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Effect of multiple mechanical weeding on growth and yield under flooded rice cultivation with zero-chemical

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Abstract

Use of excessive chemicals in agriculture becomes a serious concern for food safety and healthy ecosystem. One of the alternatives for the use of herbicide in rice cultivation is mechanical weeding. Studies were conducted from 2011 in order to elucidate the effect of multiple mechanical weeding on rice growth and yield without chemical use in the same field at the University farm, Maha-Illuppallama, Sri Lanka. The number of weeding sessions were 0 (No weeding as control), 4 and 8 times from transplanting to panicle initiation. Multiple weeding showed higher plant growth and yield compared to the zero weeding. The average number of panicle/m^2 at 30 x 30 cm plant spacing was 97, 150 and 182 in 0, 4 and 8 times weeding, respectively. The average yield was 1.79, 4.26 and 4.68 t/ha in 0, 4 and 8 times weeding, respectively. Shallow and deep water ponding did not show a significant difference in yield at 8 times weeding in the following season. It was found that the biomass is continuously accumulated at soil surface and intermittently turned down to sub layer and the subsoil was brought back to surface by mechanical weeding. Repeated mechanical mixing might have enhanced the nutrient availability and yield.

Keywords: ecosystem, mechanical weeding, no-chemical farming, rice cultivation

INTRODUCTION

Agrochemicals have been used intensively in rice farming to obtain high yield. However, in long run, this practice leads to negative impacts on public health, environment, ecosystem and costs of production. A new trend on reducing agrochemical usage with the application organic fertilizers became a hot topic among the farmers as well as policymakers. The government of Sri Lanka started its campaign to make Sri Lanka a 'Wasa visa nathi' (poison free) country by gradually switching from agro-chemicals to organic fertilizer due to the threats on public health and the ecosystem (Colombo Page, 2012; Daily mirror editorial, 2016). Most recently, glyphosate (a herbicide) was banned in Sri Lanka to avoid potential health risks (Daily News, 2015). However, alternatives and economical incentives are needed to sustain rice farming with minimum environmental effects.

Fertilizers, herbicides and pesticides are used to provide nutrients, suppress the weeds growth and control pest attacks, respectively. There is a need to find alternatives or strategies to minimize the use of chemical without compromising the yield. There is a growing interest on adopting traditional knowledge and wisdom in ensuring the effective utilization of the natural ecosystem components and processes in rice farming (Diaz et al., 2015). Although the implementation of the traditional practices in the modern context is debatable, the concept can still be used in solving the current problem.

One of the alternatives for herbicides in rice cultivation is manual or mechanical weeding. Manual weeding is preferred traditionally because of the movement of workers in the field probably facilitates soil mixing. On the other hand due to shortage of workers,

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mechanical weeding has been practiced, not only for weed control but also for turning of soil. Turning of soil may improve the soil fertility. Therefore, a study was conducted to elucidate the effects of multiple mechanical weeding on rice growth and yield with no use of herbicides, fertilizer and pesticides.

MATERIALS AND METHODS

A study was conducted in the university farm at Maha-illuppallama Sub Campus, Sri Lanka (08° 5' 52" N, 80° 26' 38" E) in three seasons (*Maha* 2011/2012, *Maha* 2012/2013, and *Maha* 2013/2014). Rice is cultivated in two seasons per year namely; *Maha* and *Yala* which are synonymous with two monsoons in Sri Lanka. Maha Season falls during "North-East monsoon" from September to March in the following year. *Yala* season is effective during the period from May to end of August.

Rectangular plots with a size of 10 x 5 m were used. After the conventional land preparation, rice (BG 352 - 105 days old variety) was transplanted. Table 1 shows the treatment combination with plant spacing, number of weeding session, type of weeding and depth of ponded water. In *Maha* 2011/12, two plant spacing; 30 x 30 and 30 x 16 cm were tested. The number of weeding sessions were 0 (No weeding as control), 4 and 8 times from transplanting to panicle initiation. A 'Cono' weeder was used for weeding.

In *Maha* 2012/13, two levels of water management, shallow (WM1: 5-10 cm) and deep (WM2: 10-15cm), were tested with selected number of weeding session from the results of previous season. In *Maha* 2013/14, the mechanical weeding was compared with hand weeding in order to verify the effect of soil mixing. Weeds were manually removed without much disturbance to the soil in hand weeding.

Table 1. Cultivation seasons and treatments.

Season	Treatment	Plant spacing	Weeding session	Type of weeding	Depth of water
Maha 2011/2012	T1	30 x 30 cm	4 times	Mechanical	5-10 cm
	T2	30 x 30 cm	8 times	Mechanical	5-10 cm
	T3	30 x 16 cm	4 times	Mechanical	5-10 cm
	T4 Control	30 x 16 cm	8 times	Mechanical	5-10 cm
		30 x 30 cm	0 times	-	5-10 cm
Maha 2012/2013	WM1	30 x 30 cm	8 times	Mechanical	5-10 cm,
	WM2	30 x 30 cm	8 times	Mechanical	10-15 cm
Maha 2013/2014	MW	30 x 30 cm	8 times	Mechanical	5-10 cm
	HW	30 x 30 cm	8 times	Hand	5-10 cm

Plant height, number of tillers and number of panicles were measured weekly for randomly selected plants in the experimental plots. The yield of the plots was measured at the end of the experiment. Temperatures in air, water layer, soil surface and at 2 cm below the soil surface were measured in *Maha* 2012/2013. Data were analysed for mean comparison and two sample t-test using SAS software.

RESULTS AND DISCUSSION

Plant growth and yield under different weeding sessions and plant spacing

Figure 1 and 2 show plant height and number of tillers with time in different treatments and control. Figure 3 shows the number of panicle per hill at the maturity stage of the crop. The differences between treatments were evident in the later stages of the crop. Plant height and number of tillers was higher in mechanical weeding compared to zero weeding (control).

Table 2 shows the panicle numbers per square meter and the grain yield. A significant difference (α=0.05) was observed among the treatments and control. Higher panicle number per unit area and yield were obtained at the combination of higher number of weeding session and large spacing. The average number of panicle/m^2 was 150 and 182 in 4 and 8

times weeding, respectively in 30 x 30 cm spacing. Higher the weeding sessions, higher the number of panicles and yield obtained regardless of the difference in spacing. However, higher spacing has facilitated the tillering under mechanical weeding probably due to less stress to the roots.

Figure 4 compares the yield under this study with conventional farming in the adjacent area using agrochemical. The yield under conventional farming was 5.85 t/ha. Although high yield was obtained in the conventional method, the cost effectiveness in the mechanical weeding cultivation is better.

Sedges and broad leaf weeds were found in the field. All the weeds found between the rows were turned into the soil by mechanical weeding. The weeds within the rows were not removed.

The yield variation under mechanical weeding could have been due to the in-situ assimilation and mineralization of nutrients by microbial activity which is induced by soil turning. The primary production (Organic matter accumulation) and mineralization in the floodwater in paddy field occurs due to the photosynthetic activities by autotrophic community. Mowjood and Kasubuchi (2002) also have shown that dissolved oxygen in the floodwater in paddy field is higher than saturated level in the day time. Therefore, the primary production and subsequent soil turning might have enhanced microbial activities by alternative anaerobic and aerobic processes.

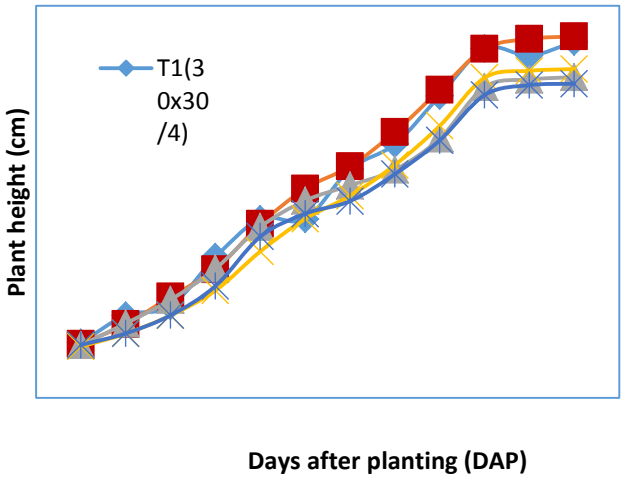

Figure 1. Plant height with days after planting (DAP) - *Maha* 2011/12.

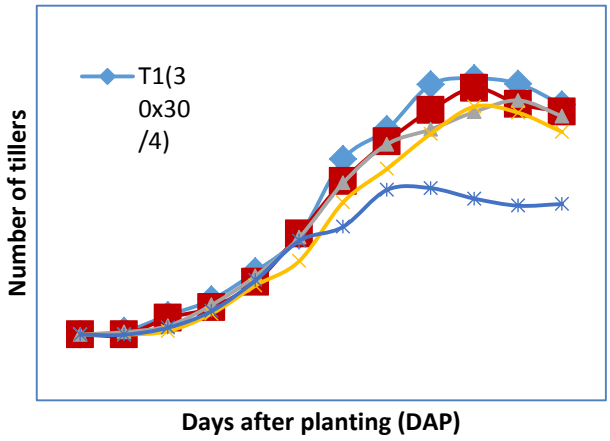

Figure 2. Number of tillers with days after planting (DAP) - *Maha* 2011/12.

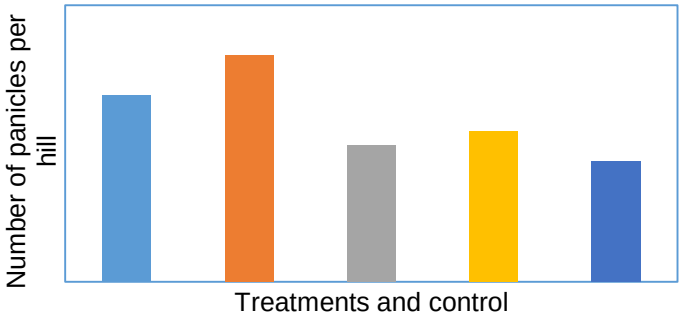

Figure 3. Average number of panicles per hill in *Maha* 2011/12.

Table 2. Panicle numbers and yield from different treatment in *Maha* 2011/12.

Treatment	T1	T2	T3	T4	Control
Panicles/m^2	150^b	182^a	110^d	121^c	97^e
Yield (t/ha)	4.26^c	4.68^d	3.39^a	3.70^b	1.79^e

Mean with same letters for each tested parameters are not significantly different at α=0.05

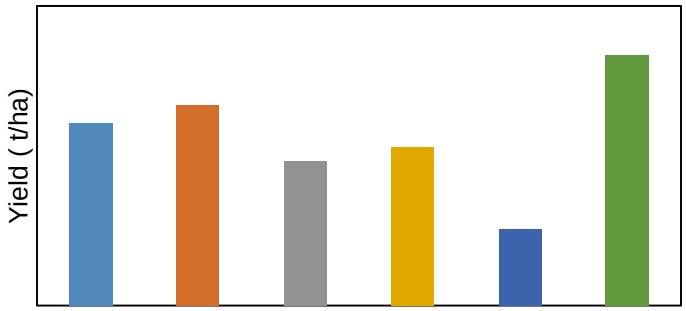

Figure 4. Rice yield under different treatments and conventional cultivation (*Maha* 2011/12).

Plant growth and yield with mechanical weeding and water management

The effect of depth of ponded water, shallow (WM1) and deep (WM2) were studied with 8 times weeding sessions which was found to be the best during the previous season. Growth performance was not significantly different between shallow and deep water depths as shown in Table 3. However, the temperature including at the soil in the deep water shows higher than that in the shallow water (Figure 5). High temperature can cause higher biological activity. However, this was not clear in this season.

Table 3. Average plant height (cm) under shallow (WM1: 5 -10 cm) and deep water (WM2: 10 – 15 cm) management.

Days After Planting	WM1	WM2
7	10.13	10.01
16	14.94	14.75
30	29.54	28.24
44	32.54	31.51
58	59.69	61.57
72	79.92	80.48
87	74.51	75.62

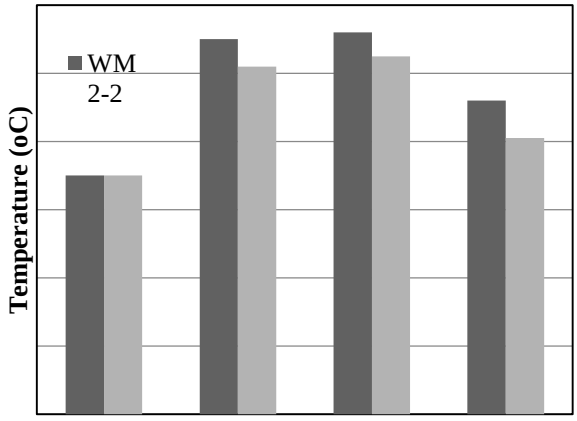

Figure 5. Temperature in shallow (WM1) and deep water (WM2).

Table 4 shows the yields obtained with shallow and deep ponded water. Very low yield was obtained in *Maha* 2012/2013 compared to the previous season due to pest attack (paddy bug). The weight of chaff (un-filled grain) was high in all the plots due to the pest.

Table 4. Average yields per plots under different depth of ponded water.

	WM-1(5 -10 cm)		WM-2(10 – 15 cm)	
Plot no.	Grain (kg)	Chaff (kg)	Grain (kg)	Chaff (kg)
1	4.95	1.05	2.6	1.9
2	2.05	1.75	2.85	1.75
3	1.1	1.1	2.05	2.15
4	1.2	1.4	0.85	0.85
5	0.75	0.65	0.95	1.25
Yield(t/ha)	0.40		0.37	

Plant Growth and Yield with Mechanical and Hand Weeding

The previous experiment showed that multiple mechanical weeding had a significant effect on plant height, number of tillers, panicles and yield. The reasons as mentioned before could be due to mixing of the topsoil or less weed competition or both. In order to verify this, mechanical weeding was compared with hand weeding. Weeds were removed carefully without much disturbance to the soil. Tillers per hill and yield per plot were higher in the plots where mechanical weeder was used compared to hand weeding (Table 5).

The topsoil (5-7 cm) was loose in mechanical weeding, while it was compacted in hand weeding. Birds frequently visited the plots when soil mixing was done using mechanical weeder. This reveals that the ecosystem is in a state of balance, although it was not quantified in this season. The study is being continued.

Table 5. Average tillers and yield under mechanical weeding (MW) and hand weeding (HW).

Plot no.	MW	HW
1	13.3	10.0
2	7.7	6.7
3	11.3	11.4
4	12.9	12.3
5	9.7	12.4
Yield (t/ha)	2.19	2.11

CONCLUSIONS

The following conclusions can be drawn from the study:

- Multiple mechanical weeding led to higher plant growth and yield compared to zero weeding.
- The number of panicle/m^2 was 97, 150 and 182 in 0, 4 and 8 time weeding sessions, respectively with 30 x30 cm plant spacing.
- The average yield was 1.79, 4.26 and 4.68 t/ha in 0, 4 and 8 time weeding sessions, respectively.
- High frequency mechanical weeding and large spacing combination gave better result.
- Shallow and deep water ponding did not show a significant difference in yield at 8 times weeding in the following season.
- Biomass is accumulated at soil surface and intermittently turned down to sub layer and subsoil was brought to surfaceby mechanical weeding.
- Repeated soil turning might have enhanced the nutrient availability to the plant, consequently the yield. The study is being continued.

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