International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2018; 6(3): 1519-1523

Received: 13-03-2018
Accepted: 15-04-2018

N Bommayasamy
Ph D., Scholar, Dept of Agronomy, AC & RI, TNAU, Madurai, Tamil Nadu, India

CR Chinnamuthu
Department of Agronomy, AC & RI, TNAU, Madurai, Tamil Nadu, India

NS Venkataraman
Department of Agronomy, AC & RI, TNAU, Madurai, Tamil Nadu, India

K Balakrishnan
Unit of Crop Physiology, Dept of Seed Science & Technology, AC & RI, Madurai, Tamil Nadu, India

A Rathinasamy
Department of Soils and Environment, AC & RI, Madurai, Tamil Nadu, India

B Gangaiah
Head, Division of NRM, ICAR-Central Island Agricultural Research Institute, Port Blair, Andaman & Nicobar Islands, India

Correspondence
N Bommayasamy
Ph D., Scholar, Dept of Agronomy, AC & RI, TNAU, Madurai, Tamil Nadu, India

Effect of entrapped slow release pre-emergence herbicide oxadiargyl with zeolite, biochar, starch and water soluble polymer formulations on weed control duration and yield of transplanted rice

N Bommayasamy, CR Chinnamuthu, NS Venkataraman, K Balakrishnan, A Rathinasamy and B Gangaiah

Abstract
Field experiment was carried out during *kharif,* 2016 at Agricultural College and Research Institute, Madurai in order to study the effect of slow release herbicide formulations on growth and yield of transplanted rice. Weed control treatments significantly reduced the total weed density and total weed dry weight over weedy check both at 20 and 40 DAT. Application of oxadiargyl loaded with zeolite on 3 DAT recorded significantly less total weed dry weight of 9.62, 19.64 g m^{-2} at 20 and 40 DAT, respectively. Weed free check treatment recorded the maximum grain yield of 5830 kg ha^{-1}. Among the weed control treatments, application of butachlor @ 1.25 kg ha^{-1} on 3 DAT *fb* hand weeding on 40 DAT and application of oxadiargyl loaded with zeolite on 3 DAT(T_2) were on par with each other with 86.7 and 77.1 per cent higher grain yield respectively over weedy check.

Keywords: oxadiargyl, slow release, weed attributes, grain yield

Introduction
Rice is the world's most important cereal food crop. More than half of the world's population depends on rice for calories and protein, especially in developing countries. World-wide rice occupies an area of about 153.77 M. ha which is about 30% of the total area under food grain cultivation. The slogan "Rice is life" is most appropriate for India because, the crop plays a vital role in our national food security and is a means of livelihood for millions of rural households. The rice productivity in India is 3.37 t ha^{-1}, while the world average is 4.25 t ha^{-1} (IRRI, 2011) [7]. Despite the significant achievement in food grain production since independence, Indian agriculture continues to face challenges from ever increasing population. It is estimated that by 2020 at least 170 to 180 M.t of rice (115-120 M.t milled rice) is to be produced in India, with an average productivity of 4.03 t/ha, to maintain the present level of self-sufficiency (Mishra *et al.*, 2006) [10], which means that the productivity should go up by one t ha^{-1} from the current level.

It is great challenge to feed the growing population with existing cultivable area. Major yield reducing factors in rice such as soil fertility decline, weed competition, incidence of disease and insects. Out of the losses caused by various biotic and abiotic stresses, weeds are known to account for nearly one third. Weeds are the major obstacle to rice production through their ability to compete for resources and their impact on product quality (Kandeshwari, 2014) [8]. Weeds offer intense competition with rice plant throughout the crop season for critical growth factors, *viz.*, space, sunlight, water and nutrients, thus causing significant yield loss. The traditional method of manual weeding is quite effective, but laborious, time consuming and high cost. Generally farmers apply herbicides by mixing them in sand for easy operation and prefer to use either single application of herbicides which fails to control diverse weed flora observed in rice (Chauhan, 2012) [1].

Slow release herbicides effectively control weeds with reasonable doses selectively non-toxic to crops, remain in the area where applied, persist throughout the growing season taking care of frequently germinating weeds and leaving no residue at the end of the season permitting subsequent crops in the sequence. Hence, the present study was contemplated on slow release herbicide formulations for season long weed control in rice.

Materials and methods

Field experiment was carried out at the Central Farm, Department of Farm Management, Agricultural College and Research Institute, Madurai during *kharif*, 2016. The farm is geographically located at 9° 54' N latitude and 78° 80' E longitude at an altitude of 147 m above mean sea level (MSL). The soil of the experimental field was sandy clay loam in texture with medium organic carbon (0.32 %) status, low available nitrogen (246.6 kg ha^{-1}), medium in available phosphorus (19.5 kg ha^{-1}) and medium in available potassium (249.0 kg ha^{-1}). The experiment was laid out in randomized block design with eight treatments and replicated thrice. The weed control treatments *viz*., pre-emergence application of oxadiargyl loaded with biochar at 3 DAT (T_1), oxadiargyl loaded with zeolite at 3 DAT (T_2), encapsulated oxadiargyl with starch at 3 DAT (T_3), encapsulated oxadiargyl with water soluble polymer on 3 DAT (T_4), oxadiargyl at 100 g ha^{-1} at 3 DAT (T_5). These treatments were compared with butachlor at 1.25 kg ha^{-1} on 3 DAT *fb* Hand weeding on 40 DAT (T_6), weed free check (T_7) and weedy check (T_8). Absolute density and relative density of individual predominant weed species and group wise weeds were calculated by the method suggested by Kim and Moody (1983) [9].

The recommended dose of fertilizer (150: 50: 50 kg N: P: K ha^{-1}) was applied through urea, single super phosphate and muriate of potash. Nitrogen was applied in four splits at 10 DAT, active tiller, panicle initiation and flowering stages while 100 per cent phosphorus and 50 per cent potassium were applied as basal. Remaining 50 per cent potassium was applied at panicle initiation stage. The paddy variety TKM-13 with 130 days duration was used for the study. Seedling with 30 days old were transplanted with a spacing of 20 cm x 10 cm during the second week of September and harvested during fourth week of December. The plots were irrigated to 2.5 cm depth of water upto establishment, thereafter cyclic submergence of 5 cm was continued thought the crop period. Need based plant protection measures were given whenever the incidences (leaf folder) more than economic threshold level. All other recommended package of practices was adopted as per the schedule. The data was statistically analyzed by following the method of Gomez and Gomez (2010) [4]. The data pertaining to weeds were transformed to square root of X+2 and analysed as suggested by Snedecor and Cochran (1967) [14].

Results and Discussion

Weed flora

Weed flora of the experimental field predominantly consists of three species of grassy weeds, three species of sedges and six species of broad leaved weeds. The predominant grassy weeds were *Echinochloa colona, Leptochloa chinensis, Cynodon dactylon,* among the sedges *Cyperus rotandus, Fimbristylis miliacea, Cyperus difformis,* and among the broad leaved weeds *Eclipta alba, Convolvulus arvensis, Ammania baccifera, Marsilea quadrifolia, Aeschynomene indica, Bergia capensis* were the found to be dominant.

Absolute density and relative density of weed

The absolute density (No. m^{-2}) and relative density (per cent) of individual weeds presented in Table 1. In general, Broad leaved weeds were the dominant weed species followed by grasses and sedges at 20 DAT, whereas at 40, 60 DAT and at harvest, sedges were the dominant followed by BLW and grasses.

The relative density of individual weed species showed that the BLW *Eclipta alba* was the predominant weed species registered a relative density of 41.98 per cent at 20 DAT with the absolute density of 176.33 m^{-2} followed by grasses (123.33 m^{-2}) and sedges (120.33 m^{-2}). Whereas, *Cyperus rotundus* was the prime grassy weed species found higher proportion in weed flora with a higher relative density of 47.41, 52.57 and 45.28 per cent with absolute density of 344.33, 481.67 and 528.00 m^{-2} observed at 40, 60 and harvest stage, respectively. The predominant occurrence of the weed species in transplanted rice might be due to the wider ecological adaptation of weeds and abundance of resources available during crop growth. This invariably resulted in higher uptake of nutrients and faster growth of the weeds than growth of crop. Similarly wide spectrum of weeds in rice fields was reported by many workers of Govindan and Chinnusamy (2014) [5], Parthipan and Ravi (2016) [12].

Total weed density and total weed dry weight

Weed control treatments significantly reduced the total weed density and total weed dry weight compared to weedy check both at 20 and 40 DAT (Table 2). Total weed density was lower with butachlor @1.25 kg ha^{-1} on 3 DAT *fb* hand weeding on 40 DAT (T_6) which was at par with application of oxadiargyl loaded with zeolite on 3 DAT (T_2). The highest weed density of 98.67 and 170.67m^{-2} was recorded in weedy check at 20 and 40 DAT. Oxadiargyl loaded with zeolite on 3 DAT (T_2) recorded significantly lower total weed dry weight of 9.62 and 19.64 g m^{-2} at 20 and 40 DAT respectively. It was comparable with butachlor @ 1.25 kg ha^{-1} on 3 DAT *fb* hand weeding on 40 DAT (T_6), application of oxadiargyl encapsulated with starch on 3 DAT (T_3), Oxadiargyl loaded with Biochar on 3 DAT (T_1). This may be attributed due to the slow release of Oxadiargyl formulations over a considerable period of crop growth and effective control of the late emerging new flushes of weeds. Similar findings were reported by Hasanuzzaman *et al.* (2007) [6].

Crop growth attributes

Weed control treatments exhibited significant influence on plant height. Weed free check registered taller plants (93.9 cm) which was on par with application butachlor @ 1.25 kg ha^{-1} on 3 DAT *fb* hand weeding on 40 DAT (T_6), application of oxadiargyl loaded with zeolite on 3 DAT (T_2), oxadiargyl loaded with biochar on 3 DAT (T_1) and oxadiargyl encapsulated with starch on 3 DAT (T_3) compared to weedy check. This may be opined that better weed control and effective utilization of available resources, resulted in better crop growth and increased plant height.

The root growth parameters such as root length, root volume and root dry weight influenced by the weed control treatments (Table 3). Weed free check (T_7) and butachlor @1.25 kg ha^{-1} on 3 DAT *fb* hand weeding on 40 DAT (T_6) recorded higher root characters. Among the weed control treatments, application of oxadiargyl loaded with zeolite on 3 DAT (T_2) recorded significantly more root length, root volume and root dry weight of 24.4 cm, 36.1 cm^{-3} and 6.04 g $hill^{-1}$ respectively which is mainly owing to reduced weed density which facilitates the crop roots to extract more water and nutrient for its metabolic activity. This is in conformity with the findings of Pandey *et al.* (2000) [11].

Weed free check exhibited its superiority by registering higher dry matter production (DMP) of 14,667 kg ha^{-1} at harvest stage. Among the weed control treatments, application of oxadiargyl loaded with zeolite on 3 DAT recorded appreciably higher DMP which was on par with T_6, T_1, and T_3. Similar results were found by Shan *et al*. (2012)[13] who obtained higher DMP with weed control treatment, which was due to less crop-weed competition leading to vigorous growth and increased nutrient availability to rice under effective weed control treatments.

Yield attributes and yield

Significant differences on productive tillers hill^{-1}, total number of grains panicle^{-1}, spikelet sterility (per cent), grain yield (kg ha^{-1}) was observed with different weed control treatment while the test weight (g) of grain did not show much variation among the treatments (Table 4). The weed free check recorded significantly higher yield attributes and grain yield. Among the weed control treatments, higher number of productive tillers hill^{-1} was registered with butachlor @ 1.25 kg ha^{-1} applied 3 DAT *fb* hand weeding on 40 DAT (T_6) which was comparable with T_2, T_1 and T_3.

Spikelet sterility was significantly influenced by weed control treatments. Irrespective of weed control treatments, weedy check (T_8) produced higher spikelet sterility compared to other weed control methods. The lowest spikelet sterility was recorded under weed free check (7.8 per cent). It was on par with oxadiargyl loaded with zeolite (9.9 per cent). The total number of grains panicle^{-1} ranged from 175.6 to 246.9 due to weed control treatment. Among the weed control treatments, the highest total number of grains panicle^{-1} was recorded under weed free check (246.9) and was at par with oxadiargyl loaded with zeolite (T_2). The weed control treatments had no significant influence on the test weight of grain, since these characters are largely decided by their genetic potential as reported by Gaganpreet Kaur *et al*. (2010) [3].

The weed free check recorded the maximum grain yield of 5830 kg ha^{-1}. Among the weed control treatments, application of butachlor @ 1.25 kg ha^{-1} on 3 DAT *fb* hand weeding on 40 DAT (T_6) and application of oxadiargyl loaded with zeolite (T_2) were on par with each other which recorded 86.7% and 77.1% higher grain yield respectively over weedy check (T_8). The next best treatment was oxadiargyl loaded with biochar (T_1), oxadiargyl encapsulated with starch (T_3) followed by oxadiargyl encapsulated with water soluble polymer T_4), oxadiargyl at 100g ha^{-1} on 3 DAT (T_5). The lowest grain yield (2858 kg ha^{-1}) was recorded in weedy check as a consequence of the highest removal of nutrients and moisture by weeds and exerted severe competition resulting in poor source and sink development lead to poor yield components. A comparable finding was also reported by Choudhary and Thakuria (1998) [2].

Conclusion

Slow release herbicide formulations recorded higher weed control of 35.5, 28.9 and 27.9, 35.0 per cent of total weed density and total weed dry weight at 20 and 40 DAT respectively compared to commercial formulations applied without any modification. Slow release formulations reduced the herbicide movement within the soil column by keeping enormous portion of the herbicide active ingredient in the upper soil layer, where the weed seeds are exist which continuously emerge and compete with crop, could be checked effectively. Release of herbicide in to soil solution slowly over a long period crop growth lead to reduction in the frequency of herbicide application as well as manual removal of weeds.

Acknowledgement

The authors of the manuscript are highly thankful to Department of Agronomy, AC & RI, Madurai, TNAU and Director, ICAR-CIARI, Port Blair for providing facility to carry out the research in this aspect

Table 1: Effect of slow release herbicide formulations on absolute and relative density of weeds in rice

Treatment	20 DAT		40 DAT		60 DAT		Harvest	
	AD (No./m^2)	RD (%)	AD (No./m^2)	RD (%)	AD (No./m^2)	RD (%)	AD (No./m^2)	RD (%)
Grasses								
Echinochloa colonum	83.67	19.92	88.67	12.21	122.67	13.39	140.33	12.04
Leptochloa chinensis	32.67	7.78	45.33	6.24	40.00	4.37	73.33	6.29
Cynodon dactylon	7.00	1.67	22.00	3.03	15.00	1.64	15.00	1.29
Total grasses	123.34	29.37	156.00	21.48	177.67	19.39	228.67	19.61
Sedge		0.00		0.00		0.00		0.00
Cyperus rotundus	113.00	26.90	328.33	45.20	448.67	48.96	496.00	42.54
Fimbristylis miliacea	6.33	1.51	8.00	1.10	15.00	1.64	14.00	1.20
Cyperus difformis	1.00	0.00	8.00	1.10	18.00	1.96	18.00	1.54
Total sedges	120.33	28.41	344.33	47.41	481.67	52.57	528.00	45.28
Broad leaved weeds (BLW)								
Eclipta alba	166.00	39.52	183.33	25.24	209.67	20.30	387.67	33.25
Ammania baccifera	2.00	0.48	17.67	2.43	18.33	1.45	4.67	0.40
Convolvulus arvensis	2.00	0.48	8.33	1.15	11.00	1.67	4.33	0.37
Aeschynomene indica	5.00	1.19	0.33	0.05	6.33	1.24	12.67	1.09
Bergia capensis	1.33	0.32	11.00	1.51	11.67	0.51	0.00	0.00
Total BLW	176.33	41.98	226.00	31.12	257.00	28.05	409.33	35.11
Total weed density	420.00	100.00	726.33	100.00	916.34	100.00	1166.00	100.00

AD- Absolute density RD- Relative density Data statistically not analyzed

Table 2: Effect of slow release herbicide formulations on total weed density (No. m^{-2}) and total weed dry weight (g m^{-2}) of rice

Treatments	Total weed density (No. m^{-2})		Total weed dry weight (g m^{-2})	
	20 DAT	40 DAT	20 DAT	40 DAT
T_1 - Oxadiargyl loading with Biochar on 3 DAT	7.43 (53.33)	9.63 (91.33)	3.45 (9.92)	4.92 (22.19)
T_2 - Oxadiargyl loading with Zeolite on 3 DAT	7.02 (47.33)	8.96 (78.33)	3.41 (9.62)	4.64 (19.64)
T_3 - Oxadiargyl encapsulated with starch on 3 DAT	6.29 (37.67)	10.13 (100.67)	3.60 (10.99)	4.94 (22.60)
T_4 -Oxadiargyl encapsulated with water soluble polymer on 3 DAT	8.21 (65.33)	10.32 (105.33)	3.79 (12.35)	4.77 (21.28)
T_5 - Oxadiargyl at 100g/ha on 3 DAT	8.81 (75.67)	11.07 (120.67)	3.84 (12.84)	5.28 (25.84)
T_6 -Butachlor at 1.25 kg/ha on 3 DAT *fb* Hand weeding on 40 DAT	6.36 (38.67)	7.83 (59.33)	3.66 (11.40)	4.47 (17.98)
T_7 - Weed free check	1.41 (0.00)	1.41 (0.00)	1.41 (0.00)	1.41 (0.00)
T_8 – weedy check	10.00 (98.67)	13.14 (170.67)	5.89 (32.79)	7.49 (54.17)
SE.d	0.33	0.38	0.15	0.28
CD (P=0.05)	0.70	0.82	0.32	0.60

Table 3: Effect of slow release herbicide formulations on crop growth characteristics of rice

Treatment	Plant height at harvest (cm)	Root characteristics at flowering			DMP at harvest (kg ha^{-1})
		Root length (cm)	Root volume (cm^{-3})	Root dry weight (g $hill^{-1}$)	
T_1 -Oxadiargyl loading with Biochar on 3 DAT	90.2	24.1	35.0	6.02	12339
T_2 -Oxadiargyl loading with Zeolite on 3 DAT	92.1	24.4	36.1	6.04	12697
T_3 - Oxadiargyl encapsulated with starch on 3 DAT	89.8	24.0	33.7	5.83	12211
T_4 -Oxadiargyl encapsulated with water soluble polymer on 3 DAT	89.1	23.6	33.0	5.91	11668
T_5 - Oxadiargyl at 100g/ha on 3 DAT	86.9	23.2	32.7	5.47	11255
T_6 -Butachlor at 1.25 kg/ha on 3 DAT *fb* Hand weeding on 40 DAT	93.9	25.7	36.5	6.12	13084
T_7 - Weed free check	97.7	30.3	37.3	7.41	14667
T_8 – weedy check	82.7	22.1	28.0	5.03	8906
SE.d	3.8	1.6	1.9	0.44	514
CD (P=0.05)	8.1	3.4	4.0	0.94	1101

Table 4: Effect of slow release herbicide formulations on yield attributes and yield of rice

Treatment	Productive tillers $hill^{-1}$	Total no of grains $panicle^{-1}$	Spikelet sterility (%)	Test weight (g)	Grain yield (kg ha^{-1})
T_1 -Oxadiargyl loading with Biochar on 3 DAT	6.24	205.9	10.3	14.2	4830
T_2 -Oxadiargyl loading with Zeolite on 3 DAT	6.42	216.2	9.9	14.3	5062
T_3 - Oxadiargyl encapsulated with starch on 3 DAT	6.15	200.1	12.0	14.0	4741
T_4 -Oxadiargyl encapsulated with water soluble polymer on 3 DAT	5.58	197.4	13.0	14.1	4275
T_5 - Oxadiargyl at 100g/ha on 3 DAT	5.57	190.7	13.7	14.0	4074
T_6 -Butachlor at 1.25 kg/ha on 3 DAT *fb* Hand weeding on 40 DAT	6.16	208.6	10.5	14.2	5337
T_7 - Weed free check	7.27	246.9	7.8	14.6	5830
T_8 – weedy check	4.76	175.6	15.0	13.5	2858
SE.d	0.37	14.4	1.1	0.58	205
CD (P=0.05)	0.80	30.7	2.4	NS	441

References

1. Chauhan BS. Weed ecology and weed management strategies for dry seeded rice in Asia. Weed technology. 2012; 26:1-13.
2. Choudhary JK, Thakuria RK. Evaluation of herbicide in wet seeded, late Sali (winter) (*Oryza sativa*) rice in Assam. Indian Journal Agronomy. 1998; 43(2):291-294.
3. Gaganpreet Kaur, Brar HS, Guriqbal Singh. Effect of weed management on weeds, nutrient uptake, nodulation, growth and yield of summer mungbean (*Vigna radiata*). Indian Journal of Weed Science, 2010; 42(1, 2):114-119.
4. Gomez KA, Gomez AA. Statistical Procedures for Agricultural Research. Edn.2, John Wiley and Sons, New York, 2010.
5. Govindan R, Chinnusamy C. Tillage, crop establishment and weed management in rice under conservation agriculture system. Indian Journal of Weed Science, 2014; 46(2):117-122.

6. Hasanuzzaman M, Kamrun N, Karim MR. Effectiveness of different weed control methods on the performance of transplanted rice. Pakistan Journal Weed Science Research. 2007; 13:17-25.
7. IRRI, Trends in the rice economy, 2011.
8. Kandeshwari M. Long term herbicidal weed management integrated with two different sources of nitrogen in transplanted rice-rice cropping system. Ph.D., Thesis, Tamil Nadu Agric. Univ., Coimbatore, 2014.
9. Kim SC, Moody K. Comparison of some methodologies for vegetation analysis in transplanted rice. Korean Journal Crop Science. 1983; 28:310-318.
10. Mishra D, Ispal Asmed M, Rao KV, Bentor JS. Rice Research in India: Green revolution to gene revolution. Journal of Rice Research. 2006; 1:38-51.
11. Pandey N, Dhurandhar RL, Tripathi RS, Grain yield. root growth and N uptake of early duration rice varieties as influenced by nitrogen levels under rainfed upland. Oryza. 2000; 37(1):60-62.
12. Parthipan T, Ravi P. Productivity of transplanted rice as influenced by weed control methods. African Journal of Agricultural Research. 2016; 11(16):1445-1449.
13. Shan FA, Anwar Bhat M, Manzoor AG, Hussain A, Bhat TA. Effect of crop establishment and weed control practices on the performance of rice (*Oryza sativa* L.). Applied Biological Research. 2012; 14(1):79-85.
14. Snedecor GW, Cochran WG. Statistical Methods. Oxford and IBH Publ. Co, New Delhi, 1967.