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Research Article

Effect of herbicides on feeding, survival and development of *Haltica cyanea,* a biocontrol agent of dicot weed, *Ammania baccifera* L. in rice ecosystem

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ABSTRACT: *Ammania baccifera* L. (Fam: Lathyraceae) is one of the predominant weeds in paddy fields. In nature, the adults and grubs of *Haltica cyanea* (Coleoptera: Chrysomelidae) feed varaciously on the leaves of this weed leading to drying of the plants. In recent times with the gradual change in cultivation practices and increase in labour shortage the use of weedicides in rice ecosystem has increased tremendously. In an endeavour to explore the possibility of the use of these beetles as biocontrol agents, laboratory studies were carried out at ICAR-IIRR to compare the efficacy of *H. cyanea* as a biocontrol agent in comparison with the two recommended herbicides and also study the effect of these herbicides on the biology of the beetle. The two recommended herbicides, 2,4-D Na salt 80% (for broadleaved weeds) @800g a.i/ha and metsulfuron methyl 10% + chlorimuron ethyl 10% WP (for broadleaved and sedges) @4ga.i/ha were tested against *A. baccifera* and the larval stages of *H. cyanea*. The effect of these herbicides on survival, feeding, longevity and biology of the bioagent was studied through leaf dip and pot spray method. It was observed that there was 21.67% reduction in shoot weight in beetle released plants as compared to herbicide treatment wherein 38.5-49.3% reduction in shoot weight was observed within 48h. Both the herbicides affected the biology of the insect and between the two herbicides, 2,4-D Na salt was more toxic to the grubs as compared to metsulfuron methyl + chlorimuron ethyl.

KEY WORDS: *Ammania baccifera***,** biocontrol agent, *Haltica cyanea* (= *Altica cyanea*), herbicides, weed control efficiency

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INTRODUCTION

Over 1800 plant species have been reported as weeds of rice in South and South-east Asia (Moody, 1989) and there is an enormous diversity of taxa considered to be weeds of rice (Soerjani *et al*., 1987). In rice cultivation the potential yield loss is estimated to be around (34%). Its estimated that the losses in direct seeded rice are higher (30 to 65%) than that in transplanted rice (15 to 35%) (DRR 1978-2010; Sridevi *et al*., 2012). Among the many broadleaf weeds (BLW) that are found in rice paddies, *Ammania baccifera* L. (Fam: Lathyraceae) is one of the predominant dicot weed (8th in the order of reporting) in transplanted rice in India (Rao *et al*., 2017), common in dry direct seeded and wet seeded rice. This weed is widely distributed in South, South Asia, Australasia, Africa and parts of central and South America. Vasudevan Poornima *et al*. (2014) had enumerated the distribution of *Ammania* sp. in the world. With the change in cultivation practices and non-availability of labour the need for use of herbicides had increased tremendously. Rice consumes a major share of herbicides used in India. Currently, pretilachlor, anilophos, oxadiargyl, pyrazosulfuronethyl, bis-pyribac sodium, chlorimuronethyl + metsulfuron methyl, and 2,4-D are more favoured by rice farmers (Bhullar *et al*., 2016). In India, it was observed that *Haltica cyanea Weber*, a gregarious metallic blue beetle feeds voraciously on the leaves and shoots of *Ammania* resulting in defoliation and death of the plants (Plate 1) (Padmakumari and Pasalu, 2004).

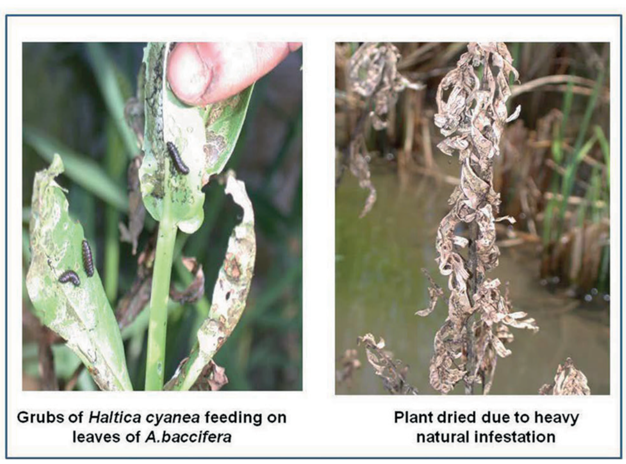

Plate. 1. Natural infestation of *Haltica cyanea* on *Ammania baccifera*

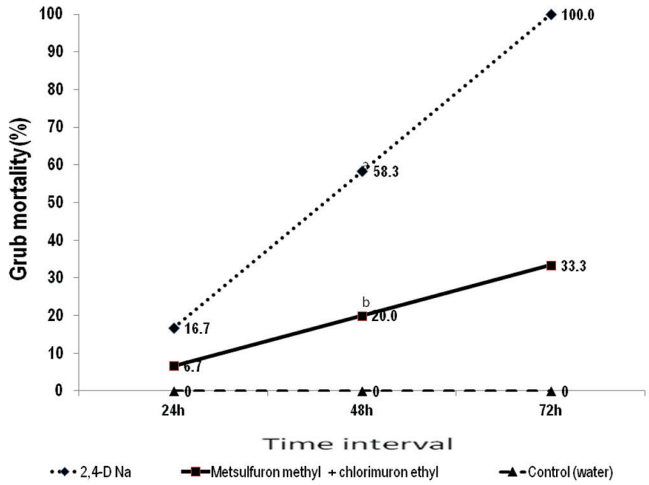

Fig. 1. Effect of herbicides on *Haltica cyanea* grubs.

This paper compares the weed control efficiency of the chrysomelid beetle, *H. cyanea* on *A. baccifera* with the two commonly used BLW herbicides in the rice ecosystem and their effect on the biocontrol agent.

MATERIALS AND METHODS

The two selective and systemic post emergent herbicides were chosen for the study were 1) 2, 4 D- Na salt 80% (Fernaxone®) an auxin mimic" applied @ 800g a.i/ha (prepared by dissolving 2 g of 2,4-D Na in 1L distilled water and 2) Metsulfuron methyl 10% + chlorimuron ethyl of sulfonylurea group (henceforth referred to as MM+CE)10% WP (Almix®) @ 4 ga.i/ha, and (0.04g of MM+CE weighed and mixed in 1 L of distilled prepared by adding water). The herbicides were tested for their weed control efficiency at the above specified field application rates along with grubs of *Haltica cyanea.*

Leaf dip method

The experiment was done on grubs collected from the field. *Ammania baccifera* leaves of similar size were collected. The leaves were dipped in 2,4-D Na, MM+CE, control (water) and then placed on blotting paper for air dry. After air drying 10 leaves were transferred into Petri-plates with the help of forceps. Each treatment comprised of 10 leaves in a Petri-plate as a replication and there were 8 replications. After that 3 equal size of blue beetle larvae were released into each replication. Observations on grub mortality was recorded at 24h, 48h and 72h and expressed as percent dead grubs. Whenever the feed was changed the larvae were fed on respective treated leaves.In a separate set, similar treatments were maintained but no insects were released.

Pot method

In this method, the study was taken up in pots for two season *kharif* 2017 and *kharif* 2018 where in plants of *Ammania* were grown.

Kharif 2017

In each pot, plants of *Ammania* were grown. Each pot was divided into two halves and plants were enclosed in a mylar sheet and 2,4 D Na treatments were applied to one half and the other half was left as control. After the spray dried, 10 field collected grubs were released. Similarly, grubs were also released in unsprayed area and an untreated control was maintained. The experiment was conducted with 4 treatments and 5 replications. The time taken for drying was also observed. The plants were uprooted; shoots and roots were collected separately, dried and weighed. Observations on the amount of weed biomass fed by the larvae were quantified in each treatment. The weed control efficiency was calculated by the following formula: (shoot weight in control-shoot weight in the treatment) $\times$ 100 / shoot weight in control. Data was analysed by completely randomized design (CRD). -ANOVA.

Kharif 2018

Ammania plants were grown in pots @ 5 plants per pot. After 4 days when the transplanted plants were healthy, recommended dose of herbicides were sprayed along with an untreated control (water). Then one set of treatment were infested with the grubs and another set of treatments was maintained without insect to discern the effect of the herbicides alone. When the plants started drying the shoot weight of the plants in each treatment was taken and analyzed by ANOVA and weed control efficiency was calculated by the above formula.

In a separate sub set of experiment the plants in each treatment were infested with 3 eggs/plant/pot on the treated plants. In all, there were 3 treatments and 8 replications per treatment. Observations on the biology of the insect were recorded.

RESULTS AND DISCUSSION

Leaf dip method

The effect of herbicides on the grubs is depicted in Fig. 1. When fed on MM+CE treated leaves there was a gradual increase in the mortality of the larva from 6.7% at 24h to 33.3% at 72h as compared to control where there was no mortality of the grubs. In 2,4 D Na treated leaves 100% mortality was observed at 72h. A slight drying was observed in the MM+CE treated leaves though they were green in the control treatment. But 72h after treatment, leaves treated with 2,4 D- Na turned black and larval mortality could be due to both toxic effect of the herbicide and non availability of fresh feed.

Pot studies

Kharif 2017

It was observed that the treatments had no significant effect on the roots. The results in Fig. 2 clearly suggest that the treatment with only larvae could reduce the shoot weight by half of that in the control treatment (F val 4.14; p=0.032). It was also evident that there's no significant difference in the shoot weight in the treatment where grubs were released along with 2,4 D Na treated plants and only 2,4 D Na treated plants. Our study revealed that for the same amount of shoot biomass 2,4 D Na resulted in drying in 3 days where as grubs could devour in 6 days. This implies that the grubs are potential weed control agents but may take more time in devouring the plants but 2,4 D Na affects the feeding of the weed by the grubs. Fig. 3 depicts the weed control efficiency of the various treatments and it is evident that the efficiency by the grubs was 59.8% as compared to 2,4 D Na+ grubs (80.3%) or 2,4 D Na alone suggesting that 2,4 D Na (80.7%) had deleterious effect on the grubs.

Kharif 2018

Fig. 4 and Table 1 depicts the interaction of herbicide treatments with and without larvae and the individual effect of each of the treatments. All the herbicide treatments were superior to control and the treatment where only larvae were released. The weed control efficiency was 47.5% for 2,4 D Na, 38.5% for MM+CE and 21.7% grubs of *Haltica cyanea.* The weed control efficiency of the herbicide was not significantly different from that of Herbicide + larvae treatment suggesting that the herbicides affected the feeding of the weed by the grubs (Table 1).

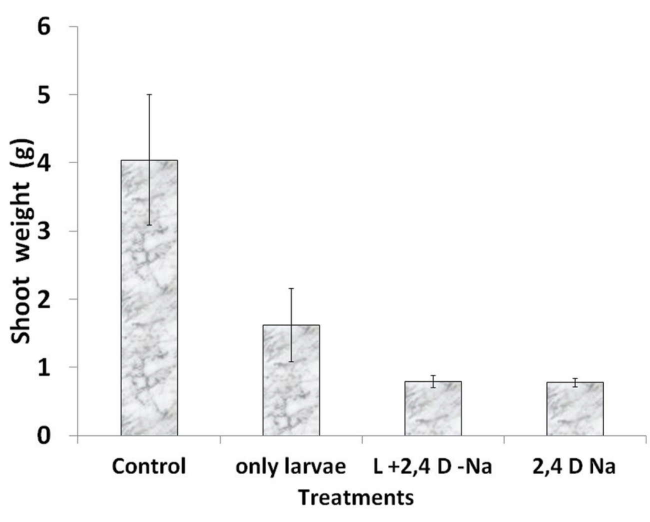

Fig. 2. Effect of 2, 4 D Na and *Haltica cyanea* on *Ammania baccifera.*

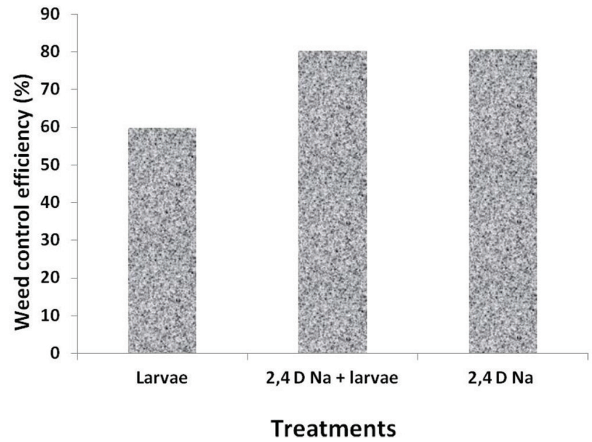

Fig. 3. Comparison of weed control efficiency of 2,4 D Na with grubs of *Haltica cyanea.*

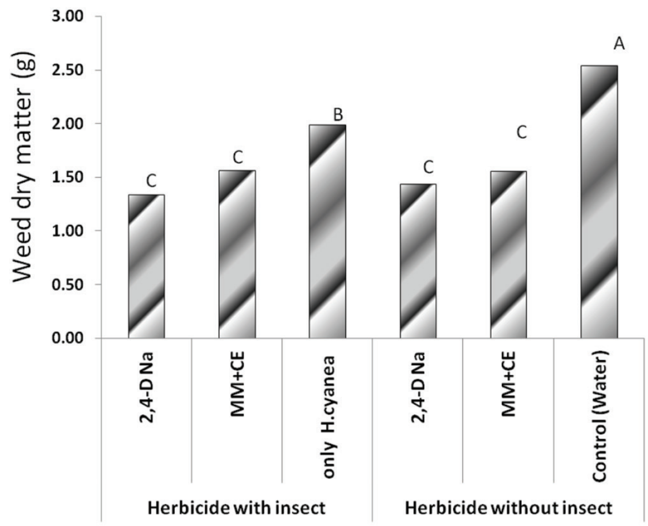

Fig. 4. Effect of herbicides on *Ammania baccifera* in comparison to *Haltica cyanea.*
(Bars followed by same letter are not significantly different from each other)

Table 1. Interaction of herbicide treatments with and without larvae and the individual effect of each of the treatments.

	DF	F	P	SEM	sig
With and without insects (Main treatments)	1	11.04	0.0293	0.05	*
Individual treatments and larvae (sub treatment)	2	83.27	0	0.05	**
Main ×sub	2	8.34	0.003	0.0721	***

Effect on the biology of *Haltica cyanea*

Each adult female on an average laid 177.4 eggs in 5 days. Eggs are yellow in colour and laid in groups of 18-70 eggs with a mean of 35.5 eggs/day per female. Larval period is 8 days, 10 days pupal period, adult longevity was 15 days for 69.3 % insects and 16 days for 30.7 %. Egg period was 4 days and both the herbicide treatments did not affect the egg laying. But hatching and larval development was drastically

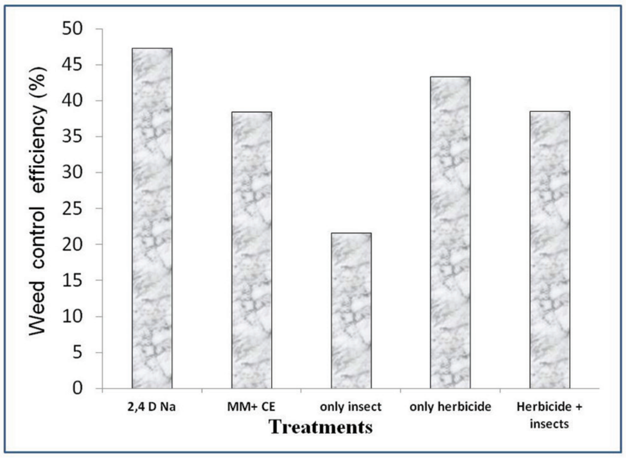

Fig. 5. Weed control efficiency of various treatments on *Ammania baccifera.*

affected. Though the larvae hatched from the treated plants they did not survive for long. Precocious development was observed when mature larvae were exposed to plants in MM+CE and few larvae became adults.

Our study concludes that the weed control efficiency of *H. cyanea* is 21.7 % to 59.6 % on *A. baccifera*. It can serve as a good biocontrol agent for control of *A. baccifera.* Both the herbicides were superior to the biocontrol agent in controlling the weed. Both the herbicides did not inhibit the egg lying on the treated plants but affected the neonate grubs. Upto 24h after spraying, the older grubs could feed on the leaves. Plants sprayed with 2, 4 D - Na dried faster as compared to MM+CE. MM+CE was safer to the beetle as compared to 2, 4 D-Na. As the plants sprayed with 2, 4 D- Na dried fast there would be no feed for the beetle to survive, thus affecting the habitat of *H. cyanea*. 2, 4 D- Na and MM+CE affected the biology of the insect.

Haltica cyanea has a wide host range. In rice ecosystem, *H. cyanea* is reported to feed on weeds like *Ludwigia, Ammania* sp. *and Rotala* sp. Though they are gregarious on rice and *Cyperus*, they do not feed on them. It was also reported to feed on *Melastomamalabaricum, Eupatorium odoratum, Jussia earepens* (Nayek and Banerjee, 1987; Mitra *et al*., 2017; Nayan Roy, 2018) and the biocontrol potential of *Haltica* on *Ludwigia adescendens* is well proven through various studies (Xiao-Shui, 1990). Studies also suggest that *Zircona caerulea* is a predator of this grub in the rice ecosystem.

Hence while deploying it as a biocotrol agent, the reports of natural parasites and predators may be taken note of along with the weed species, intensity and distribution and no herbicide may be sprayed so as to achieve maximum success as a biocontrol agent.

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