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Performance of Various Weed Management Approaches on Weed Dynamics, Yield Attributes and Yield of Puddled Rice under Different Planting Techniques

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ABSTRACT

Background: Rice is a major food source worldwide and direct seeding can shorten crop duration and reduce labour. The system of rice intensification (SRI) can boost yields with fewer inputs. Weed management is crucial for high yields, but chemical herbicides may not be necessary with SRI. A study evaluated herbicide performance based on rice establishment methods.

Methods: An field experiment was conducted in January to May, 2021 (*Navarai*) to find out the efficient weed control techniques in puddled rice. The experiment has been carried out in split-plot design, which included two planting techniques *viz*., drum seeded rice and system of rice intensification (SRI) in main plot, as well as eight weed control techniques *viz*., hand weeding, cono weeding, pretilachlor, bispyribac sodium and fenoxaprop - p - ethyl as pre and post emergence application in sub plot.

Result: The results of the experiment demonstrated that among the planting techniques and weed management practices tested, the system of rice intensification and sequential application of pretilachlor @ 0.5 kg a.i ha^{-1} *fb* bispyribac sodium @ 20 g a.i ha^{-1} has revealed lowest weed density and highest weed control efficiency, yield attributes and yield and energetics.

Key words: Bisyribac sodium, Drum seeded rice, Pretilachlor, Puddled rice, SRI.

INTRODUCTION

Rice is the most significant staple food crop for more than half of the world's population, particularly in densely populated areas experiencing fast expansion. In irrigated lowland rice, transplanting is the most common and traditional establishment technique. Increasing water scarcity is becoming a severe danger to rice cultivation. Thus, it is necessary to create water-saving technology that simultaneously preserves soil sustainability and health while still being profitable (Hugar *et al*., 2010).

Drum-seeded rice under puddled conditions has significant relevance in modern production systems since it saves time, labour, energy and profitability while increasing cropping intensity by lowering turnaround time and avoiding onerous activities like nursery preparation and hand transplanting. Across the world, especially in India, the SRI cultivation technique is gradually gaining popularity. In comparison to the traditional technique of farming in India, the SRI is a methodology to boost rice output by altering microclimate and soil conditions and also minimises the usage of inputs like water and labour (Mohanty *et al*., 2014).

In agroecosystems, weeds are the main factor in low productivity and financial loss. Weeds also extrude chemicals from their roots and leaves that are harmful to plant crops, interfering with normal crop growth and resulting in a drop in yield and quality (Vikram sai *et al*., 2022). Chemical weed management is increasingly popular and is the ideal alternative to manual weeding since hand weeding is labour-intensive, tedious, time-consuming and impracticable in adverse weather. Using herbicides was the more appealing choice as the operation would be finished in one application and save time. Moreover, it broadens the range of weed control in a single application, lowers the cost of treatment and minimizes herbicide damage and consumption rate to crops (Guru *et al*., 2020).

In this light, the current study was conducted to assess "The performance of various weed management approaches on weed dynamics and yield of puddled rice under different planting techniques."

MATERIALS AND METHODS

A field experiment was conducted in experimental farm of Faculty of Agriculture, Annamalai University during the

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Navarai season of 2021 which is located at a latitude of 11°24′N, longitude of 79°44′E and at an altitude ± 5.79 MSL. The climate of the experimental area is humid tropic, with an average rainfall of 1248 mm and maximum and minimum temperatures recorded during the planting season were 22.6°C and 32.3°C, respectively. The experiment has been laid out in split plot design which consists of two planting techniques - drum seeded rice, system of rice intensification (SRI) in main plot and eight weed management approaches - weedy check, Hand weeding twice, Cono weeding thrice, Pretilachlor @ 0.5 kg a.i ha^{-1} *fb* Cono weeding on 30 DAS/DAT, Fenoxaprop - p - ethyl @ 56.60 g a.i ha^{-1} *fb* Cono weeding on 40 DAS/DAT, Bispyribac sodium @ 20 g a.i ha^{-1} *fb* Cono weeding on 40 DAS/DAT, Pretilachlor @ 0.5 kg a.i ha^{-1} *fb* Fenoxaprop - p - ethyl @ 56.60 g a.i ha^{-1}, Pretilachlor @ 0.5 kg a.i ha^{-1} *fb* Bispyribac sodium @ 20 g a.i ha^{-1} in sub plot and was replicated thrice. ADT 43 variety was used as test crop.

In drum seeding, germinated seeds were planted using a manually operated rice drum seeder with a spacing of 20 × 10 cm. In SRI, 14-day-old seedlings were manually transplanted with a spacing of 25 × 25 cm @ 2 seedlings hill^{-1}.

Hand weeding was done twice, once on 20 DAS/DAT and second on 40 DAS/DAT. Conoweeding was done thrice at 10 days interval starting from 20, 30 and 40 DAS/DAT. Pretilachlor was applied as pre-emergence on 8 DAS in drum seeding and 3 DAT in SRI method of planting while both Fenoxaprop - p - ethyl @ 56.38 g ha^{-1} and Bispyribac sodium @ 20 g ha^{-1} as a post-emergence herbicide with 500 l of water ha^{-1} were applied on 20 DAS/DAT. The observations on weed density and weed control efficiency were recorded on 30DAS/DAT and 60DAS/DAT. Yield parameters were taken from five randomly selected places using 1 m^2 quadrant from net plot area. Square root of transformation was done for weed density by using the formula $\sqrt{(X + 0.5)}$, the data relating to weed control efficiency was transformed by arc sin transformation. All the observations recorded in the experiment were statistically analysed by AGRES software.

Data regarding cultural energy used through various inputs was computed and energetics were worked out as suggested by Mittal *et al*., 1985.The energy equivalents used for different inputs and outputs were mentioned in Table 1.

Energy use efficiency (EUE)

$$\text{Energy use efficiency} = \frac{\text{Energy output (MJ ha}^{-1})}{\text{Energy input (MJ ha}^{-1})}$$

Energy productivity

$$\text{Energy productivity} = \frac{\text{Output (Grain yield) (ha}^{-1})}{\text{Energy input (MJ ha}^{-1})}$$

Energy profitability

$$\text{Energy profitability} = \frac{\text{Net energy (MJ ha}^{-1})}{\text{Input energy (MJ ha}^{-1})}$$

Specific energy

$$\text{Specific energy (MJ kg}^{-1}) = \frac{\text{Input energy (kg ha}^{-1})}{\text{Grain yield (kg ha}^{-1})}$$

RESULTS AND DISCUSSION

Weed flora of the experiment site

The prominent weeds appeared in the experimental field at all stages of observation were *Echinochloa colona, Echinochloa crusgali, Leptochloa chinensis* among grasses and in sedges *viz*., *Cyperus diffoirmis, Cyperus iria, Cyperus rotundus* and among broad leaved weeds *viz*., *Eclipta alba, Sphenoclea zelyancia, Bergia capensis* and *Marsilea quadrifolia*.

Weed density and dry weight

Weed density and dry weight was considerably influenced by different weed management approaches and planting techniques (Table 2). Among the planting techniques, the SRI method of planting recorded the lowest weed density (29.90 and 60.45 no.m^{-2}) and weed dry weight (26.47 and 5313 g m^{-2}) on both 30 and 60 DAT. This might be attributed to SRI resulting in decreased weed density owing to puddling, which buries weeds into the deeper layer of the mud where anaerobic activity can degrade them, resulting in less emergence of deeply planted weed seeds (Kumar *et al*., 2021).

Irrespective of the weed management approaches evaluated, the combined application of pretilachlor @ 0.5 kg a.i ha^{-1} *fb* bispyribac sodium @ 20 g a.i ha^{-1} as resulted in the lower weed density (10.03 and 25.91 no m^{-2}) and dry weight (8.76 and 22.11 g m^{-2}). This might be attributed to pretilachlor, as PE is particularly effective on grasses and sedges. When sprayed, it penetrates predominantly by the sprouting shoots and secondly through the roots, with translocation throughout the plant resulting in the impact on weed seed at early stages. Since bispyribac sodium is an ALS (acetolactate synthase) inhibitor, it interferes with producing a plant enzyme necessary for growth. It reduces plant amino acid synthesis, resulting in weed control at a

Table 1: Energy equivalence for direct and indirect sources.

Input	Units	Equivalent energy (MJ)
Human labour		
Adult men	Hrs	1.96
Adult women	Hrs	1.57
Diesel	Litre	56.31
Fertilizers		
Nitrogen	Kg	60.6
Phosphorus	Kg	11.1
Potassium	Kg	6.7
Pesticides		
Herbicides	Kg	102
Insecticides	Kg	102
Seeds	Kg	14.7

later stage of the crop. These results were in concordance with (Surayakala *et al*., 2019).

Weed control efficiency

The findings in Table 2 reveal that among the planting techniques followed, the highest weed control efficiency was registered by SRI method of planting (69.96 and 67.04 on 30 and 60 DAT). This might be because the smothering effect of rice seedlings on developing weeds resulted in minimal weed emergence. These findings are in agreement with those of (Hassan *et al*., 2010).

The consecutive application of pretilachlor @ 0.5 kg a.i ha^{-1} *fb* bispyribac sodium @ 20 g a.i ha^{-1} recorded highest weed control efficiency (90.26 and 86.09 at 30 and 60 DAS/DAT).This might be owing to the persistence of pretilachlor *fb* bispyribac sodium, which could have considerably helped to control the weeds for longer period. Pretilachlor was reported to have a half-life period of 7.52-9.58 days (Kaur *et al*., 2015) and bispyribac sodium is comparatively more persistent with a half-life of 9.93 days (Ramprakash*et al*., 2015) and persists up to 42-115 days (Singh and Singh, 2015) in soil and may have delivered the highest weed control efficiency. These findings were in agreement with the findings of (Chinnamani*et al*., 2018 and Rathika and Ramesh, 2018).

Yield attributes and yield

The data in Table 3 shows that in terms planting techniques evaluated, the SRI technique of transplanting produced higher productive tillers m^{-2} (309.70) and filled grains panicle^{-1} (91.25). This might be because seedlings were transplanted earlier, allowing for extra tillering and roots. In addition, larger spacing in a square pattern allowed for increased canopy and root growth and subsequent grain filling. These findings are concurrence with those of (Nazir *et al*., 2020; Sai *et al*., 2022).

The yield attributes were significantly altered by weed management practices (Table 3). However, the application of pretilachlor @ 0.5 kg a.i ha^{-1} *fb* bispyribac sodium @ 20 g a.i ha^{-1} registered higher productive tillers m^{-2} (359.24) and filled grains panicle^{-1} (100). This might be because early weed control with PE herbicides favoured strong crop development, followed by later PoE herbicide treatment of emerging weeds, decreased competition, enhanced the capacity of source and sink and resulted in higher yield characteristics. This was in accordance with the results of (Kuotosu and Singh, 2020).

The highest grain yield was registered by SRI method of planting (5.01 t ha^{-1}). This is most likely due to the massive root volume, profuse and vigorous tillers with longer and more panicles with higher grain weight, all of which contributed to increased grain yield. These findings agree with those of Kumar *et al*. (2015); Nath and Dev (2018) and Kuotsu and Singh (2020).

The grain yield was substantially affected by different weed management approaches. Among the weed management approaches tested, the application of

Table 2: Effect of planting techniques and weed management practices on weed density, dry weight and weed control efficiency on 30 and 60 DAS/DAT.

Treatments	Weed density m^{-2}		Weed dry weight g m^{-2}		Weed control efficiency	
	30 DAS/DAT	60 DAS/DAT	30 DAS/DAT	60 DAS/DAT	30 DAS/DAT	60 DAS/DAT
Planting techniques						
Drum seeded rice	6.39(40.35)	8.91(78.91)	6.09(36.55)	8.34(69.11)	61.40	57.99
SRI	5.51(29.90)	7.81(60.45)	5.19(26.47)	7.32(53.13)	69.96	67.04
S.Ed	0.06	0.07	0.08	0.10	-	-
C.D (p=0.05)	0.24	0.29	0.36	0.45	-	-
Weed management practices						
Weedy check	10.13(102.04)	13.64(185.62)	9.64(92.52)	12.88(165.38)	-	-
Hand weeding twice	3.59(12.42)	5.49(29.62)	3.37(10.89)	5.08(25.35)	87.91	84.08
Conoweeding thrice	5.07(25.21)	7.26(52.27)	4.78(22.40)	6.76(45.27)	75.52	71.95
Pretilachlor @ 0.5 kg a.i ha^{-1} *fb* Cono weeding on 30 DAS/DAT	6.58(42.77)	9.14(83.13)	6.24(38.47)	8.57(72.96)	58.22	55.28
Fenoxaprop - p - ethyl @ 56.60 g a.i ha^{-1}*fb* Cono weeding on 40 DAS/DAT	6.47(41.35)	9.02(80.88)	6.15(37.34)	8.44(70.22)	59.61	56.49
Bispyribac sodium @ 20 g a.i ha^{-1}*fb* Cono weeding on 40 DAS/DAT	4.62(20.81)	6.67(44.02)	4.34(18.32)	6.21(38.04)	79.69	76.33
Pretilachlor @ 0.5 kg a.i ha^{-1} *fb* Fenoxaprop - p - ethyl @ 56.60 g a.i ha^{-1}	5.19(26.41)	7.52(56.00)	4.89(23.40)	7.00(48.57)	74.21	69.89
Pretilachlor @ 0.5 kg a.i ha^{-1} *fb* Bispyribac sodium @ 20 g a.i ha^{-1}	3.24(10.03)	5.14(25.91)	3.04(8.76)	4.75(22.11)	90.26	86.09
S.Ed	0.23	0.31	0.23	0.29	-	-
C.D (p=0.05)	0.47	0.63	0.48	0.60	-	-

Note: Weed density and Weed dry weight: Figures in the parenthesis are original values; Values are square root transformed values.

pretilachlor @ 0.5 kg a.i ha^{-1} *fb* bispyribac sodium @ 20 g a.i ha^{-1} (5.98 t ha^{-1}) was the most effective approach. This could be due to the sequential application of pretilachlor @ 0.5 kg a.i ha^{-1} as a PE herbicide, which effectively controlled the weeds during the germination phase and bispyribac sodium @ 20 g a.i ha^{-1} as a PoE, which further reduced the late germinating weeds, resulting in an increase in plant biomass and productive tillers, resulting in the highest grain yield. These are congruent with the findings of (Bhattacharya *et al*., 2022, Kumaran *et al*., 2013 and Walia *et al*., 2012).

Energetics

The data regarding the energy use efficiency and profitability was furnished in Table 4. Among the planting techniques evaluated the highest energy use efficiency (13.96 MJ ha^{-1}), profitability (12.96 MJ ha^{-1}) and energy productivity (0.40 kg MJ^{-1}) was found in the SRI method of planting along with PE application of pretilachlor @ 0.5 kg a.i ha^{-1} *fb* bispyribac sodium @ 20 g a.i ha^{-1}. It might be due to the high output energy generation in the SRI technique. However, in both planting techniques and weed management practices the lowest specific energy was registered by SRI planting (2.63 MJ kg^{-1}) and pretilachlor @ 0.5 g a.i ha^{-1} *fb* PoE application of bispyribac sodium @ 20 g a.i ha^{-1}(2.08 MJ kg^{-1}) due to higher grain yield.

Irrespective weed management practices tested, highest energy use efficiency, profitability and energy productivity was registered by the sequential application of

Table 3: Effect of planting techniques and weed management practices on yield attributes and yield.

Treatments	Productive tillers m^{-2}	Filled grains $panicle^{-1}$	Grain yield (t ha^{-1})
Planting techniques			
Drum seeded rice	277.72	87.38	4.40
SRI	309.70	91.25	5.01
S.Ed	4.60	0.86	0.08
C.D (p=0.05)	19.78	3.69	0.34
Weed management practices			
Weedy check	202.08	76.50	2.84
Hand weeding twice	354.75	97.50	5.90
Conoweeding thrice	306.65	91.00	4.94
Pretilachlor @ 0.5 kg a.i ha^{-1} *fb* Cono weeding on 30 DAS/DAT	253.15	83.50	3.92
Fenoxaprop - p - ethyl @ 56.60 g a.i ha^{-1}*fb* Cono weeding on 40 DAS/DAT	259.63	84.50	4.04
Bispyribac sodium @ 20 g a.i ha^{-1}*fb* Cono weeding on 40 DAS/DAT	320.13	92.00	5.25
Pretilachlor @ 0.5 kg a.i ha^{-1} *fb* Fenoxaprop - p - ethyl @ 56.60 g a.i ha^{-1}	294.07	89.50	4.75
Pretilachlor @ 0.5 kg a.i ha^{-1} *fb* Bispyribac sodium @ 20 g a.i ha^{-1}	359.24	100.00	5.98
S.Ed	8.77	2.40	0.15
C.D (p=0.05)	17.98	4.92	0.31

Table 4: Effect of planting techniques and weed management practices on yield attributes and yield.

Treatments	EUE	EP	Energy productivity	Specific energy
Planting techniques				
Drum seeded rice	12.32	11.32	0.35	0.32
SRI	13.96	12.96	0.40	0.37
Weed management practices				
Weedy check	8.13	7.13	0.23	0.21
Hand weeding twice	16.02	15.02	0.46	0.42
Conoweeding thrice	13.82	12.82	0.40	0.36
Pretilachlor @ 0.5 kg a.i ha^{-1} *fb* Cono weeding on 30 DAS/DAT	11.07	10.07	0.32	0.29
Fenoxaprop - p - ethyl @ 56.60 g a.i ha^{-1}*fb* Cono weeding on 40 DAS/DAT	11.41	10.41	0.33	0.30
Bispyribac sodium @ 20 g a.i ha^{-1}*fb* Cono weeding on 40 DAS/DAT	14.70	13.70	0.42	0.38
Pretilachlor @ 0.5 kg a.i ha^{-1} *fb* Fenoxaprop - p - ethyl @ 56.60 g a.i ha^{-1}	13.36	12.36	0.38	0.34
Pretilachlor @ 0.5 kg a.i ha^{-1} *fb* Bispyribac sodium @ 20 g a.i ha^{-1}	16.62	15.62	0.48	0.44

Note: Data was not analyzed.

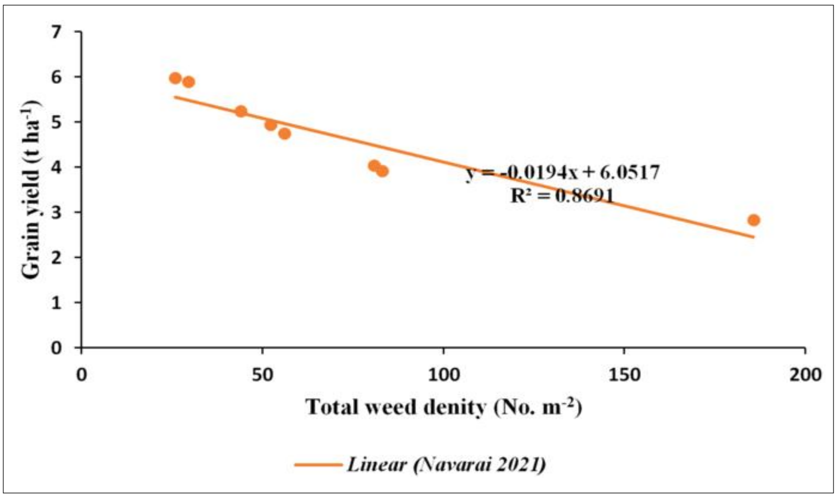

Fig 1: Linear relationship between total weed density (no m^{-2}) and grain yield (t ha^{-1}).

PE pretilachlor @ 0.5 kg a.i ha^{-1} *fb* PoE application of bispyribac sodium @ 20 g a.i ha^{-1} (16.62, 15.62 MJ ha^{-1} and 0.48 kg MJ^{-1}, respectively). This might be attributed to more incredible output energy by reducing weed competition and improving crop production.

Linear relationship

Fig 1 depicts that in *Navarai*, 2021 the linear association between total weed density and grain yield was strongly and negatively correlated (r = -0.931). The study found that weed interference contributed to the negative influence on crop yield attributes, which reduced the yield in both SRI and drum-seeded rice, with uncontrolled weeds causing over 52.51 and 53.56% yield reduction in both the planting techniques.

CONCLUSION

The results of the field experimentation concluded that the SRI strategy of planting, along with the application of PE pretilachlor @ 0.5 kg ha^{-1} *fb* PoE bispyribac sodium @ 20 g ha^{-1} reduced the infestation of dominant weed species and these practises could be suggested as an efficient, economically viable, ecologically desirable and practically feasible management system for controlling weed species in the puddled rice wetland ecosystem.

Conflict of Interest

All authors declare that they have no conflicts of interest.

REFERENCES

Bhattacharya, U., Ghosh, A., Sarkar, S. and Maity, S. (2022). Response of Rice (*Oryza sativa* L.) to weed management methods in the lower gangetic plain zone. Indian Journal of Agricultural Research. 56(5): 1-7. doi: 10.18805/IJARe.A-5919.

Chinnamani, I., Aasif, M., Kumar, N.S., Velayutham, A. and Suresh, S. (2018). Influence of weed management practices on weed dynamics and yield of drum seeded rice under puddled condition. International Journal of Advances in Agricultural Science and Technology. 5(7): 17-23.

Guru, R.K., Dwivedi, S.K., Khajanji, S.N. and Jha, S.K. (2020). Efficacy of herbicides in managing weeds in direct-seeded rice. Indian Journal of Weed Science. 52(3): 222-226.

Hassan, D., Upasani, R.R., Thakur, R., Singh, M.K. and Puran, A.N. (2010). Productivity of rice as affected by planting method and weed management. Indian Journal of Weed Science. 42(1and2): 67-69.

Hugar, A.Y., Chandrappa, H., Jayadeva, H.M., Sathish, A. and Mallikarjun, G.B. (2010). Comparative performance of different rice establishment methods in bhadra command area. Karnataka Journal of Agricultural Sciences. 22: 992-994.

Kaur, P., Kaur, P. and Bhullar, M.S. (2015). Persistence behaviour of pretilachlor in puddled paddy fields under subtropical humid climate. Environmental Monitoring Assessment. 187: 1-7.

Kumar, R., Singh, D.K., Nanda, G. and Rawat, A. (2021). Weed dynamics in rice *(Oryza sativa* L.) as influenced by different establishment methods and nutrient management practices. Biological Forum. 13: 680-687.

Kumar, S., Sinha, K.K. and Singh, D. (2015). Crop establishment, fertility and weed management practices in scented hybrid rice. Indian Journal of Weed Science. 47: 113-116.

Kumaran, S.T., Kathiresan, G., Muraliarthanari, P., Chinnusamy, C. and Sanjivkumar, V. (2013). Evaluation of new herbicide (bispyribac sodium 10% SC) on weed control in direct seeded lowland rice (*Oryza sativa* L.). Journal of Ecobiology. 32: 177-183.

Kuotsu, K. and Singh, A.P. (2020). Establishment and weed management effects on yield of lowland rice (*Oryza sativa*). Journal of Pharmacognosy and Phytochemistry. 9: 1742-1744.

Mohanty, T.R., Maity, S.K. and Roul, P.K. (2014). Response of rice to establishment methods and nutrient management practices in medium land. Oryza. 51: 136-142.

Nath, R and Dev, J. (2018). Effect of establishment methods under different weed management technique on rice and associated weeds. Journal of Pharmacognosy and Phytochemistry. 7(5): 807-810.

Nazir, A., Bhat, M.A., Bhat, T.A., Rashid, Z., Mohiuddin, R., Fayaz, S. and Wani, S.A. (2020). Crop establishment and weed management effect on weed parameters and rice yield under temperate zone of Kashmir. Indian Journal of Weed Science. 52: 217-221.

Ramprakash, T., Madhavi, M., Yakadri, M. and Srinivas, A. (2015). Bispyribac sodium persistence in soil, plant and grain in direct seeded rice and its effect on soil properties. Nature Environment and Pollution Technology.14: 605609.

Rathika, S. and Ramesh, T. (2018). Weed management effect in system of rice intensification. Indian Journal of Weed Science. 50: 388-390.

Sai, M.V., Chettri, P., Murugan, G., Kumar, M.S. and Kalyan, B.V. (2022). Influence of different age of seedlings and micro nutrient management practices on growth and yield attributes of rice (*Oryza sativa* L.) under system of rice intensification. Bhartiya Krishi Anusandhan Patrika. 37(1): 76-79. doi: 10.18805/BKAP411.

Singh, N and Singh, S.B. (2015). Adsorption and leaching behaviour of bispyribac-sodium in soils. Bulletin of Environmental Contamination and Toxicology. 94: 125-128.

Suryakala, P., Murugan, G., Saravanaperumal, M., Suseendran, K. and Stalin, P. (2019). Effect of weed management practices with new generation herbicides in transplanted rice. Journal of Pharmacognosy and Phytochemistry. 8: 3913-3915.

Vikram Sai, M., Murugan, G., Saravana Perumal, M. and Kathiravelu, C. (2022). A phytosociological survey on weed flora and diversity in rice fields of chidambaram block, T.N., India. Ecology Environment and Conservation. 28(Nov Suppl issue): 454-458.

Walia, U.S., Walia, S.S., Sidhu, A.S., Nayyar, S. (2012). Bio efficacy of pre- and post-emergence herbicides in direct-seeded rice in Central Punjab. Indian Journal of Weed Science. 44: 30-33.