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Effect of *Cassia siamea* and *Gliricidia sepium* leaf in controlling weed of transplanted *aman* rice on the Madhupur tract of Bangladesh

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Abstract

Over use of herbicide may cause several environmental hazards and development of herbicide-resistant weeds along with high cost. Allelopathy is a component of integrated weed management (IWM) could be potentially used for weed control by producing and releasing allelochemicals. A field study was conducted to evaluate the allelopathic potentiality of *Cassia siamea* and *Gliricidia sepium* leaf in controlling weed at the experimental farm of the Bangabandhu Sheikh Mujibur Rahman Agricultural University, Salna, Gazipur during *aman* season of 2010. Treatment consists of 11 weed control methods (weedy, weed-free, pretilachlor 1 L a.i. ha^{-1}, fresh leaves of *Cassia siamea* 2.5, 5, 7.5, and 10 tha^{-1}, and *Gliricidia sepium* 2.5, 5, 7.5, and 10 tha^{-1}. *C. siamea, and G. sepium* leaves incorporation effectively controlled weeds; however, higher rate was more effective than lower rate. The highest weed control efficiency (WCE) was recorded from *G. sepium* 10 t ha^{-1}. WCE of *C. siamea* 7.5 and 10 t ha^{-1} and *G. sepium* 2.5, 5, and 7.5 t ha^{-1} had similar results to herbicide treatment pretilachlor 1 L a.i. ha^{-1}. Across the rates of leaves incorporation, *C. siamea* and *G. sepium* had 14-27 and 8-22% lower yield, respectively, when compared with weed-free treatment. Grain yield increased significantly when *C. siamea* and *G. sepium* leaves incorporation rates increased from 2.5 to 10 t ha^{-1}. The results of the study indicates that *C. siamea* and *G.* sepium leaf have strong allelopathic potential against weeds and farmers can use fresh leaves of *C. siamea* around 10 t ha^{-1} and *G.* sepium 7.5 -10 t ha^{-1} to effective control of weeds in transplanted rice.

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Introduction

Weed causes economic loss of rice farmers by reducing in crop yields, increase cost of production and reduce the quality (Bhuler *et al.*, 1998; Ahmed *et al.*, 2014). Weed can also causes total crop failure, especially in direct dry-seeded rice if weeds are not controlled (Ahmed and Chauhan, 2014). In rice production, the yield losses due to weed infestation are greater than the combined yield losses caused by insects and diseases (Abbas *et al.,* 1995). In addition to causing considerable reductions in yield, weeds reduce the soil fertility by absorbing nutrient, particularly nitrogen (Ahmed *et al.,* 2007).

There have many tactics to manage weeds such as manual, mechanical, biological and chemical methods. Manual weeding is very common in Bangladesh as well as many Asian countries. Due to recent trend in unavailability of farm labours and it is high wage rate, manual weeding is replacing to chemical weeding (Chauhan *et al.,* 2015). The chemical weed control using herbicides offers easy and low cost means of weed management resulting herbicidal weed management in world agriculture is increasing. In Bangladesh, the use of herbicides during 1986-87 was only 108 metric tons which reached 2600 metric tons in 2006 (Anonymous, 2007). Although chemical weed control are very cost effective method; however, over use of herbicide may cause several environmental hazards and development of herbicide-resistant weeds (Holethi *et al.,* 2008). In addition, soil environment which consists of soil pH, nutrient availability, cation exchange capacity (CEC), and soil microbes may be affected by herbicides use; however, it depends on nature of chemical, concentration and persistence in soil (Huston and Roberts, 1987).

Considered with the negative effect of herbicides on environment and weed resistance problem, weed management needs an integrated approach (Chauhan *et al.,* 2015). Allelopathy is considered as a component of integrated weed management (IWM), work as a chemical released from plant to environment which influence on the growth of another plant (Kim, 2001). Allelopathy could be potentially used for weed control by producing and releasing allelochemicals from leaves, flowers, seeds, stems, and roots of living or decomposing plant materials (Weston, 1996). It involves release of a wide variety of chemicals (alkaloids, phenolics, flavenoids, terpenoids, glucosionlates, etc.) by a plant into its surrounding environment, which is taken up by a sensitive plant resulting in growth promotion or inhibition (Narwal, 1994).

When allelochemicals use to control weeds, the target species are affected by these chemical in many different ways. The toxic chemicals may inhibit shoot or root growth, they may inhibit nutrient uptake, or they may attack a naturally occurring symbiotic relationship thereby destroying the plant's usable source of nutrient (Hierro and Callaway, 2003).

There are many plant species which have allelopathic in nature and can be used as weed suppressing agent. Among the allelopathic plant species *Cassia siamea* and *Gliricidia sepium* inhibit the growth and development of several weed species. Hussain *et al.* (2007) investigated that plant extract of *C. siamea* affected on germination and seedling growth characters of weed species of *Avena fatua, Dactyloctenium aegyptium, Echinocloa colona, Phalaris minor* and *Sorghum halepense*. Fujii *et al.* (2004), under laboratory study, revealed allelopathic potentials of *G. sepium*. Linhares *et al.* (2009) showed that, soil mulching with *G. sepium* branches does not have an allelopathic effect on corn, but decreases weed populations. Smith and Alli (2007) found that mulching by plant residues of *G. sepium* reduced the infestation of several dicot weeds. Similar results was reported by Kamara (1995) where it was shown that *G. sepium* mulch had no allelopathic effect on maize and beans but significantly decreased the population of some weed species.

C. siamea and *G. sepium* species not only suppressed the weed but also used as a green manure. Green manuring of *C. siamea* and *G. sepium* fresh leaves can bring a number of advantages to the crop plant

and soil such as increase biological activity, adding organic matter to the soil, increase the supply of nutrients availability to plants (particularly by adding nitrogen to the system by fixation), reducing leaching losses etc (Mafongoya *et al.,* 1998).

Results from previous studies revealed that both *C. siamea* and *G. sepium* have the potentiality to suppress weeds apart from their green manuring benefits in crop production. Both species are abundant throughout the Bangladesh; however, no information are available on the allelopathic potential of these two species in wetland rice environments. If allelopathic species could be incorporated in certain cropping systems to provide weed suppression, this could reduce dependency on synthetic herbicides as well as inorganic fertilizer. Considering with the benefit mentioned above the present study was undertaken with the objectives of-effects of *C. siamea* and *G. sepium* on rice growth, yield, and weed suppression in transplanted aman rice.

Materials and methods

Experiment site and soil description

Field study was conducted at the experimental farm (24°09/ N, 90°26/ E with an elevation of 8.4 m from the mean sea level) of the Bangabandhu Sheikh Mujibur Rahman Agricultural University, Salna, Gazipur during the wet season (*aman*) of 2010 (September to December). The area is under Madhupur Tract (AEZ 28), a region of upland, closely or broadly dissected terraces associated with either shallow or broad, deep valleys and soils developed over the Madhupur Clay. The soil of the experimental site was silty clay of Shallow Red Brown Terrace type, having pH 6.9. The climate of the experimental site is characterized by heavy rainfall during the months from May to September and scanty rainfall during the rest of the year.

Treatments and design treatments

The experiment was consists of eleven different weed control treatments such as weedy (allow weeds season-long), weed-free (not allow any weeds during experiment period and weeding was done by several times manually), pretilachlor 0.5 kg a.i. ha^{-1}, *Cassia siamea* fresh leaves (2.5, 5, 7.5, and 10 t ha^{-1}), and *Gliricidia sepium* fresh leaves (2.5, 5, 7.5, and 10 t ha^{-1}). The experiment was laid out in a randomized complete block design (RCBD) with three replications. The size of unit plots was 3m × 4 m. Plot to plot distance was 0.5 m and block to block distance was 1m.

Crop management

BU Dhan 1, a newly released modern rice variety (slightly aromatic in nature) developed by the Bangabandhu Sheikh Mujibur Rahman Agricultural University was used as the test crop in the experiment. The sprouted seeds were sown in the nursery bed on 1 August 2010. The land was puddled thoroughly by ploughing and cross ploughing four times followed by laddering using a two wheel power tiller on 25 August 2010. Weeds and stubbles were removed from the land to make it ready for transplanting. Thirty-five-day old seedlings were uprooted on 6 September 2010 form nursery bed and transplanting was done with two or three seedlings per hill at a spacing of 20×20cm on the same day. Fertilizers were applied at the rate of 80-60-40-20-4 kg ha^{-1} of N- P- K- S- Zn in the form of Urea, Triple super phosphate, Murate of Potash, Gypsum and Zinc sulphate, respectively. The whole amount of P, K. S and Zn were applied as basal dose during final land preparation. Nitrogen fertilizer was applied in three equal splits in a top dress at 20, 40 and 55 days after transplanting (DAT).

The crop was kept under keen observation from transplanting to date of harvesting. Intercultural operations such as irrigation, pest management and other necessary cultural operations were done as and when required. The crop was infested with yellow stem borers *(Scirpophaga incertulas)* and Furadan 5G @ 10 kg ha^{-1} was applied at 70 DAT to control the infestation.

Observation

The weeds were collected from each unit plot at 60, 90 DAT, and at physiological maturity (PM). A

quadrate of (50 cm x 50 cm) 0.25 m^2 was placed randomly at three different spots outside the yield measured area. The infested weed species within each quadrate were cleaned, counted number. The weeds were first dried in the sun and then in an electric oven for 72 hours a constant temperature of 70 ^{0}C for biomass.

Weed control efficiency (WCE) was calculated using formula

$$WCE = \frac{(DMC-DMT)x\ 100}{DMC}$$

Where, DMC is weed dry matter production in weedy treatment and DMT is weed dry matter production in weed control treatment.

The tiller density was counted from fixed five hills of each plot at 60 and 90 DAT. Rice dry biomass (oven dried at 70°C for 72 hours) was also measured from randomly selected five hills at 60 and 90 DAT.

At physiological maturity, 5 hills were uprooted to measure yield-contributing characters. The crop of individual plots was harvested at well-matured stage (80 percent of the grains were turned yellow colour) on 15 December 2010.

To determine grain and straw yield a (2m × 2m) 4m^2 area from the center of each plot was harvested. Panicle density was counted from all five hills collected for yield components. Number of florets was counted from randomly selected 20 panicles. Grain yield was finally converted at 14% moisture level and straw yield at constraint oven dried at 70°C for 72 hours.

Data analysis

The data were analysis using computer based software MSTAT. The means were separated through LSD test at 5% level of significance.

Results and discussion

Effect of weed control methods on weed density, weed biomass, and weed control efficiency

Weed density, weed biomass, and weed control efficiency were significantly influenced by weed control methods at all data recorded date (30, 60 DAT, and PM) (Table 1). Herbicide pretilachlor 1 L a.i. ha^{-1}, *C. siamea, and G. sepium* leaves incorporation *at* different rates had always lower weed density than weedy treatment. At 30 DAT, weed density for *C. siamea, and G. sepium* treatment at different rates had similar result; however, weed biomass decreased when rate increased from 2.5 to 7.5 for *C. siamea,* and 2.5 to 5 for *G. sepium* leaves. Compared with the weedy treatment, the highest weed control efficiency (66.0%) was recorded from the herbicide treatment. *G. sepium* 7.5 and 10 t ha^{-1} leaves incorporation had similar weed control efficiency to herbicide treatment. Among the weed control treatments, the lowest weed control efficiency was recorded from *C. siamea* 2.5 t ha^{-1}; however, *C. siamea* 5 t ha^{-1} and *G. sepium* 2.5 t ha^{-1} leaves have similar results. At 60 DAT *C. siamea* 7.5 and 10 t ha^{-1} had significantly lower weed density and biomass than *C. siamea* 2.5 t ha^{-1}. At this stage, there was no effect of *G. sepium* leaves incorporation at different rates on weed density; however, decreased weed biomass when rate increased from 2.5 to 10 t ha^{-1}. At PM stage, the weed density and biomass followed almost similar treads to 60 DAT. At this stage, among the weed control treatment, the highest weed control efficiency (WCE) was recorded from *G. sepium* 10 t ha^{-1}. WCE of *C. siamea* 7.5 and 10 t ha^{-1} and *G. sepium* 2.5, 5, and 7.5 t ha^{-1} had similar results to herbicide treatment pretilachlor 1 L a.i. The *C. siamea* 2.5 and 5 t ha^{-1} had significantly lower WCE than herbicide treatment. Results of our study shown that *C. siamea, and G. sepium* leaves incorporation effectively controlled weeds; however, higher rate was more effective than lower rate. Weed density and biomass data at 30 DAT shown that WCE of *C. siamea, and G. sepium* leaves incorporation of different rates were comparably lower than herbicide treatment; however, at PM stage, higher rate of both plant leaves incorporation had higher WCE than herbicide and it might be due to fresh leaves decomposed and allelopathic chemicals release in soil needed time. Higher rates of leaves incorporation had higher WCE and it was due to greater contribution of allelochemical in soil environment. Allelopatic potential of *C. siamea, and G. sepium* leaves to

suppress growth of many weed species reported from many previous studies on different crops such as corn, wheat soybean etc (Abugre *et al*., 2011; Fujii, 1994; Oyun, 2006; Smith and Alli, 2007).

Table 1. Weed density (number m^{-2}), weed biomass (g m^{-2}), and weed control efficiency (%) of BU dhan1 as affected by weed control methods.

Treatment	30 DAT			60 DAT			PM		
	WD	WB	WCE (%)	WD	WB	WCE (%)	WD	WB	WCE (%)
Weedy	86	12.6	0	143	33.0	0	124	45.6	0
Weed-free	0	0.0	100.0	0	0.0	100	0	0.0	100
Pretilachlor 1 L a.i. ha	22	4.3	66.1	63	18.3	45	36	22.6	51
C. siamea 2.5 t ha^{-1}	28	7.7	38.9	68	26.2	21	48	34.2	25
C. siamea 5 t ha-1	27	5.8	53.5	55	25.2	24	38	36.6	20
C. siamea 7.5t ha-1	72	6.7	46.9	36	19.2	42	50	19.0	58
C. siamea 8 t ha-1	73	8.2	34.5	48	15.8	52	35	20.5	55
G. sepium 2.5 t ha-1	36	7.1	43.7	65	23.2	30	36	21.4	53
G. sepium 5 t ha-1	27	5.7	54.8	65	20.0	39	41	21.0	54
G. sepium 7.5t ha-1	34	5.0	60.3	56	19.6	40	37	18.9	59
G. sepium 10t ha-1	37	4.9	60.6	57	14.7	55	48	9.7	79
LSD	20.0	1.4	10.1	12.8	4.9	4.3	11.2	4.1	8.6

C., *Cassia*; G., *Gliricidia*; WD, weed density; WB, weed biomass; WCE, weed control efficiency; PM, Physiological maturity; DAT, days after transplanting.

Effect of weed control methods on tiller density

Tiller density was significantly influenced by the weed control methods (Fig. 1). The highest tiller density (303 and 263 m^{-2} at 60 and 90 DAT, respectively) was recorded from weed-free treatment and similar tiller density to *G. sepium* 10 t ha^{-1}. The weedy plots had always lower tiller density than any others weed control treatments. At 60 DAT, *C. siamea* 2.5 and 5 t ha^{-1} had significantly similar tillers, and tiller density increased significantly when *C. siamea* leaves incorporation rate increased to 7.5 and 10 t ha^{-1}. However, at 90 DAT, *C. siamea* 2.5, 5, and 7.5 t ha^{-1} had similar tiller density and 10 t ha^{-1} had significantly higher than other rates. In both stage of data recording, tiller density increased significantly when *G. sepium* leaves incorporation rate increased from 2.5 to 5 t ha^{-1} and later increment. A higher rate of *C. siamea and G. sepium* had higher tiller density and it was due to higher WCE of leaves incorporation at higher rate compared with lower rate. Under favorable condition rice can produce more tillers, but when weed competition occurs tiller density decreased (Khaliq *et al.,* 2011).

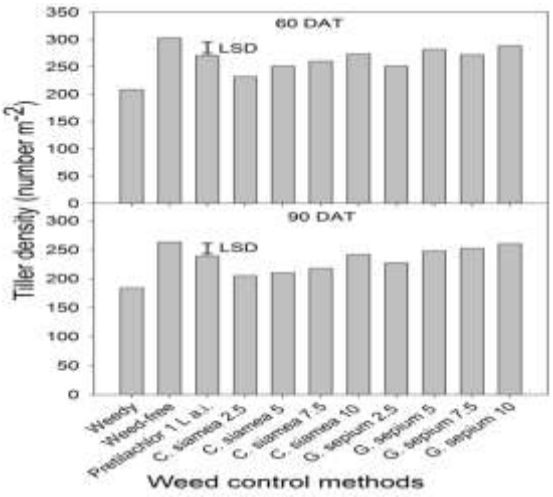

Fig. 1. Effect of weed control methods on tiller density of BU dhan1 at 60 and 90 days after transplanting (DAT).

Effect of weed control methods on rice biomass

Rice biomass was significantly affected by weed control methods both at 60 and 90 DAT (Fig. 2). At 60 DAT, the weed control treatments *siamea* 2.5 and 5 t ha^{-1}, and *G. sepium* 2.5 t ha^{-1} had similar biomass to the weedy treatment (the lowest biomass recorded treatment). The highest weed biomass was recorded from *G. sepium* 10 t ha^{-1} leaves incorporation which was similar biomass to weed-free, pretilachlor 1 L a.i.

ha^{-1}, *C. siamea* 2.5 and 5 t ha^{-1}, and *G. sepium* 5 and 7.5 t ha^{-1}. At 90 DAT, although the highest rice biomass was recorded from the weed-free treatment, the pretilachlor 1 L a.i. ha^{-1}, *C. siamea* 7.5 and 10 t ha^{-1}, and *G. sepium* 5, 7.5, and 10 t ha^{-1} had similar biomass. At this stage, all weed control treatments had higher biomass than weedy treatment. When weed present in the field with rice crop, it competes for light, air, water, and nutrient and resulting reduce rice biomass. Ahmed and Chauhan (2014) reported, rice biomass negatively co-related with weed biomass.

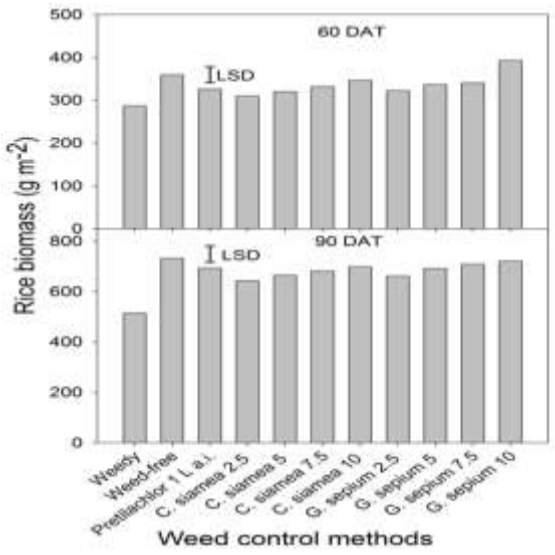

Fig. 2. Effect of weed control methods on rice biomass of BU dhan1 at 60 and 90 days after transplanting (DAT).

Effect of weed control methods on rice yield and yield components

Panicle m^{-2}, florets panicle^{-1}, grain yield, and straw yield were significantly affected by weed control methods (Table 2). The highest panicles (215 m^{-2}) was recorded from *G. sepium* 10 t ha^{-1} treatment which was similar to weed free, pretilachlor 1 L a.i. ha^{-1}, *C. siamea* 10 t ha^{-1}, and *G. sepium* 5 and 7.5 t ha^{-1} treatments. The *C. siamea* 2.5 t ha^{-1} had similar panicles (171 m^{-2}) to the lowest panicles (161 m^{-2}) recorded treatment which is weedy. The highest florets panicle^{-1} (111) was recorded from the weed-free treatment. The pretilachlor 1 L a.i. ha^{-1}, *C. siamea* 10 t ha^{-1}, and *G. sepium* 10 t ha^{-1} had similar florets panicle^{-1} to weed-free treatment. Florets panicle^{-1} increased significantly when *C. siamea* rate increased from 2.5 to 7.5 t ha^{-1} and *G. sepium* rate increased from 2.5 to 10 t ha^{-1}. *G. sepium* 10 t ha^{-1} had significantly similar yield to the highest yield obtained treatment (weed-free, 3.7 t ha^{-1}). Compared with the weed-free treatment, herbicide treatment pretilachlor 1 L a.i. ha^{-1} had 11% lower yield. On the other hand, across the different rates, leaves incorporation of *C. siamea* and *G.* sepium had 14-27 and 8-22% lower yield, respectively, when compared with weed-free treatment. Grain yield increased significantly when *C. siamea* and *G.* sepium leaves incorporation rates increased from 2.5 to 10 t ha^{-1}. Straw yield followed almost similar trends to grain yield.

Table 2. Yield and yield contributing characters of BU dhan1 as affected by weed control methods.

Treatment	Panicle m^{-2}	Florets panicle^{-1}	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
Weedy	161	81	2.4	2.2
Weed-free	212	111	3.7	3.6
Pretilachlor 1 L a.i. ha	200	105	3.3	3.2
C. siamea 2.5 t ha^{-1}	171	85	2.7	2.6
C. siamea 5 t ha^{-1}	185	93	2.9	2.7
C. siamea 7.5t ha^{-1}	190	97	3.0	2.9
C. siamea 10 t ha^{-1}	203	102	3.2	3.1
G. sepium 2.5 t ha^{-1}	190	95	2.9	2.8
G. sepium 5 t ha^{-1}	201	100	3.1	3.0
G. sepium 7.5t ha^{-1}	210	100	3.2	3.1
G. sepium 10t ha^{-1}	215	104	3.4	3.4
LSD $_{0.05}$	15.7	10.8	0.32	0.36

C., *Cassia*; G., *Gliricidia*

Crop yield generally depends on soil and weather conditions, crop variety, and management factors (Yoshida, 1981). Weed naturally grow with crop plant and compete for resources resulting crop growth hamper and yield decline if not manage proper time (Ahmed and Chauhan, 2015). Final yield of any crops

depends on better growth, development, and finally yield components (for example, rice yields depend on rice tiller number, rice biomass, panicle number, florets panicle^{-1}, florets fertility, and average grain weight). When weed compete more with crop, crop growth decreased and ultimately reduced yield. In agricultural systems, allelopathy is a component of IWM and proper utilization of this component in weed management can reduce the reliance on synthetic herbicide which is intensively used in worldwide to control weed.

Conclusion

From the present study it can be concluded that *C. siamea* and *G.* sepium have strong allelopathic potential against weed. Despite the numerous allelopathic potentialities of *C. siamea* and *G.* sepium leaves, these have not yet practices in weed control in rice. Incorporation of *C. siamea* (around 10 t ha^{-1}) and *G.* sepium (7.5-10 t ha^{-1}) fresh leaves in this study provided similar WCE, and similar yield to herbicide treatment.

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