Journal of AgriSearch 2(4): 251-256
Peer Reviewed Quarterly
ISSN : 2348-8808 (Print), 2348-8867 (Online)

Impact of Soil Seed Bank Dynamics on Weedy Rice Distribution and Farmer Involvement in Management: Case Study in Marata District, Sri Lanka

DISNA RATNASEKERA*, **UIP PERERA, APT SUBHASHI**

Department of Agricultural Biology, Faculty of Agriculture, University of Ruhuna, Sri Lanka.

ARTICLE INFO

Received on : 26.07.2015
Accepted on : 02.09.2015
Published online : 01.12.2015

ABSTRACT

Weedy rice (*Oryza sativa* f. *spontanea*) reduces rice yield qualitatively and quantitatively. This case study was carried out to assess the impact of weedy rice seed soil bank dynamics to the temporal density variation in consecutive two years and to assess the farmers' involvement on the management of weedy rice in the area. For soil seed bank dynamics, soil samples were collected from 12"x12" 3" space with ten random samples per each location while number of weedy rice plants in 1m^2 quadrate was counted in five different places per each location with at least 5m distance between populations in following two consecutive seasons. Our results revealed significantly wide range of variability of weedy rice seed persistency (153.9 - 42.2) in soil seed bank showing their high adaptability and direct correlation to temporal density in rice ecosystems. The 77% of weedy rice infested paddy lands were direct seeded and collective approaches were used by farmers to control weedy rice in the area. The best preventive measure identified was practice of high-quality paddy seeds. The understanding of the soil seed bank dynamics, diversity, density and distribution is vital to implement successful and efficient management practices.

Keywords: Distribution, Soil seed bank, Variation, Weedy rice

INTRODUCTION

Rice (*Oryza. sativa* L.) is one of the nutritionally important cereal crops and is the principal staple food for more than half of the population (Singh *et al*., 2012). About 90% of rice production and consumption worldwide occurs in Asia (Gealy *et al*., 2003 and Singh *et al*., 2009). One of the major obstacles to rice production is the lack of stable yields due to several major diseases and pests, in addition to weeds. Of the weeds affecting rice production, weedy rice is the main constraint. Weedy rice (*Oryza sativa f. spontanea*) of the Poaceae is one of the most persistent and noxious weeds widely distributed in rice-planting areas all over the world (Ferrero *et al*., 1999; Mortimer *et al*., 2000 and Laik *et al*., 2014). It is botanically classified as the same species as cultivated rice, but is strongly characterized by its enhanced ability to disseminate seeds rapidly, which apparently increases its' distribution. Populations of weedy rice tend to be genetically diverse and highly heterogeneous (Chang, 2003).The seeds have high levels of shattering and dormancy, which enhances the re-seeding rates and increases the weediness of this species (Kumar *et al*., 2015 and Singh *et al*., 2010). Morphologically, weedy rice is highly variable and appears to be an intermediate between wild and cultivated rice (Singh *et al*., 2008). Hand removal of weedy rice seedlings in rice fields at the early growth stages is impractical because once established, weedy rice is phenotypically very similar to cultivated rice (He *at al*., 2014). The reason to spread out the weedy rice in rice fields is believed to be as a result of shifting from transplanting to direct seeding. Weedy rice is distributed over a wide area and seems to possess a wide variation in characteristics. It was first identified as a threat from Vavunia, Ampara, and Batticaloa, districts in Sri Lanka (Marambe and Amarasinghe, 2000). At present, weedy rice infestation is recorded in Puttlam, Anuradhapura, Polonnaruwa, Kurunegala and Matara districts becoming a major issue for rice production. Matara district situated in Southern Province of Sri Lanka, having a mean annual rainfall between 1,750

* Corresponding author email: disnaratnasekera@gmail.com

to 2,500 mm, with a short and less prominent dry season, contributing 45455MT of rice to the national rice production (Central Bank, 2010). The paddy lands in Matara district infested by weedy rice rapidly apparently within a short period of time, has become a serious challenge for rice production. Therefore, continuous attention on the emergence of weedy rice, role of soil seed bank enrichment, potential management practices adopting and the resulting changes of density and distribution of weedy rice has become an important issue for rice production in the area.

MATERIALS AND METHODS

A field survey was carried out during late June to early September in South Western Monsoon season 2012 and 2013 in Matara district and samples were collected. The longitude and latitude of each location was recorded using a Global Positioning System (GPS). In the selected fields, 10 soil samples were randomly collected from space of 12″*12″*3″. The collected soil samples were thoroughly washed out using a sieve and the number of weedy seeds and improved seeds were counted. For temporal density of weedy rice, five rice fields with a distance of at least 1 km from each other were randomly selected for each location. The number of weedy rice plants in a randomly placed 1m^2 quadrate was counted in five different places assuming an each place at the same field as a replicate. The locations and corresponding agro ecological regions were tabulated in table 1. In addition, information on the occurrence of weedy rice during the past years and the effect of crop establishment method (direct seeding or transplanting) on weedy rice emergence were recorded. Farmers' efforts and practices adopting on control of weedy rice in the field and their perspectives on weedy rice management was obtained by field investigations and questionnaires to local farmers who owned the rice fields with weedy rice and to regional agricultural extension officers in Matara district.

RESULTS AND DISCUSSION

Temporal distribution of weedy rice

Most of the paddy fields have been infested with different densities of weedy rice. The density and distribution pattern of weedy rice in Matara district in 2012 and 2013 was shown in fig.1a and b. According to the density and distribution map of weedy rice, Thihagoda was highly infested with weedy rice having a density of 22-25 plants per square meter followed by Kirinda-Puhulwella (20/m^2) and Kamburupitiya (15-20/m^2). The least infestation was (3-7/m^2) observed at Kotapola, Pitabeddara and Akuressa. In contrary, all the locations showed a strong reduction of weedy rice population in 2012 than in 2013 in the South Western monsoon season showing awareness and successive involvement of farmers in controlling weedy rice.

Soil seed bank dynamics

The higher variation of weedy rice seeds in soil seed bank was observed among selected populations in Matara district in Sri Lanka.

The letters behind the mean value indicate significant differences between populations based on Duncan's Multiple Range Test. Mean with the same letters are not significantly different at P<0.05.

Table 1: Agro ecological zone, longitude and latitude of the tested locations

Population Code	Location	AEZ	Longitude	Latitude
P1	Kirinda-Puhulwella	IL1a	6^0 3' 18"	80^0 37' 53.4"
P2	Kotapola	IM3c	$6^0$16′ 15.3″	$80^0$31′ 47″
P3	Mulatiyana	IL1b	6^0 9' 21"	80^0 34' 30.5"
P4	Pitabeddara	WL1b	6^0 11′ 10.08″	80^0 27′ 51.1″
P5	Kamburupitiya	IL1a	6^0 4' 21"	80^0 33' 39.95"
P6	Akuressa	IL1a	6^0 06′ 01.6″	80^0 26′ 59.2″
P7	Pasgoda	IL1b	6^0 14' 37"	80^0 36' 35.91"
P8	Akurugoda	IL1a	6^0 02′ 38.3″	80^0 33′ 44.58″
P9	Thihagoda	IL1a	6^0 00′ 28.3″	80^0 33′ 59.58″
P10	Malimbada	IL1a	5^0 58′9.3″	80^0 31′ 9.58″

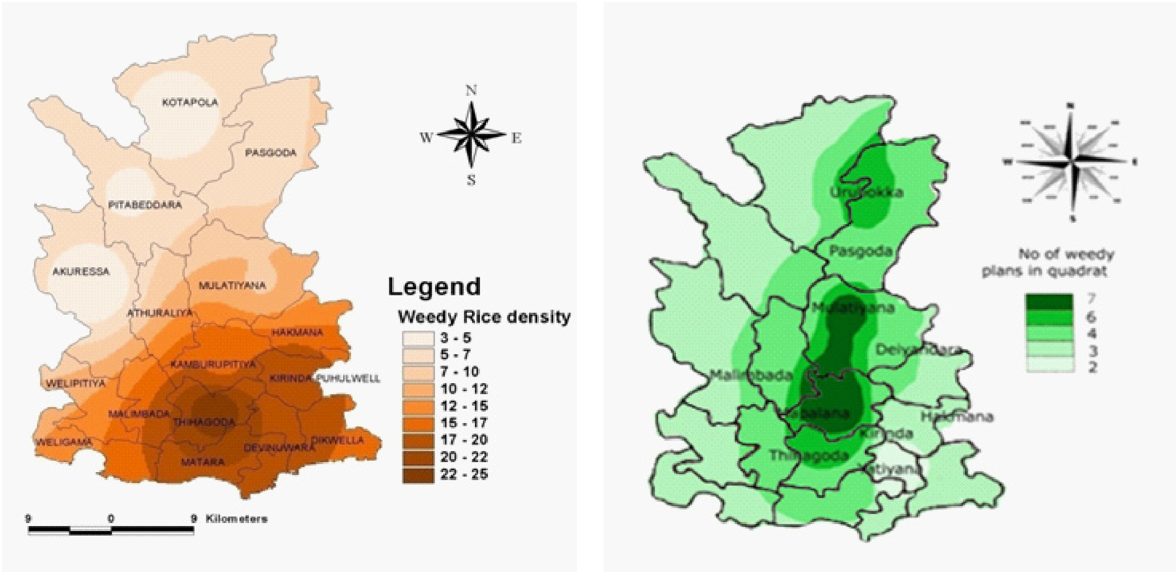

Fig.1: Density and distribution pattern of weedy rice in selected locations (a) 2012 (b) 2013

The significant differences ($p<0.05$) were found in number of weedy rice seeds and the number of improved seeds (Table 2). Significantly highest number of weedy rice seed collection was observed at P9-Thihagoda (153.9) population while no significant differences observed among P7-Pasgoda (100.5), P1-Kirinda-Puhulwella (88.6) and P3-Mulatiyana (94). Comparatively higher number of improved seeds were observed at Kirinda-Puhulwella and Malimbada (17.7) populations. The high levels of seed shattering and seed dormancy have enriched the soil seed bank of weedy rice in infested fields. Seed shattering and the number of spikelets (grains) per plant are the most variable traits for weedy rice in Sri Lanka, which might explain the extent of the yield losses of cultivated rice, estimated to be >90% in Sri Lanka (Ratnasekera *et al.*, 2014). Seeds in the soil seed bank may germinate as soon as conditions are favorable while other seeds will germinate later or when other factors change. The variable and prolonged periods during that seeds persist dormant are major factors that contribute to the weedy rice as a success "weed." Weedy rice seed banks therefore play an important role in determining the severity of infestation in rice fields.

The results of ANOVA (analysis of variance) in table 3 showed variation of soil seed bank among and within populations and reflects the higher (93.29%) variation among populations and lower variation (6.71%) within population. The number of weedy seeds is the most variable (98.38%) among selected populations in Matara district. Overall, soil seed bank accumulation

Table 2: Mean comparison of weedy and cultivated rice seeds in paddy field among selected populations in Matara district

Population Code	Location	No of weedy rice seeds	No of cultivated seeds
P1	Kirinda-Puhulwella	88.6 ^{bcd} ± 12.76	17.7 ^{a} ± 7.602
P2	Kotapola	42.9 ^{f} ± 7.78	15.3 ^{abc} ± 4.270
P3	Mulatiyana	94 ^{bc} ± 11.47	17 ^{abc} ± 6.799
P4	Pitabeddara	42.2 ^{f} ± 9.41	14.7 ^{abc} ± 7.409
P5	Kamburupitiya	77.7 ^{d} ± 10.42	4.7 ^{d} ± 3.335
P6	Akuressa	86.8 ^{cd} ± 9.62	17.3 ^{ab} ± 6.056
P7	Pasgoda	100.5 ^{b} ± 11.33	3.2 ^{d} ± 1.398
P8	Akurugoda	89.6 ^{bcd} ± 13.60	11.8 ^{bc} ± 5.712
P9	Thihagoda	153.9 ^{a} ± 26.35	12.8 ^{abc} ± 4.566
P10	Malimbada	83.4 ^{cd} ± 13.00	17.7 ^{a} ± 6.219

directly correlate with the temporal density variation of weedy rice in particular location, inferring significant contribution of seed shattering and enriching the soil seed bank in the study area. Weed seed banks are the main source of weed infestation in any crop and they are depleted by germination, physiological aging, decay, and predation (Chauhan and Johnson, 2010a). Seed bank dynamics regulate the communities of many of the most important weed species; therefore, a better understanding of seed bank dynamics could contribute to the development of more efficient weed management strategies. However, factors affecting weed seed germination and emergence are complex under natural conditions and poorly understood.

Farmers' perspective and weedy rice distribution in transplanted and direct seeded rice fields in Matara district

Farmer based survey clearly inferred that 77% of the weedy rice infested paddy lands were direct seeded (Fig. 2) indicating high potential of weedy rice emergence than in transplanted and row seeded fields where the management practices are easily adopted. There were only 23% of the fields practicing transplanting techniques where relatively a very less weedy rice plants were observed. In Asia, hand weeding and herbicides are used to control weeds, but manual weeding is becoming less common because of labor scarcity and its high cost. Difficulty in identification at early stages is an additional constraint with respect to weedy rice. The results of this study probably indicate the impact of selection on plant height by farmers when they manually remove taller weedy rice plants in rice fields before their maturity (Gressel and Valverde, 2009). In addition, the analysis suggests that the traits of the seeds had the least variability, indicating that these traits, such as grain shape, grain color and awn characteristics, can be used for the identification of weedy rice (Arrieta-Espinoza *et al.*, 2005). The use of herbicides in rice has increased because it saves labor and is less costly, and the herbicides are easy to apply. Different techniques have been adopted by farmers to manage weedy rice infestation. Herbicides, hand weeding, high quality paddy seeds and transplanting are the main methods used by farmers to control weeds in the study area. Rouging (hand weeding) during the tillering, booting, and flowering stages of rice is the only method with confidence to control weedy rice in the field adopted by farmers in the area. Most of the farmers (14%) preferred the transplanting for effective control of weedy rice but because of the labor shortage and cost, it was found to be difficult for them. According to the farmers' the best preventive measure to control weedy rice is the use of high-quality rice seeds (Fig. 2).

Previous reports highlighted that in addition to other effective weed management strategies, promoting the application of certified rice seeds with no weedy rice contamination should be the immediate action to significantly reduce the proliferation and infestation of this weed in rice ecosystems in the country (He *et al.* 2014). This is important to prevent the introduction or dissemination of weedy rice in rice fields. Although

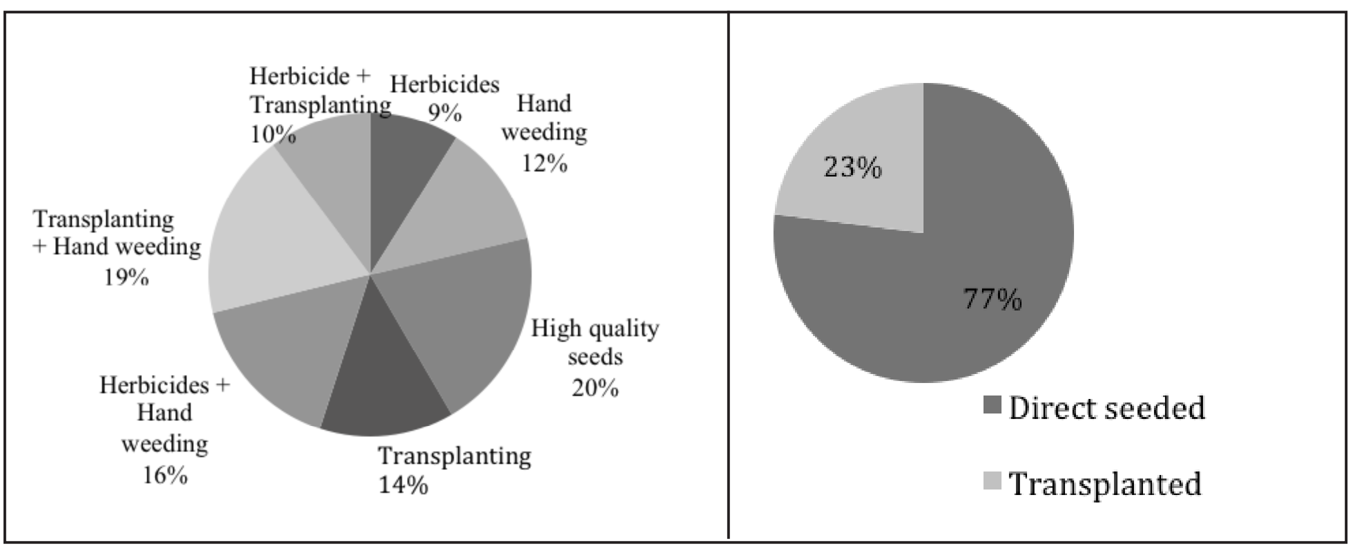

Fig 2: Statistics of farmers' perspective on method of weedy rice control and weedy rice distribution in transplanted and direct seeded rice fields in Matara district

9% of the farmers practice chemical methods such as herbicides to control weedy rice, there was no effective chemical to control only weedy rice as it also belongs to the same family as cultivated rice, *Oryza sativa*. Transplanting followed by continuous weeding during the cropping season was more reliable to the farmers. With the farmers' experiences, manual weeding is effective for reducing initial infestations of weedy rice. But that can be practiced only in small paddy lands and hard to accomplish in larger and direct seeded lands. Therefore, considering management aspects, adoption of suitable cultural practices will be effective to avoid the sources of contaminations to less or zero contaminated areas to minimize the infestation, as it is known to be that weedy rice seeds could be introduced by the use of contaminated seeds, combine harvesters or in mud or tractors or field implements and their seeds may also have been introduced into irrigation water, particularly if canals are infested. Efforts should be made to develop and apply strategic and integrated weedy rice management to minimize the infestation and spread of weedy rice that increasingly is becoming a threat to the sustainable production of cultivated rice in Sri Lanka (Chauhan and Johnson 2010b).

CONCLUSION

A higher weedy rice infestation was observed at Thihagoda indicating that higher attention should be given for the management while to prevent weedy rice seeds from being introduced into lowest contaminated fields such as Akuressa, Pitabeddara and Kotapola. Although the weedy rice population was comparatively low in 2013 compared to the previous year, continuous attention of the farmers and the extension officers should be given to manage the condition. The abundant diversity of weedy rice populations accompanied by the changes of farming practices will complicate weedy rice control and accordingly will threaten rice production. Thus, effective methodologies for weed control and management must be developed to prevent weedy rice from extensive spreading and infestation across all rice planting areas.

ACKNOWLEDGEMENT

Authors wish to acknowledge the financial support by the project grant "Transforming University of Ruhuna to International Status" (TURIS).

REFERENCES

Arrieta-Espinoza G, Sanchez E, Vargas S, Lobo J, Quesada T, Espinoza AM. 2005. The weedy rice complex in Costa Rica. I. Morphological study of relationships between commercial rice varieties, wild Oryza relatives and weedy types. *Genet. Resour. Crop Ev.* **52**: 575–587.

Central Bank. 2010. Central bank annual report, Colombo: Central Bank of Sri Lanka.

Chang, TT. 2003. Origin, Domestication and Diversification. *Rice Origin, History, Technology, and Production.* (eds. WC Smith, RH Dilday), John Wiley and Sons Inc, Hoboken. New Jersey. 3-25.

Chauhan BS and Johnson DE. 2010a. The role of seed ecology in improving weed management strategies in the tropics. *Adv. Agron*. **105**: 221-262.

Chauhan BS and Johnson D. 2010b. Weedy rice (*Oryza sativa*) I. Grain characteristics and growth response to competition of weedy rice variants from five Asian countries. *Weed Sci*. **58**: 374–380.

Ferrero A, Vidotto F, Balsari P and Airoldi G .1999. Mechanical and chemical control of red rice (*Oryza sativa* L. *Var. sylvatica*) in rice (*Oryza sativa* L.) per-planting. *Crop Protection* **18**: 245–251.

Gealy DR, Mitten DH and Rutger JN. 2003. Gene flow between red rice (*Oryza sativa*) and herbicide-resistant rice (*O. sativa*): implications for weed management. *Weed Technol*. **17**: 627–645.

Gressel J and Valverde B. 2009. A strategy to provide long-term control of weedy rice while mitigating herbicide resistance transgene flow, and its potential use for other crops with related weeds. *Pest Manag. Sci.* **65**: 723–731.

He Z, Jiang X, Ratnasekera D, Grassi F, Perera U. and Lu BR. 2014. Seed mediated gene flow promotes within-population genetic variation of weedy rice: implication for weed management. PLOS One **9**(12): e112778.

Kumar S, Dwivedi SK, Haris AA, Ved Prakash, Mondal S. 2015. Screening and identification of rice genotypes for drought tolerance at reproductive stage under rainfed lowland condition. *Journal of AgriSearch* **2** (2): 105-111.

Laik R, Sharma S, Idris M, Singh AK, Singh SS, Bhatt BP, Saharawat Y.2014. Integration of conservation agriculture with best management practices for improving system performance of the rice–wheat rotation in the Eastern Indo-Gangetic Plains of India. *Agriculture, Ecosystems & Environment* 195: 68-82.

Marambe B and Amarasinghe, L 2000.Weedy rice in Sri Lanka. In: *Proceedings of Wild and Weedy Rice in Rice Ecosystems in Asia-A Review* (eds. B.B. Baki, D.V. Chin and A.M. Mortimer), Ho Chi Minh City, Vietnam, 10–11 August 1998. International Rice Research Institute, Los Banos, Philippines, 79-82.

Mortimer M, Pandey S and Piggin C. 2000. Weedy rice: approaches to ecological appraisal and implications for research priorities. In: *Proceedings of Wild and Weedy Rice* *in Rice Ecosystems in Asia-A Review* (eds. BB Baki, DV Chin and M Mortimer), Ho Chi Minh City, Vietnam, 10–11 August 1998. International Rice Research Institute, Los Banos, Philippines, 97–1

Ratnasekera D, Perera UIP, He Z, Senanayake SGJN, Wijesekara GAW, Lu BR 2014. High level of variation among Sri Lankan weedy rice populations, as estimated by morphological characterization. *Weed Biol Manag* **14** (1): 68–75.

Singh AK**,** Chandra N and Bharti RC. 2012. Effects of genotype and planting time on phenology and performance of rice (*Oryza sativa* L.). *Vegetos*. **25** (1): 151-156.

Singh AK, Manibhushan, Chandra Naresh and Bharati RC. 2008. Suitable crop varieties for limited irrigated conditions in different agro climatic zones of India. *Int. J. Trop. Agri*. 26 (3-4): 491-496.

Singh AK, Singh RV, Bharati RC, Chandra N, Kumar C and Dimree SK. 2010.Introduction of wilds and weedy relatives of crop plants in India. *Envi. & Ecol.* **28** (3A): 1602-1606.

Singh AK, Verma VS, Nigam HK, Manibhushan, Chandra N and Bharati RC. 2009. Growth, development, yield attribute and yield of upland rice (*Oryza sativa*) under varying environmental condition and genotypes. *Envi. & Ecol.* **27**(2A): 880-884.

Citation:

Ratnasekera D, Perera, UIP and Subhashi APT.2015. Impact of soil seed bank dynamics on weedy rice distribution and farmer involvement in management: Case study in Marata district, Sri Lanka. *Journal of AgriSearch* **2**(4): 251-256