ACTA SCIENTIFIC MICROBIOLOGY (ISSN: 2581-3226)

Volume 2 Issue 9 September 2019

Research Article

Management of Glyphosate-Resistant *Chloris Virgata* Grass in Mung Bean Using Crop Competition

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Received: August 06, 2019; **Published:** August 19, 2019

DOI: 10.31080/ASMI.2019.02.0345

Abstract

Chloris virgata, a glyphosate-resistant grass has been identified as a major weed problem in central Queensland and northern New South Wales. It was hypothesised that mung bean as a crop competitor would suppress *Chloris virgata*. For this purpose, pot experiments were established for two seasons in a glasshouse. Phenology aspects of both mung bean and *Chloris virgata* were studied in the field. The current study results indicated *Chloris virgata* biomass of 43-48 g dry weight in both seasons was significantly reduced by 74% when surrounded by 5-6 mung bean plants. Phenology aspects showed a different growth pattern of *Chloris virgata* when surrounded by six mung bean plants spaced 25 cm apart. Our recommendation to farmers facing the problem of *Chloris virgata* is to sow mung bean plants 25 cm apart to suppress *Chloris virgata* in Australian conditions.

Keywords: Suppression; Biomass; Phenology; Annual Grass; Density; Row Spacing; Light

Introduction

Feathertop Rhodes grass (*Chloris virgata*) a native of North America, a major weed in cotton (*Gossypium hirsutum*) in the subtropical region of Australia has been found to be an emerging weed problem in central Queensland and northern New South Wales (NSW), Australia [1]. The major reason for this problem has been suggested to be the adoption of zero tillage practices and tolerance of *Chloris virgata* to glyphosate, a widely used systemic herbicide [1]. Across Australia, *Chloris virgata* cause yield losses in all crops of about 39,329 tonnes with a revenue loss of $7.7 m [2].

Crop competition involves the application of agronomic practices to suppress weed growth, including high crop density, weed competitive cultivars and high seeding rates [3]. These practices are under-exploited, but if used properly, are environmentally benign weed management strategies [4]. Crop density or the number of plants per unit of area is an important decision for competition studies considering the relationship among plant yield and the number of individuals and resources present in an area [5,6]. An increase in plant density can increase the competitive ability of the crop [7]. Along with plant density, narrow row spacing can increase light interception by crops with a reduction in weed biomass and a consequent increase in crop yield [8].

Mung bean (*Vigna radiata*) is cultivated as a grain legume in central Queensland and northern New South Wales in Australia [9]. Approximately 95% of the total mung bean production in Australia is exported to various countries like India, Vietnam, Philippines and China [9]. Mung bean is generally grown with a wide row spacing of 1per meter in central and southern Queensland and Northern New South Wales [9]. In a crop like mung bean, narrow row spacings (25 and 50 cm) lowered, weed biomass with a consequent increase in grain yield of mung bean [9]. There is no information in the literature of using crop competition for *Chloris virgata* control. I hypothesised that mung bean would suppress *Chloris virgata* growth and my experiments had following objectives (i) to study the crop competition between mung bean and *Chloris virgata* grass and (ii) the effect of different densities of mung bean on *Chloris virgata* growth.

Materials and Methods

Glasshouse studies were established in two seasons at the GRDC glasshouse complex, International Grains Research Centre, Narrabri, Australia.

Experimental methodology

The pot experiment for *Chloris virgata* and mung bean was established on January 31, 2017, and repeated on November 27, 2017, with the same species and densities. The seeds of *Chloris virgata* were brought from Osten weeds consulting (Emerald, QLD, 4720). Seeds of both *Chloris virgata* and mung bean were sown in plastic trays filled with potting mix (Searles premium potting mix

65 L). The potting mix was composed of organic compost, peat, zeolite and trace elements. Minimum and maximum temperatures during the period of experiments were 20^{0}C and 35^{0}C, respectively. Ten days after sowing the two-leaf plants were transplanted to pots (26 cm length x 28 cm width x 26 cm height) filled with potting mix. Mung bean and *Chloris virgata* were co-established by using a seeding template in order to eliminate size biases [10-13]. The density treatments [mung bean plants- 0-6 plants m-2; *Chloris virgata* plants- 0-1 plants m-2) were arranged in a target neighbour design. The target neighbour design is an additive design in which one of the competing species is represented by a single individual (the target, *Chloris virgata*) and the density of surrounding individuals (the neighbours, mung bean) is manipulated [14]. The density of the target species was reduced to a single individual to preclude significant intraspecific interactions [14].

Glasshouse study-measurements

For pot experiments, measurements included plant height (from the soil surface to the tip of the uppermost outstretched leaf) and the number of leaves per plant. Measurements were taken weekly for the entire season. Waterings were done as per the moisture meter. The moisture meter/ hygrometer had a scale (1-10 cm) with three different ranges (Dry, Moist, and Wet). The probe tip of the moisture meter was inserted into the root zone (10 mm) to measure soil moisture. If the probe indicated a moisture level of dry or moist, lots of frequent watering were done to reduce run-off. Plants were watered up to the wet range. At the end of the experiment, aboveground biomass of all the plants was harvested and their dry weights were recorded. The plants were dried at 70°C for 48 hours in a dehydrator (Sterdium, Micro digital).

Phenology aspects

To study phenology aspects 6 mung bean plants (3 in each row with a plant to plant distance of 10 cm) and 1 *Chloris virgata* plant were co-established in the field with three replications by hand following the same transplanting procedure outlined above for the glasshouse. Mung bean plants were transplanted by hand in rows 25 cm apart with a plant to plant spacing of 10 cm based on a previous study [9] with *Chloris virgata* plant at the centre between the rows on November 23, 2017, and harvested on January 26, 2018. For control treatments, *Chloris virgata* plants were not surrounded by mung bean plants. The root and shoot biomass of both mung bean and *Chloris virgata* plants were recorded by a scale and assessment of seed parameters (length of spikelet, seeds in each spikelet by manual counting, and the total weight of spikelet for *Chloris virgata* plant were completed with a scale. The roots of both mung bean and *Chloris virgata* plants were excavated manually by spade. The roots after collection were washed and dried for the assessment of root weights separately for both mungbean and *Chloris virgata* plants.

Results

Biomass of Chloris virgata, Feathertop Rhodes (FTR)

There was a significant reduction in *Chloris virgata* biomass in the glasshouse when surrounded by 5 or 6 mung bean plants (Figure 1 and Figure 2).

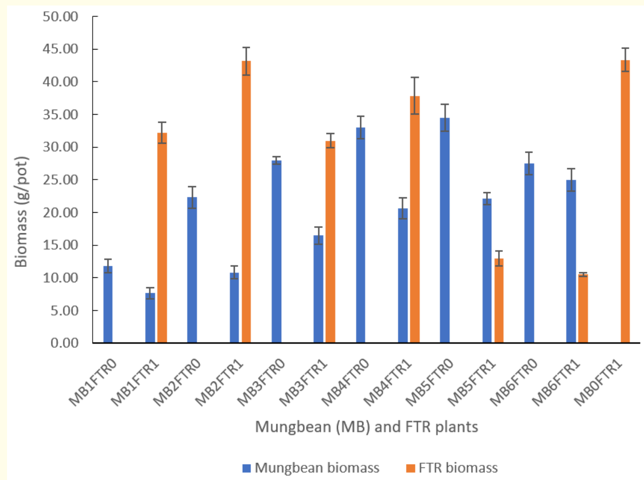

Figure 1: Mung bean (MB) and FTR biomass in the January of the 2016-2017 season.

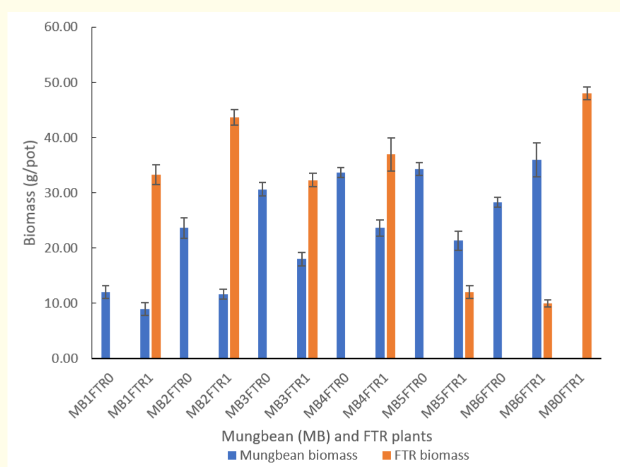

Figure 2: Mung bean (MB) and FTR biomass in the January of the 2017-2018 season.

Error bars represent ± standard errors of the mean (n=3). The treatment abbreviations on the horizontal axis refer to MB (mung bean density; 0,1,2,3,4,5,6) and FTR (Feathertop Rhodes density; 0 and 1) in the glasshouse experiment

Error bars represent ± standard errors of the mean (n = 3). The treatment abbreviations on the horizontal axis refer to MB (mung bean density; 0,1,2,3,4,5,6) and FTR (Feathertop Rhodes density; 0 and 1) in the glasshouse experiment *Chloris virgata* was of 43-48g dry weight in both seasons, which was significantly reduced by 74% when surrounded by 5-6 mung bean plants. (Figure 1, Figure 2). Our findings demonstrated that *Chloris virgata* can be suppressed at higher densities of mung bean.

The number of leaves per mung bean and FTR plants

The number of leaves of *Chloris virgata* per plant were decreased 36-48% after 21 days but only in treatments with 5 and 6 mung bean plants (Table 1). There was no reduction in the number of leaves over time in other treatments. The maximum number of *Chloris virgata* leaves after 42 days were 13 when surrounded by 6 mung bean plants. The plausible reason was the greater competition from more mung bean plants that resulted in reduced resource acquisition and leaf production by *Chloris virgata.*

Leaves (no. plant^{-1})										
Treatment (No. of plants - 0,1,2,3,4,5,6)	7 Days		14 Days		21 Days		28 Days		42 Days	
	MB	FTR	MB	FTR	MB	FTR	MB	FTR	MB	FTR
MB1FTR0	2	0	5	0	11	0	17	0	17	0
MB1FTR1	2	2	5	11	10	26	15	59	15	59
MB2FTR0	2	0	5	0	11	0	16	0	16	0
MB2FTR1	2	2	5	10	10	26	15	51	15	51
MB3FTR0	2	0	5	0	11	0	14	0	14	0
MB3FTR1	2	2	5	9	9	24	11	58	11	58
MB4FTR0	2	0	5	0	9	0	13	0	13	0
MB4FTR1	2	2	5	9	10	23	12	37	12	37
MB5FTR0	2	0	5	0	9	0	12	0	12	0
MB5FTR1	2	2	5	8	8	16	12	16	12	16
MB6FTR0	2	0	5	0	8	0	12	0	12	0
MB6FTR1	2	2	5	7	7	13	12	13	12	13
MB0FTR1	0	2	0	17	0	25	0	60	0	60
SEs	(± 0.32)	(± 0.33)	(± 0.58)	(± 0.64)	(± 0.58)	(± 0.51)	(± 0.64)	(± 0.54)	(± 0.75)	(± 0.80)

Table 1: The number of leaves per plant for mung bean (MB) and Feathertop Rhodes (FTR) in two glasshouse experiments. SE (±) values represent standard errors with n=3.

The height of mung bean and FTR plants

In comparison to the control, a 32% reduction in height in *Chloris virgata* when surrounded by five or six mung bean plants at day 42 was observed (Table 2). This pattern of *Chloris virgata* was similar to that of spiny amaranth weed, the height of which was suppressed due to a higher density of rice plants [15].

Seed production of Chloris virgata (FTR)

Phenology aspects in the field indicated that on an average, the length of Chloris virgata spikelet was 7.9 cm (Table 3) when there was no mung bean competition.

Chloris virgata produced two spikelets without competition, whereas, in competition with 6 plants, Chloris virgata produced no spikelets (Table 3). Weed seed production is an important aspect with respect to Chloris virgata from the sustainability point of view and any practice reducing the weed seed input to the soil seed bank can contribute substantially towards weed management approach related to the control of Chloris virgate [16].

The growth pattern of Chloris virgata, when grown alone in the phenology study was different from more vertical growth of Chloris virgata when surrounded by mung bean plants (Figure 3, Figure 4).

Plant Height (cm)										
Treatment (No. of plants -0,1,2,3,4,5,6)	7 Days		14 Days		21 Days		28 Days		42 Days	
	MB	FTR	MB	FTR	MB	FTR	MB	FTR	MB	FTR
MB1FTR0	9.3	0.0	22.0	0.0	36.7	0.0	66.3	0.0	72.3	0.0
MB1FTR1	9.0	25.3	19.3	45.0	34.7	67.7	48.0	127.6	67.7	115.0
MB2FTR0	9.3	0.0	19.3	0.0	35.7	0.0	48.3	0.0	71.0	0.0
MB2FTR1	8.7	24.1	15.3	41.7	35.3	62.7	42.3	112.7	59.3	110.0
MB3FTR0	9.0	0.0	17.0	0.0	34.0	0.0	40.7	0.0	70.0	0.0
MB3FTR1	8.7	21.3	15.3	39.0	33.0	60.0	33.3	105.7	56.0	98.0
MB4FTR0	8.0	0.0	18.7	0.0	33.7	0.0	42.0	0.0	64.0	0.0
MB4FTR1	7.7	18.0	15.0	38.0	33.0	53.7	37.7	84.0	57.0	97.3
MB5FTR0	9.3	0.0	18.0	0.0	34.7	0.0	36.0	0.0	62.0	0.0
MB5FTR1	8.1	17.0	16.5	35.3	34.0	52.0	35.7	67.0	58.0	90.0
MB6FTR0	8.0	0.0	18.0	0.0	27.0	0.0	35.7	0.0	50.3	0.0
MB6FTR1	7.5	17.0	16.0	34.3	26.3	61.0	35.0	64.0	47.0	89.0
MB0FTR1	0.0	17.0	0.0	36.0	0.0	65.7	0.0	127.7	0.0	131.3
SEs	(± 0.33)	(± 0.29)	(± 0.58)	(± 0.80)	(± 0.58)	(± 0.58)	(± 0.33)	(± 0.80)	(± 0.33)	(± 0.36)

Table 2: Mean plant height (cm) for mung bean (MB) and Feathertop Rhodes (FTR) averaged over two glasshouse experiments. SE (±) values represent standard errors with n=3.

Treatment	Shoot weight (g)	Root weight (g)	Length of spikelet (cm)	Seeds in spikelet	Total weight of spikelet (g)
With competition	9.6 (±0.15)	0.6 (±0.01)	No spikelet	No spikelet	No spikelet
Without competition	68.0 (±0.15)	1 (±0.05)	7.9 (±0.05)	1806 (±0.85)	1.2 (±0.02)

Table 3: Shoot, root and seed parameters of *Chloris virgata* (FTR) grass with and without competition with mung bean for the phenology aspects. The numbers in the parentheses are the standard error of the mean (n=3).

The vertical growth of *Chloris virgata* in competition with mung bean plants represents an adaptation. Due to shading of mung bean plants, *Chloris virgata*, showed more upright growth to capture sunlight. When surrounded by 6 mung bean plants, the average *Chloris virgata* root biomass decreased by 40 percent and shoot biomass decreased by over 85 percent (Table 3).

Figure 3: *Chloris virgata* plant (Left) without removal of mung bean

Figure 4: The reduction in biomass of *Chloris virgata* plant (Left) after removal of mung bean plants. The *Chloris virgata* plant on the left is now exposed after the six mung bean plants have been removed.

Figure 5: Roots of mung bean (Left) and *Chloris virgata* plant (Right) from the field excavation to study phenology aspects..

Similarly, in competition with mung bean plants, the *Chloris virgata* average shoot weight reduced about seven times (Table 3) due to competition effect.

It can be inferred from the phenology aspects that high root and shoot weights of mung bean resulted in the suppression of *Chloris virgata*.

Discussion

An increase in mung bean density was found to be the reason of suppression of *Chloris virgata* population. The role of plant density of crop species has also been observed in previous studies to suppress weed species [17-19]. Increased beet density has been found to increase beet plant capacity to suppress weeds [20]. Under drought stress, *Cyperus rotundus* was observed to be a superior competitor to mung bean, while Eleusine indica and Synedrella nodiflora were inferior [21], however, no information related to *Chloris virgata* has been observed [22].

High- density crop plants can result in the reduction of water and nutrient availability to weeds more effectively than a low- density crop [6]. It is likely that the major reason for the reduction in biomass of *Chloris virgata* was greater shoot and root biomass of mung bean planted at higher density. The finding is valuable in case of suppression of annual grass weeds like *Chloris virgata*. We advocate the option of crop competition to farmers, as it is environmentally friendly and does not require a significant increase in the cost of production [4].

Acknowledgements

Authors deeply appreciate funding in the form of USydIS (University of Sydney International Scholarship) (Student Id- 440059389) from the University of Sydney and project support from IA Watson Grains Research Centre, Narrabri.

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