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Novel wiper device for the management of weedy rice

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ABSTRACT

The research programme undertaken at Rice Research Station, Moncompu, Kerala Agricultural University, for the post-emergence management of weedy rice by direct contact application (DCA) of broad-spectrum non-selective herbicides using specially designed novel hand held weed wiper device could selectively dry the panicles of weedy rice at 60-65 DAS, taking advantage of the height difference of 15-20 cm between weedy rice and cultivated rice. The study revealed that DCA can be effectively done in weedy rice infested cropped field using non-selective herbicides, *viz*. glufosinate ammonium, paraquat dichloride or glyphosate at 10-15% concentration. Weed control efficiency by this method in terms of drying of the weedy rice panicles was as high as 83 to 88%. The device has been filed for Indian Patent at Patent Office, Chennai (Application No. 1763/CHE/2014 dated 01.04.2014). The technology can reduce the seed rain and buildup of soil seed bank of weedy rice. It is highly energy efficient, less labour intensive, and eco-friendly compared to hand weeding, cutting of weedy rice ear heads or application of large quantity of herbicides using sprayers. The device has become popular among the farming community of Kerala and transfer of technology of the device was done during 2015. The product is now marketed as *'KAU Weed Wiper'* by M/s Raidco Ltd, for large scale manufacturing and sale to farmers

INTRODUCTION

Weedy rice (*Oryza sativa* f. *spontanea*) infestation has become a serious threat to global rice production. India has the earliest history of rice cultivation and introgression between perennial wild rice and cultivated rice, which has given rise to highly variable population of weedy/wild rice forms, including annuals and perennials (Chang *et al.* 1982 and Espinoza *et al.* 2005). Angiras and Singh (1985) observed that grains of weedy rice ripe earlier and less regularly than those of cultivated rice, and were extremely prone to shattering. This situation has forced many farmers to abandon the rice crop without harvesting and subsequently leave the field fallow. Heavy infestation of weedy rice and subsequent reduction in crop yield (50-70%) in rice fields of the country have become a threat to profitable rice production (Abraham *et al.* 2012). Management of weedy rice infestation is complex mainly because of its morphological similarities to cultivated rice making hand weeding ineffective. Lack of herbicides for selective control of weedy rice in cropped fields, seed shattering and variable seed dormancy lead to staggered germination of weedy rice (Abraham and Jose 2015). Direct contact application (DCA) of non-selective broad-spectrum post-emergent herbicides is a management strategy for the control of tall growing weeds in standing crop only with the help of specially designed applicators (Stroud and Kempen 1989).

Under the circumstances, a research programme was undertaken during 2013-15 for the post-emergence management of weedy rice by DCA of broad-spectrum herbicides taking advantage of the earliness in flowering and 15-20 cm height difference of weedy rice to cultivated rice. With this objective, a novel 'Weed Wiper Device' (WWD) was fabricated for doing DCA, for selective drying of weedy rice panicles and thus preventing the build-up of soil seed bank in weedy rice infested areas, its further spread and invasion.

MATERIALS AND METHODS

The research programme was undertaken during 2013-15 at Rice Research Station, Moncompu of Kerala Agricultural University. Design and fabrication of the equipment was done locally and the experiment on identifying the most efficient herbicide for DCA was conducted in farmers' fields in Kuttanad region during *Rabi* 2013-14 and *Kharif* 2014. For optimum development of the equipment, experiments were laid out. Variants of weedy rice and the cultivated species *Uma* were collected from different polders and observations were recorded.

To prevent the shattering of grains and build-up of soil seed bank, management of weedy rice by DCA was attempted. A new hand held WWD (**Figure 1**) was fabricated and the experimental trials on the post-emergence management of weedy rice using the device were done at KAU during 2013-15. The device consisted of a herbicide holding tank of five litre capacity, sprayer pump, 'U' shaped frame fitted with handle, 'U' shapped hose with 8 holes of 3 mm diametre, control valve, end cap, nozzle and cloth towel to smear the herbicide.

The prototype of the hand held WWD fabricated was tested for DCA at 60-65 DAS in infested cropped fields of Kuttanad region. The possibility of using weed wiper for DCA was assessed by counting the density of weedy rice plants, the height difference between the rice and weedy rice plants and days to 50 per cent flowering of weedy rice and rice plants. The efficiency of herbicides in selective drying of weedy rice panicles by DCA using the WWD was experimented using three broad-spectrum herbicides, glufosinate ammonium 15 SL, paraquat dichloride 24 SC or glyphosate 41 SL at 5-15 per cent concentration of the final formulated product. Rice variety '*Uma*' (MO 16) was used for field experimental studies. It is a medium duration, red, medium bold, non-lodging, high yielding rice with average yield of 7-8 t/ha.

RESULTS AND DISCUSSION

Design and fabrication of the WWD

Most of the herbicides currently available in the market do not function selectively against weedy rice without affecting cultivated rice in cropped field (Chen *et al*., 2004). Seed longevity was identified as a major characteristic of weedy rice population and management to reduce the size of the buried weed seed bank was suggested to be equally important (California Department of Food and Agriculture, 2001). The new prototype of the hand held WWD (**Figure 1**) has a five litre herbicide containing tank which can be hung on the shoulder of the operator. A sprayer pump is attached to the herbicide tank to develop pressure. The pressurized herbicide from the tank flows through a hose, placed on a 'U' shaped frame fitted with a handle. Nozzle present at the proximal end of the hose is used to dispense the herbicide. Chances for dripping of the herbicide can be avoided by an easy to operate control valve with button switch or by tilting the device to spread the chemical on to the cloth towel, fastened on the herbicide carrying 'U' shaped frame of the device. The 'U' shaped hose mounting frame is connected to the front end cap of the handle, which in turn is connected to the rear end

Figure 1. Weed wiper device

cap. The hose dummy is present at the distal end of the hose to seal the end of the hose.

The 'U' shaped hose has eight pores, four pores on each parallel limb (**Figure 2**). The hose and the pores are covered with cloth towel which gets saturated by the herbicide coming out from the pores. The 'U' shaped frame increased the working efficiency and area coverage by the device. Herbicide can be smeared on both the sides of the panicle along the entire length by the horizontal swinging movement of the WWD. Patent application has been filed for the fabricated hand held WWD at the Patent Office, Chennai (Application No. 1763/CHE/2014 dated 1.04.2014) and has been published in the Patent Journal (Jose *et al*. 2015b) and is awaiting examination.

Traits of weedy rice favourable for DCA

The morphotypes of weedy rice seen in different polders of Kuttanad were compared with the cultivated rice variety of the polder, *Uma* (**Table 1**). It was observed that the height of weedy rice morphotypes ranged from 65-87 cm, while that of cultivated rice was 53 - 66 cm at 60 DAS. The plant height at 80 DAS was 92-191 cm and 99-109 cm for weedy rice and cultivated rice, respectively. This clearly reveals that as weedy rice approaches 60 DAS, it maintains height difference of more than 15 cm with rice plant and favours DCA for the selective drying of tall weedy rice plants in standing crop. At the time of ear head emergence of weedy rice, it was seen that the second internode from the top elongates, pushing the ear head above the crop canopy to a height of 15-20 cm. As the crop approaches 80 DAS, the height difference between weedy rice and

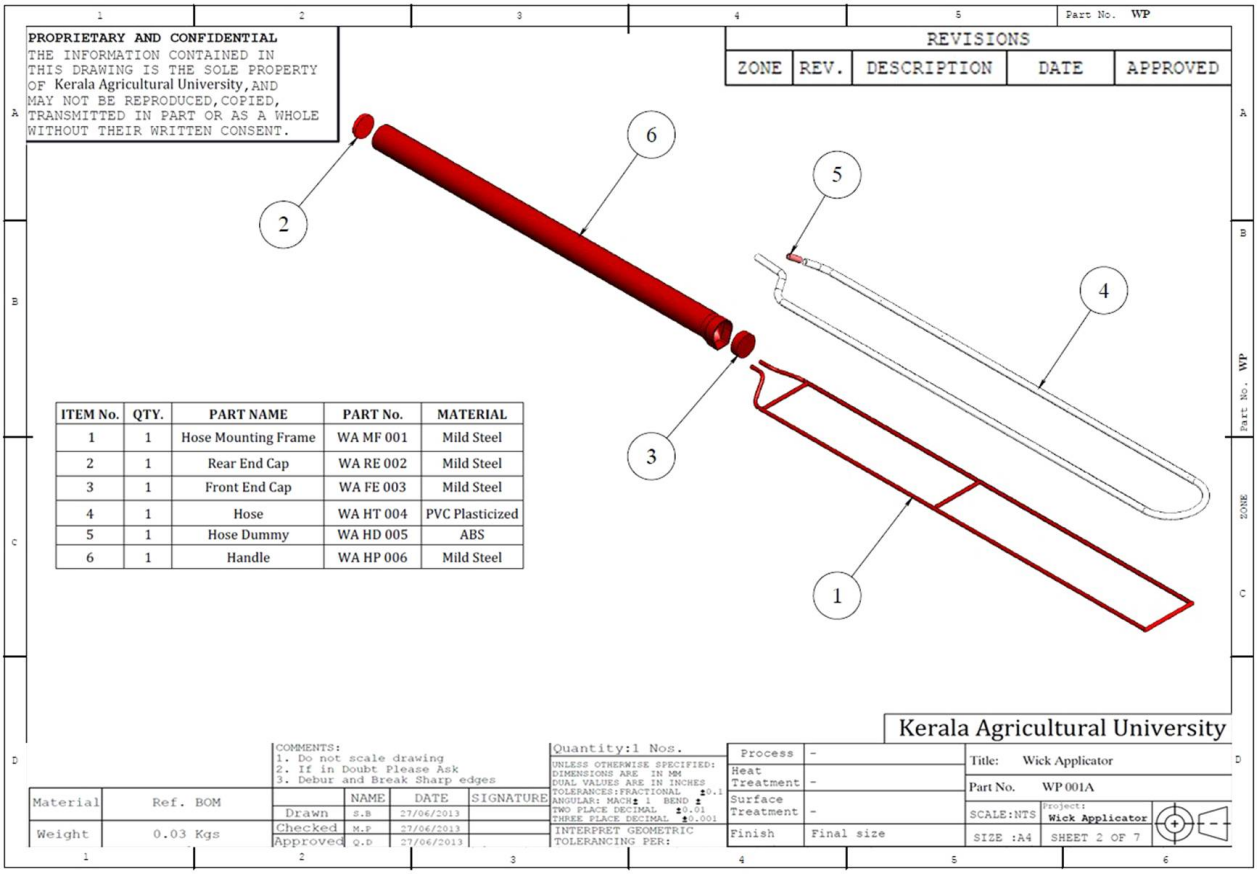

Figure 2. Illustration of the weed wiper device

cultivated rice decreases. Hence, control of weedy rice by DCA is possible only within 60 -75 DAS in cropped field.

The study also observed that flowering in weedy rice was between 55-70 DAS, while that in rice was between 82-88 DAS (**Table 1)**. As weedy rice has staggered germination and panicle emergence under field conditions, use of DCA should be initiated at a stage when more than 50-70% of the weedy rice panicles have emerged. Under certain situations, second application of herbicides by DCA may become necessary if there is late emergence of weedy rice panicles. As crop approaches 80-85 DAS, rice plants would have initiated flowering. Exertion of panicle in rice increases the plant height, reducing the height difference between weedy rice and rice. Hence, control of weedy rice by DCA is possible only within 60-75 DAS in cropped field. The uniformity among the rice plants and that among weedy rice population in a crop stand decides the effectiveness of the device in selective drying of the ear heads of weedy rice without affecting the crop stand beneath. As weedy rice has staggered germination in cropped field, repeated DCA can be resorted at around 60-65 and/or 70-75 DAS, when the weedy rice panicles are at a height of 15 cm above the crop canopy (Jose *et al*. 2015a).

Table 1. Variation in the height and time of flowering in cultivated rice and weedy rice

Morphotype	No. of tillers/weedy rice plant/m^2	No. of weedy rice panicles/m^2	Height of weedy rice (cm)		Height of rice (cm)		Days to 50% flowering	
	60 DAS	65 DAS	60 DAS	80 DAS	60 DAS	80 DAS	Weedy rice	Rice
Kainakari	5.6	20	87.7	119.1	60	105	55	88
Champakulam	4.5	35	69.9	101.4	53	105.5	58	82
Nedumudy	6.2	30	65.8	98.3	58.7	102.6	68	85
Ambalapuzha North	4	19	68	107	55.2	99.8	70	86
Ramankary	5.1	24	87.5	140.5	68.5	100.7	57	85
Ambalapuzha South	5.5	17	85	119.5	65.9	102.4	60	86
Punnapra	2.5	18	80	113	66.7	109.2	59	88
Alapuzha	4.7	40	69	92.5	62.5	105	65	85
LSD (p=0.05)	3.2	15	NS	23	NS	NS	10.3	NS

Chauhan (2013) reported that earliness in flowering of weedy rice plants compared to cultivated rice varieties also favoured DCA. Olguin *et al*. (2007) and Rathore *et al*. (2016) reported that early flowering in weedy rice is an additional advantage for survival in rice fields. It was observed that the weedy rice plants had very early flowering which resulted in early grain maturation and seed shattering. In the population studied, all most 70 per cent of grains in a panicle shattered within 15 days after flowering and there was no sequence in the nature of shattering. Both fully matured (black or brown coloured) and partially matured grains (light straw coloured) shattered randomly along the entire length of the panicle (Jose 2015). Ferrero (2010) reported that this behaviour could most likely be explained by the incomplete development of the early shattered grains, which broke off mainly because of the environmental causes like wind. Shattered seeds added to the soil seed bank would intensify the problem in future (Perreto *et al*. 1993). Early seed shattering was identified as a specific characteristic of weedy rice, controlled by the gene Sh which shows the shattering character in dominant homozygosys (Sh Sh) or heterozygosys (sh Sh) conditions (Sastry and Seetharaman 1973).

Effect of herbicides on selective drying of weedy rice panicles

Post-planting chemical control of weedy rice in cropped field should be considered only as a salvage operation and it mainly relies on difference in size or growth stage between weedy rice and commercial rice. The experiment on identifying the most efficient herbicide was conducted in farmers' fields in Kuttanad region during *Rabi* 2013-14 with severe infestation of weedy rice. Among the chemicals used in the experiment, the efficacy of glufosinate ammonium at 5% concentration was inferior to all other treatments (**Table 2**). At 15% concentration, it was at par with glyphosate at 10 and 15% and paraquat dichloride at 15% concentration in drying the panicle. The number of ear heads that were not dried by herbicidal action varied significantly among treatments. Number of ear heads that escaped the DCA was significantly higher in glufosinate ammonium at 5% concentration while, it was significantly lower and at par in the treatments with glyphosate at 10 and 15%, and paraquat dichloride and glufosinate ammonium at 15% concentration. The treatments which were at par in the control of weedy rice ear heads exhibited 83 to 88% control efficiency.

Similar experiment was also conducted in severely weedy rice infested direct-seeded rice fields of Kuttanad during *Kharif*, 2014. Different concentrations of glyphosate (10 and 15%) did not vary significantly in the control of weedy rice ear heads (**Table 2**). Glufosinate ammonium at 5% was inferior in controlling weedy rice compared to its higher concentrations at 10 and 15%, which were at par. Among the different herbicides tried, glufosinate ammonium 15% had the highest per cent control followed by glyphosate and paraquat dichloride at 15% and glufosinate ammonium at 10% concentration. The number of ear heads that escaped from the herbicidal contact varied significantly among treatments. No. of ear heads that remained unaffected was significantly higher for the contact herbicides, glufosinate ammonium (5%) followed by glufosinate ammonium (10%) and paraquat dichloride at 10% concentration. Number of weedy rice panicles that were skipped in DCA was significantly low and at par at higher concentration of glufosinate ammonium (15%), paraquat dichloride (15%) and glyphosate (at concentrations, 10% and 15%).

The dried ear heads were collected for checking the viability using Tetrazolium test and it was found that majority of the spikelets were either in the dough stage or sterile. The ear heads which dried within 2-5 days after application of the herbicide subsequently fell off from the plant within 10-15 days of

Table 2. Effectiveness of DCA on selective drying of weedy rice panicles

Herbicide formulation	Dose of application (%)	Panicles (no./m^2)				Panicles dried (%)	
		Before sweeping		Not dried			
		2013 *Rabi*	2014 *Kharif*	2013 *Rabi*	2014 *Kharif*	2013 *Rabi*	2014 *Kharif*
Paraquat dichloride 24 SC	10	42	41	*4 (11)^{cd}	*4 (15)^{bc}	74^{bc}	63^{bc}
Paraquat dichloride 24 SC	15	41	44	3 (7)^{de}	3 (7)^{c}	83^{ab}	78^{ab}
Glyphosate 41 SL	10	43	44	3 (6)^{de}	4 (13)^{bc}	85^{ab}	71^{ab}
Glyphosate 41 SL	15	41	45	2 (5)^{e}	4 (12)^{bc}	88^{a}	73^{ab}
Glufosinate ammonium 15 SL	5	40	39	5 (22)^{b}	4 (19)^{b}	45^{d}	52^{c}
Glufosinate ammonium 15 SL	10	43	43	4 (13)^{c}	4 (15)^{bc}	69^{c}	67^{bc}
Glufosinate ammonium 15 SL	15	43	44	3 (7)^{de}	3 (9)^{c}	85^{ab}	80^{a}
Control	-	44	42	7 (44)^{a}	7 (42)^{a}	0^{e}	0^{d}
LSD (p=0.05)		NS	NS	1.7 (5)	1.3 (8.4)	12.7	16

*Square root transformed value. Figures in the parentheses are original values and those followed by the same alphabets in a column do not vary significantly in DMRT

application. Ferrero and Vidotto (1999) have observed 90% reduction in germination of dried seeds collected after sweeping weedy rice panicles with wick applicator using glyphosate (10-15%) at 65 DAS in infested cropped fields. The possibility of using weed wiper for DCA depends on the density of weedy rice plants, the height difference between the rice and weedy rice plants and days to 50% flowering of weedy rice and rice plants.

Precautions while using WWD

While sweeping the herbicide over the crop stand, utmost care should be taken to prevent dripping of the herbicide from the applicator lance and touching the crop canopy which is at minimum permissible height difference with weedy rice ear heads. The efficiency of the wick applicator depends primarily on the mode of action of the chemical and its concentration. The skill of the person using the equipment and his perceptions on the mode of action of the chemical, either contact or systemic also affects the efficacy of DCA. The efficiency of selective drying depends on the herbicide used, its concentration, stage of the crop and weed, and skill of the personal engaged for DCA. While selecting herbicides for swabbing, it is always better to use those with contact broad-spectrum action (glufosinate ammonium and paraquat dichloride) than systemic action (glyphosate) to prevent accidental drying of the rice plants. However, if skilled personnel are engaged, even systemic herbicides can be used to dry the entire weedy plants. The quantity of herbicide required for swabbing an area of one hectare with moderate weedy rice infestation (6-10 weedy rice ear heads per square metre) was recorded as 1.5 to 2.0 litre, at 10 per cent concentration of the herbicide. Using the novel WWD, one hectare of moderately infested fields was covered in 3-4 hours.

It can be concluded that early flowering in weedy rice 20 to 25 days earlier than cultivated rice and height difference of 15 to 20 cm between weedy rice and cultivated rice at the time of flowering make post-emergence management by selective drying of weedy rice panicles by DCA with specially designed WWD very effective. This can be done with non-selective broad-spectrum herbicides, glufosinate ammonium 15 SL at 15%, paraquat dichloride 24 SC at 15% or glyphosate 41 SL at 10-15% concentration. The novel method is effective in reducing the weedy rice infestation by preventing seed rain and subsequent build-up of soil seed bank. The device developed in the project was filed for the Indian Patent at Patent Office, Chennai (Application No. 1763/CHE/2014 dated 01.04.2014) and the technology of the device has been transferred to M/s Raidco Ltd, for large scale manufacturing and sale to farmers.

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