DMRT). Values in the parenthesis indicate the inhibitory (-) or stimulatory (+) effects in comparison to control (T₀) treatments.

Number and Development of lateral roots

Considering the number of lateral root development, it was revealed that root development was significantly inhibited with the increase of extract concentrations (Table-8). In all cases, most significant effect was found at T₄ treatment and complete inhibition was occurred at T₄ and T₅ treatments in *A. procera*. The effect was more or less evenly increased from 10% concentration to onward. In all the treatments, control had the highest average lateral root number in comparison to other treatments. Among the survivors, highest inhibitory effect (-90.44%) was found on *A. auriculiformis* at T₄ treatment and the lowest (-37.11%) was found on *P. falcataria* at T₅ treatment whereas the maximum number of lateral roots (16.22 nos.) were found in *A. auriculiformis* (Table-8). Lateral root development was completely inhibited in *A. procera* seedling at T₄ and T₅ treatments.

The results of the study confirms the findings of Bansal (1998), who reported the suppressed seed germination and seedling growth in all associated weeds and the suppressive effects increase with an increase in percent content of *Lantana* extracts. The result also revealed that root elongation and lateral root development of receptor crops were markedly inhibited in comparison to that of shoot elongation. These may be due to the direct contact of roots with leachates.

These findings also were in accordance with the results of Alam (1990); Chou *et al.* (1986) and Zackrisson and Nilsson (1992), in which root growth was more sensitive and responds more strong to the increasing concentration of the aqueous extracts. The suppressive effect of *Lantana* on other weeds may be caused by allelopathy.

Lantana has also been reported to be allelopathic against milk weed vine (*Morrenia odorata*), velvet leaf (*Abutilon theophrasti*) and fern (*Cyclossus dentatus*) because of phenolic compounds (Jain *et al.*, 1989).

Table-8. Number of lateral roots in receptor Forest crops to distill water (T₀) and different concentration of *Lantana camara* leaf extracts (T₁-T₅).

Treatment	<i>A. auriculiformis</i>	<i>P. falcataria</i>	<i>A. procera</i>
T ₀	16.22 a*	10.78 a	3.89 a
T ₁	10.11 b (-37.67)	5.56 bc (-48.42)	2.22 b (-42.93)
T ₂	7.22 c (-55.49)	4.11 d (-61.87)	1.11 c (-71.47)
T ₃	3.00 d (-81.50)	5.89 b (-45.36)	0.67 cd (-82.78)
T ₄	1.55 e (-90.44)	4.22 cd (-60.85)	0.00 d (-100)
T ₅	3.67 d (-77.37)	6.78 b (-37.11)	0.00 d (-100)

* - Values in the columns followed by the same letter (s) are not significantly different ($p \leq 0.05$) according to Duncan's Multiple Range Test (DMRT). Values in the parenthesis indicate the inhibitory (-) or stimulatory (+) effects in comparison to control (T₀) treatments.

The plantation forests and the secondary degraded forest lands of Bangladesh are being progressively invaded and suppressed by this alien invasive woody shrub *Lantana camara* L. in an alarming rate. The invasion of *Lantana* threatens the natural regeneration and survival of many young plantation species. *Lantana* occurs in diverse site conditions ranging from open, un-shaded conditions such as wastelands, the edges of forests, in agricultural areas, grasslands, scrub/shrub lands, urban areas, wetlands and degraded forests recovering from fire or logging, roadsides, railway tracks and canal banks. In addition, this weed is exerting allelo-chemicals that also inhibit the growth and development of both the common agricultural and forest crops in diverse ecosystems. A strategy and action plan is essential to eradicate and control this noxious weed from further spread in new ecosystems.

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