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Rajath HP
M. Sc. (Agri.), Department of Agronomy, College of Agriculture, University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, India

Jadeyegowda M
Assistant Professor, Department of Agronomy, College of Agriculture, University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, India

Umesha C
Assistant Professor, Department of Agronomy, College of Agriculture, University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, India

Veeranna HK
Professor, Department of Agronomy, College of Agriculture, University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, India

Correspondence
Rajath HP
M. Sc. (Agri.), Department of Agronomy, College of Agriculture, University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, India

Efficacy of herbicide molecules to control composite weed flora in transplanted Paddy for Kodagu region

Rajath HP, Jadeyegowda M, Umesha C, and Veeranna HK

Abstract
Rigorous research efforts are being made by scientists around the world to evolve different strategies for improving paddy yield, among all agronomic practices weed management is the one which improve the crop growth and yield considerably. Studies for weed management in transplanted paddy were carried out at the experimental farm Agricultural and Horticulture Research Station, Ponnmapet, Virajpet taluk, Kodagu district of Karnataka during the Kharif seasons 2016 to find out the best suitable herbicide molecules for weed control in transplanted Paddy (*Oryza sativa* L.). The experiment was laid out in randomized complete block design and replicated thrice with a net plot size of 3.2 m X 2.6 m. Tunga (IET 13901) a prominent variety of Kodogu district was used as a experiment material. The seedlings were transplanted during second week of August. Three days after transplanting, butachlor, bensulfuron methyl + pretilachlor, Oxadiargyl at as pre emergence herbicide. Penoxsulum, bispyribac sodium, 2,4 D and ethoxysulfuron were sprayed as post emergent sprays at 20 days after transplanting, pre emergence followed by post emergent treatment also used in the experimental material to check the efficacy of the herbicide. Oxadiargyl at 3 DAT fb penoxsulum at 20 DAT and oxadiargyl @ 3 DAT fb bispyribac-Na at 20 DAT recorded higher weed control efficiency (92.79 to 77.91 % and 89.24 to 75.42 %, respectively) throughout the crop growth period. Whereas, highest (100.00 to 91.06 %) and lowest (0.00) weed control efficiency was recorded in hand weeding twice at 20 and 40 DAT and in unweeded control, respectively. The lower grain and straw yield was recorded with butachlor 5% G @ 30 kg a.i. ha^{-1} at 3 DAT (2836 and 4434 kg ha^{-1}, respectively). However, unweeded control recorded significantly lower grain and straw yield (1821 and 2410 kg ha^{-1}, respectively). Whereas, hand weeding twice at 20 and 40 DAT recorded significantly higher grain and straw yield (4300 and 5362 kg ha^{-1}, respectively).

Keywords: herbicide, molecules, control composite, Kodagu region

Introduction
Paddy (*Oryza sativa* L.) is the most important crop in tropical and subtropical regions of the world and it is a staple food for more than 60 per cent of the world's population. More than 80 per cent of world paddy is being produced and consumed in Asia alone (Mohanty 2013, Chauhan *et al*., 2014) [9, 3]. Globally paddy is cultivated to the tune of 154 m ha with an annual production of around 426 million tonnes and with an average productivity of 2.76 t ha^{-1} (Parameswari and Srinivas, 2017) [14].

In recent years, the area under paddy in hilly zone is declining because of scarcity of labour to carryout timely crop management practices. Among the various crop management practices, management of weed flora under low land situation is tedious task to the farmers. Weeding is the important operation in paddy cultivation which consumes major labour force. There is a need to reduce dependence of labour on these operations especially in this area where labour is very costly and scarce. The prevailing climatic and edaphic factors are highly favorable for numerous species of weeds that strongly compete with the paddy crop. Competition occurs when one of the resources (nutrients, light, moisture and space) fall short of total requirement of paddy and weeds. Weeds by virtue of their high adaptability and faster growth dominate the crop habitat and reduce the yield potential. The yield losses due to uncontrolled weed growth in lowland and upland paddy ranges from 12 to 81 per cent (Mukherjee and Singh, 2005) [11].

Major weed flora observed in the experimental plot was *Cyperus difformis*, *Fimbristylis miliacea* and *Cyperus rotundus* (sedge), *Echinochloa colona*, *Cynodon dactylon* and *Echinochloa crusgalli* (among grasses). Whereas broad leaved weeds namely *Monochoria vaginalis, Eclipta alba*, *Ammannia baccifera*, *Ludwigia parviflora* and *Euphorbia hirta*. The major weed flora observed in the present study was also reported in the earlier studies by Abhishek (2014) [1] at Jabalpur,

Deepthi *et al*. (2010) [4] at Tirupati and Roy and Dharminder (2014) [15] at Delhi under transplanted paddy.

Now a days, the uses of herbicides are gaining popularity in paddy cultivation due to their rapid effects and lower costs compared to traditional methods. Many herbicides are being used successfully for weed control in paddy both as pre and post emergence spray. The study on use of herbicides of different chemical composition is desirable to reduce the problem of residue buildup, shift in weed flora and development of herbicide resistance in weeds. Hence the present investigation was to study the influence of herbicide molecules on weed control efficiency and productivity of transplanted Paddy in Kodagu region.

Material and Methods

This study was conducted at Agricultural and Horticultural Research Station, Ponnampet, Virjarpet taluk, Kodagu district comes under the agro climatic zone 9 (hilly zone) of Karnataka and is situated at 12^0 06' North latitude and 74^0 83' East longitude at an altitude of 867 meters above mean sea level to find out the suitable herbicide for effective weed control in transplanted paddy crop. The experiment having three replications was laid out in a Randomized Complete Block Design (RCBD) with net plot size of 3.2 m X 2.6 m. Tunga (IET 13901) was used as an experimental material.

Three days after transplanting, butachlor (5 % G) 30 kg ha^{-1} at 3 DAT and bensulfuron methyl 0.6 % G @ 60 g a.i. ha^{-1} + pretilachlor 6 % G @ 600 g a.i. ha^{-1} were applied by mixing with sand @ 75 kg ha^{-1} and broadcasted. Oxadiargyl (80 % WP) 100 g a.i. ha^{-1} at 3 DAT is sprayed with the help of knapsack sprayer as pre emergence herbicide. Penoxsulum 240 SC @ 22.5 g a.i. ha^{-1}, bispyribac sodium 10 SL @ 20 g a.i. ha^{-1}, 2, 4 D (80 % WP) at 2.5 kg ha^{-1} were sprayed as post emergent application at twenty days after transplanting with the help of hand operated knapsack sprayer and Ethoxysulfuron 15 WG @ 18.75 g a.i. ha^{-1} applied as post emergence were compared with weedy check in which no weeds were eradicated as well as with manual hand weeding. The quantity of water used in knapsack spray was 500 liters per ha.

Long duration (150-155) high yielding paddy variety was seedlings were transplanted with a spacing of 20 cm X 10 cm. The crop was fertilized with recommended doses of nitrogen, phosphorous and potassium (75:75:90 kg ha^{-1}). Full dose of phosphorous and half dosage of potassium, $^1/_3$ rd the dose of nitrogen, were supplied as a basal. The remaining nitrogen was top dressed twice in equal quantities; once during tillering stage (30 DAT) and the other during panicle initiation stage of the crop (55-60 DAT), remaining half dosage of potassium were applied at panicle initiation stage. Weed population and weed dry weight are subjected to $\sqrt{x+0.5}$ transformation, by using Fischer method of ANOVA the data was analyzed statistically for the test of significance. The level of significance of F test was 5 per cent. (Gomez and Gomez, 1984) [6].

Table 1: Influence of weed management practices on total weed population of broad leaved, grasses, sedges and total weed population in transplanted paddy

Treatment	Broad leaved Weeds	Grasses	Sedges	Total weed population
T_1:Butachlor 5 % G @ 30 kg ha^{-1} at 3 DAT	4.96 (24.12)	6.63 (43.42)	5.07 (25.16)	9.65 (92.7)
T_2:Oxadiargyl 80 % WP @ 100 g a.i. ha^{-1} at 3 DAT	4.86 (23.15)	6.21 (38.12)	4.97 (24.16)	9.27 (85.43)
T_3:Ethoxysulfuron 15 % G @ 18.75 g a.i. ha^{-1} at 20 DAT	4.43 (19.15)	6.05 (36.15)	4.91 (23.56)	8.91 (78.86)
T_4:Bispyribac-Na 10 % SL @ 20 g a.i. ha^{-1} at 20 DAT	4.24 (17.46)	6.01 (35.64)	4.64 (21.05)	8.64 (74.15)
T_5:Penoxsulum 240 SC @ 22.5 g a.i. ha^{-1} at 20 DAT	4.11 (16.42)	5.94 (34.84)	4.43 (19.15)	8.42 (70.41)
T_6:Butachlor @ 30 kg ha^{-1} at 3 DAT fb ethoxysulfuron 18.75 g a.i. ha^{-1} at 20 DAT	3.75 (13.56)	5.54 (30.23)	3.92 (14.85)	7.69 (58.64)
T_7:Butachlor @ 30 kg ha^{-1} at 3 DAT fb bispyribac-Na @ 20 g a.i. ha^{-1} at 20 DAT	3.14 (9.35)	5.40 (28.63)	3.61 (12.51)	7.14 (50.49)
T_8:Butachlor @ 30 kg ha^{-1} at 3 DAT fb penoxsulum @ 22.5 g a.i. ha^{-1}at 20 DAT	3.11 (9.15)	5.20 (26.51)	3.45 (11.38)	6.89 (47.04)
T_9: Oxadiargyl @ 100 g a.i. ha^{-1} at 3 DAT fb ethoxysulfuron @ 18.75 g a.i. ha^{-1} at 20 DAT	2.91 (7.98)	4.93 (23.8)	3.28 (10.23)	6.52 (42.01)
T_{10}:Oxadiargyl 100 g a.i. ha^{-1} at 3 DAT fb bispyribac-Na @ 20 g a.i. ha^{-1} at 20 DAT	2.76 (7.13)	4.81 (22.6)	3.10 (9.12)	6.27 (38.85)
T_{11}:Oxadiargyl @ 100 g a.i. ha^{-1} at 3 DAT fb penoxsulum @ 22.5 g a.i. ha^{-1} at 20 DAT	2.59 (6.23)	4.69 (21.54)	2.65 (6.51)	5.90 (34.28)
T_{12}:Bensulfuron methyl 0.6 G @ 60 g a.i. ha^{-1} + pretilachlor 6 % G @ 600 g a.i. ha^{-1} at 3 DAT	2.92 (8.05)	4.93 (23.85)	3.35 (10.75)	6.57 (42.65)
T_{13}: Butachlor 30 kg ha^{-1} fb 2, 4 D (80 % WP) at 2.5 kg ha^{-1} at 3 weeks after planting.	3.88 (14.52)	5.80 (33.15)	4.20 (17.15)	8.08 (64.82)
T_{14}: Hand weeding at 20 and 40 DAT	2.46 (5.53)	3.97 (15.23)	2.38 (5.15)	5.14 (25.91)
T_{15}: Unweeded check	6.83 (46.15)	6.73 (44.86)	6.99 (48.35)	11.83 (139.36)
S. Em. ±	0.17	0.18	0.17	0.32
CD at 5 %	0.51	0.52	0.48	0.94

Note: Data subjected to $\sqrt{x+0.5}$ transformation and figure in the parentheses indicate original values; DAT: days after transplanting; a.i.: active ingredient

Table 2: Influence of weed management practices on dry weight of broad leaved, grasses total dry weight, weed control efficiency and Grain yield in transplanted paddy

Treatment	Broad leaved weeds	Grasses	Sedges	Total weed dry weight	WCE (%)	Grain yield (kg/ha)
T_1:Butachlor 5 % G @ 30 kg ha^{-1} at 3 DAT	1.91 (3.15)	1.93 (3.24)	1.86 (2.96)	3.14 (9.35)	40.49	2836
T_2:Oxadiargyl 80 % WP @ 100 g a.i.ha^{-1} at 3 DAT	1.89 (3.07)	1.91 (3.14)	1.75 (2.56)	3.04 (8.77)	44.00	3078
T_3:Ethoxysulfuron 15 % G @ 18.75 g a.i. ha^{-1} at 20 DAT	1.84 (2.87)	1.89 (3.07)	1.57 (1.96)	2.90 (7.9)	49.55	3182
T_4:Bispyribac-Na 10 % SL @ 20 g a.i. ha^{-1} at 20 DAT	1.78 (2.67)	1.82 (2.82)	1.55 (1.89)	2.81 (7.38)	52.87	3299
T_5:Penoxsulum 240 SC @ 22.5 g a.i. ha^{-1} at 20 DAT	1.69 (2.35)	1.74 (2.51)	1.52 (1.82)	2.68 (6.68)	57.34	3396
T_6:Butachlor @ 30 kg ha^{-1} at 3 DAT fb ethoxysulfuron 18.75 g a.i. ha^{-1} at 20 DAT	1.60 (2.05)	1.65 (2.21)	1.37 (1.39)	2.48 (5.65)	63.92	3494
T_7:Butachlor @ 30 kg ha^{-1} at 3 DAT fb bispyribac-Na @ 20 g a.i. ha^{-1} at 20 DAT	1.56 (1.94)	1.63 (2.15)	1.35 (1.32)	2.43 (5.41)	65.45	3573
T_8:Butachlor @ 30 kg ha^{-1} at 3 DAT fb penoxsulum @ 22.5 g a.i. ha^{-1}at 20 DAT	1.49 (1.72)	1.59 (2.03)	1.32 (1.23)	2.34 (4.98)	68.20	3600
T_9:Oxadiargyl @ 100 g a.i. ha^{-1} at 3 DAT fb ethoxysulfuron @ 18.75 g a.i. ha^{-1} at 20 DAT	1.40 (1.45)	1.50 (1.74)	1.23 (1.02)	2.17 (4.21)	73.12	3862
T_{10}:Oxadiargyl 100 g a.i. ha^{-1} at 3 DAT fb bispyribac-Na @ 20 g a.i. ha^{-1} at 20 DAT	1.30 (1.2)	1.47 (1.67)	1.22 (0.98)	2.09 (3.85)	75.42	3907
T_{11}:Oxadiargyl @ 100 g a.i. ha^{-1} at 3 DAT fb penoxsulum @ 22.5 g a.i. ha^{-1} at 20 DAT	1.22 (0.98)	1.42 (1.53)	1.20 (0.95)	1.99 (3.46)	77.91	4068
T_{12}:Bensulfuron methyl 0.6 G @ 60 g a.i. ha^{-1} + pretilachlor 6 % G @ 600 g a.i. ha^{-1} at 3 DAT	1.47 (1.67)	1.55 (1.89)	1.28 (1.15)	2.28 (4.17)	73.37	3721
T_{13}:Butachlor 30 kg ha^{-1} fb 2,4 D (80 % WP) at 2.5 kg ha^{-1} at 3 weeks after planting.	1.66 (2.25)	1.71 (2.43)	1.40 (1.45)	2.57 (6.13)	60.86	3418
T_{14}:Hand weeding at 20 and 40 DAT	1.04 (0.58)	0.86 (0.24)	1.04 (0.58)	1.38 (1.40)	91.06	4300
T_{15}:Unweeded check	2.45 (5.48)	2.69 (6.73)	1.99 (3.45)	4.02 (15.66)	0.00	1821
S. Em. ±	0.11	0.08	0.11	0.40	1.97	145
CD at 5 %	0.32	0.23	0.32	1.16	5.70	421

Note: Data subjected to √x+0.5 transformation and figure in the parentheses indicate original values; DAT: days after transplanting; a.i.: active ingredient

Result and Discussion

The dominant weed flora of experimental fields consisted of *Echinochloa colona, Echinochloa crusgalli, Panicum repens* among grasses, *Cyperus difformis, Fimbristylis miliacea* and *Cyperus rotundus* among sedges and *Eclipta alba, Monocoria vaginalis, Ammannia baccifera, Ludwigia parviflora, Euphorbia hirta* and *Marselia quadrifolia among* broad leaved weeds The major weed flora observed in the present study was also reported in the earlier studies by Abhishek (2014) [1] at Jabalpur, Deepthi *et al*. (2010) [4] at Tirupati and Roy and Dharminder (2014) [15] in transplanted paddy.

In the experimental field, grassy weeds were dominated, followed by sedge and the broad leaf weeds at all stages of the crop growth. Considering the dry weight of weeds grasses dominated, followed by broad leaf and it was lower with sedge weeds. In the present study, grasses namely *Echinochloa colona*, *Echinochloa crusgalli* were higher in density initially and consequently had higher dry weight, by virtue of higher stature, than other weeds which have short stature sedge (*Fimbristylis miliacea*, *C. rotundus*) and broad leaf weeds (*Monochoria vaginalis*, *Eclipta alba*, *Ammannia baccifera*, *Ludwigia parviflora* and *Euphorbia hirta*). As observed in the present study, Roy and Dharminder (2014) [15], Vimal *et al.* (2014) have also observed the dominance of grasses by virtue of their tall stature in causing more dry weight than other weeds. Further, *Monochoria vaginalis* showed higher density and dry weight in the present study indicating the second next category of weed competing in paddy, as also spelt out by Hasanuzzaman *et al.* (2008), Pal *et al.* (2009) in transplanted paddy.

Total weed population and dry weight of weeds were more in unweeded control when compared to other treatments. Unweeded control recorded significantly higher weed population (139.36 0.25 m^{-2}) throughout the crop growth period (Table 1). This can be attributed to no weed control in unweeded plot which lead to severe crop weed competition resulted in poor crop growth and yield. The reduction in crop yield due to crop weed competition was indicated by weed index values. Significantly lower weed index (5.40 %) value was recorded in oxadiargyl 80 % WP @ 100 g a.i. ha^{-1} at 3 DAT fb penoxsulum @ 22.5 g a.i. ha^{-1} at 20 DAT (Table 2). These findings are in agreement with the findings of Pal and Banerjee (2007). The lower weed index was due to higher weed control efficiency. The higher weed control efficiency (77.91 to 92.79 %) was recorded with oxadiargyl 80 % WP @ 100 g a.i. ha^{-1} at 3 DAT fb penoxsulum @ 22.5 g a.i. ha^{-1} at 20 DAT was due to effective control of all types of weed by its biochemical inhibition of protoporphyrinogen oxidase enzyme in the plant by oxadiargyl and acetolactase synthase inhibition by penoxsulum herbicide which resulted in the lower dry weight of the weed population. These findings are in line with Moorthy and Sanjoy (2002).

The weed population and dry weight of different weeds differed significantly due to herbicide treatments at all the growth stages of crop. Differences in weed population and dry weight were might be due to better weed control efficiency of herbicides. Among different herbicide sequential application of oxadiargyl 80 % WP @ 100 g a.i. ha^{-1} at 3 DAT fb penoxsulum @ 22.5 g a.i. ha^{-1} at 20 DAT and oxadiargyl 80 % WP @ 100 g a.i. ha^{-1} at 3 DAT fb bispyribac-Na 10 % SL @ 20 g a.i. ha^{-1} at 20 DAT were found more effective in controlling all types of weeds viz., grasses, sedges and broad leaved weeds throughout the crop growth period as evidenced from lower weed population and dry weight when compared to other herbicides (34.28 and 38.85 0.25 m^{-2} and 3.46 & 3.85 g 0.25 m^{-2} respectively) whereas hand weeding at 20 & 40 DAT found superior over all the treatments (25.91 m^{-2} & 3.46 g 0.25 m^{-2}).

Weed control efficiency denotes the efficiency of applied herbicide or treatment affect in reducing the dry weight of

weeds. All the weed control treatments varied significantly with respect to weed control efficiency at 60 DAT and harvest. Weed control efficiency gradually decreased from 60 DAT to harvest. significantly highest weed control efficiency was obtained with oxadiargyl @ 100 g a.i.ha^{-1} at 3 DAT fb penoxsulum @ 22.5 g a.i. ha^{-1} at 20 DAT (92.79 %) followed by oxadiargyl @ 100 g a.i. ha^{-1} at 3 DAT fb bispyribac-Na @ 20 g a.i. ha^{-1} at 20 DAT (89.24 %).Whereas, butachlor 5 % G @ 30 kg ha^{-1} at 3 DAT followed by oxadiargyl @ 100 g a.i. ha^{-1} at 3 DAT and ethoxysulfuron 15 WG @ 18.75 g a.i. ha^{-1} at 20 DAT recorded significantly lower weed control efficiency (43.10, 50.44 and 52.29, respectively).

Significantly higher grain yield was recorded in the treatment hand weeding twice at 20 and 40 DAT (4300 kg ha^{-1}) which was comparable to application of oxadiargyl @ 100 g a.i. ha^{-1} at 3 DAT fb penoxsulum @ 22.5 g a.i. ha^{-1} at 20 DAT (4068 kg ha^{-1}) followed by oxadiargyl @ 100 g a.i. ha^{-1} at 3 DAT fb bispyribac sodium @ 25 g a.i. ha^{-1} at 20 DAT (3907 kg ha^{-1}) are found significantly superior over other treatments in the study (Table 2). On the other hand the lowest yield (1821 kg ha^{-1}) was obtained in the treatment unweeded check. This better yield is due to better weed control efficiency and that leads to better growth and yield parameters in the paddy crop. The better weed control efficiency might be due to combination of herbicide treatment which are effective against management of complex weed flora observed in the experimental plot. These results are in conformity with the findings of Chandra *et al.* (2013) [2] and Deepti and Subramanyam, (2010) [4], Jayadeva (2010) [8], Sunil *et al.* (2010) [16].

Conclusion

Application of oxadiargyl 80 % WP @ 100 g a.i. ha^{-1} at 3 DAT as a pre-emergence spray in combination with penoxsulum 240 SC @ 22.5 g a.i. ha^{-1} at 20 DAT as a post-emergence and oxadiargyl @ 100 g a.i. ha^{-1} at 3 DAT fb bispyribac sodium @ 25 g a.i. ha^{-1} at 20 DAT spray is the best combination to obtaine better yield by effective control of weeds in transplanted paddy in Kodagu region. No doubt, the results of two hand weeding are significantly better in terms of weed control and grain yield, but as it is time consuming, labouries and expensive and it can't be recommended for labour scares area like Kodagu region.

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