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Studies on weedy rice infestation and assessment of its impact on rice production

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ABSTRACT

A preliminary survey on weedy rice infestation in rice fields was carried out during 2008 in all the rice producing states of the country including Jabalpur district and adjoining areas in Madhya Pradesh in particular. The study revealed that almost all rice fields were found heavily infested with weedy rice. The extent of infestation was found 5-60% in different states of India, whereas it was observed in the range of 11.32 to 44.28% in cultivators' field and 0.78 to 2.40% at research farm of DWSR. Ten types of weedy rice (known as *Sada* or *Sadwan*) found in the farmers' field and other two types found in water ponds / tanks (called as *Pasai Dhan* in Madhya Pradesh) were identified and characterized. Considering mean 10% infestation, the average loss in rice production was assessed to the extent of 9.15 million tones. The damage is likely to increase exponentially in subsequent years, if not managed effectively, challenging the rice production system in the country.

Key words: Weedy rice, Rice.

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Dr. Varshney in his long career spanning over more than three decades had held various important positions like National Coordinator of AICRP on prominent grain legume crops; Head, Division of Crop Production at Indian Institute of Pulses Research, Kanpur; Founder Head, Regional Center of Directorate of Pulses Research, Gwalior. He also worked as Editor, Indian Journal of Pulses Research, Kanpur during 1995-2001 and was also elected as General Secretary of Indian Society of Pulses Research and Development. He has published more than 150 peer reviewed research papers in journals of national and international repute in addition to several books and book chapters in the field of weed science and also on tropical grain legumes.

His current activities include providing leadership to the national weed research programme, coordinating the network research with state agricultural universities, collaborating with national and international agencies and providing consultancy on matters related to weed science.

Rice, as any other crop, has various constraints to its production and productivity. Among them there are several pests and diseases – most of which nowadays can be well managed, even by implementing Integrated Pest Management. Weeds are also a serious problem. With one particular weed problem affecting rice fields since several decades, is weedy rice, a weedy form of cultivated rice (*Oryza sativa*) crossed with wild rice that competes aggressively with the crop, reducing yields and contaminating harvests. As a result, weedy rice has been identified as one of the most problematic weeds in the 21st century which seriously affects rice yields. Weedy rice is now affecting rice areas of various countries in Asia, including India, Malaysia, Sri Lanka, Philippines, Thailand and Viet Nam. South Korea also has problems with this weed, while China is facing the problem in sites with bad water management. In some areas of the region the weed infestations are so high that rice crop has to be replaced for a while by another crop, a solution that is not everywhere effective and feasible. In most rice areas the spread of weedy rice became significant mainly after the shift from rice transplanting to direct seeding, and has started to become very severe over the last few years. The spread has generally been favored by the planting of commercial rice seeds that contain grains of the weedy rice.

Oryza sativa is a widely cultivated species of rice in tropical and temperate region of South-East Asia. Another cultivated species- *O. glaberrima* is confined to tropical Western Africa. The phylogenetic origin of the weedy forms is closely related to that of cultivated rice. Many weedy plants share most of the features of the two cultivated species (Khush 1997). In South-East Asia, cultivated rice has two closely related wild species, a perennial and an annual one. The perennial species grows in swamps often suspended in water, or is procumbent on the ground. Its panicles are lax and its spikelets are long

(7-10 mm), slender (2.2-2.5 mm wide) and are well filled with anthers. This species is referred as *O. balunga* after Yeh and Henderson (1961) even though the specific name *Oryza perennis* is being used for this taxon. Sampath (1964) has published an emended description of it from specimens collected from Orissa. If this emendation is accepted as valid the Asian perennial wild rice is to be designated *O. perennis* (Moench.) emend Sampath.

The annual species grow in seasonal ditches of plateau regions. It is about a meter tall, has semi-spreading habit, semi-open panicles and bolder spikelets and awns. The anthers do not fill the spikelets completely. This species has been referred to as *O. nivara* after Sharma and Shastry (1965). The cultivated rice (*O. sativa*) hybridizes in nature with the annual (*O nivara*) as well as with the perennial wild rice (*O. balunga*). The hybrids back-cross both ways and produce morphological inter-grades (Sampath and Rao 1951, Negi and Saini 1956, Richharia 1960, Nezu *et al.* 1960, Oka and Chang 1961, Sampath 1962). These are known as *O. sativa f. spontanea* after Roschevicz (1931) and after Sampath and Govindaswami (1958). *Oryza sativa f. spontanea* invades the cultivated fields and poses a great problem as weedy rice. The main characteristic of weedy rice is shattering of grain on maturity. They are difficult to identify before panicle emergence. By that time they utilize the nutrients, water, solar energy and space and cause competitive stress on cultivated rice. Another weeding at panicle initiation is required, which results in both increased cost of cultivation and reduction in yield and quality. With this view, survey of weedy rice was conducted.

MATERIALS AND METHODS

The information pertaining to infestation of weedy rice in rice fields in different states of the country was obtained on the basis of random surveys conducted in different parts of the state by various centres of AICRP Weed Control. In depth survey at different villages in and around Jabalpur district *viz.*, Raipura, Budhagar, Darshni, Pondi, Kakardehi, Singpura, Majholi, Majholi Tola, Boria, Boria road and Nagana located on road sides of Jabalpur– Sihora – Majholi– Katangi – Jabalpur route; Timari, Aga Sondha, Udna, Patan, Ghughuri on Jabalpur - Shahpura - Patan route; and Bharraw, Mehagown, Ghunsor and Sadafal on Jabalpur - Kundam – Shahpura route was conducted in October, 2008. Using the list count quadrate method, in which the number of weedy rice and number of cultivated rice plants were noted separately in each quadrate. In all, 84 quadrates were randomly sampled in 21 villages. At each village, 3-5 quadrates were used for these studies. Means were worked out and percentage of weedy rice in comparison to cultivated rice was computed. Counting of weedy rice was also done on the Research Farm of NRCWS, Jabalpur from an area of 10 m x 4 m plots at six spots selected randomly in different fields. Means were computed and the percentage of weedy rice was worked out. The plant samples of different weedy rice types were collected and then classified into different group on the basis of various distinguishing plant characters. The impact of weedy rice on future production level of rice in the country was also assessed.

RESULTS AND DISCUSSION

The survey of weedy rice revealed that the infestation of weedy rice was reported in different states from 5 to 60% on the basis of random survey carried out in rice fields by the staff of AICRP on Weed Control. The

Table 1. Present status of weedy rice infestation in different states of India during 2008

S.No	State	Location	Percent infestation	Local Name
1.	Madhya Pradesh	RVSKVV, Gwalior NRCWS, Jabalpur	1-5% 11-45%	Kargha, Kanhi, Sathia, Lama, Samasa, Sada, Sadwan and jharua (cultivated field) Pasi Dhan(water body)
2.	U.P.	GBUAT, Pant Nagar CSAUAT, Kanpur	No infestation 5-20%	-
3.	Punjab	PAU, Ludhiana	5%	-
4.	Chhattisgarh	IGKVV, Raipur	10%	-
5.	Himachal Pradesh	CSKHPKV, Palampur	50-60%	Reesa / Jangli Dhan
6.	Assam	AAU, Jorhat	17%	Uridal
7.	Jharkhand	BAU, Ranchi	10-45%	
8.	Orissa	OUAT, Bhubaneshwar	10-15%	Balung, Jhara
9.	W. Bengal	BCKVV, Kalyani V.B. Sriniketan	10-15% 10-15%	
10	Tamil Nadu	TNAU, Coimbatore	5-10%	
11.	Kerala	KAU, Thrissur	Major problem	-
12.	Gujarat	AAU, Anand	5-10%	-
13.	Maharastra	DBSKKV, Dapoli	-	Dev Bhat/ Ner Bhat / Nyar Bhat

population of weedy rice in the rice crop of the cultivators' fields varied from 11.32 to 44.28%, while at the farm of NRCWS, it varied from 0.78 to 2.40% (Table 1). The density per meter square area varied from 8 to 21 plants at cultivators' fields. The mean density of weedy rice at NRCWS farm was from 0.17 to 0.55 plants/m^2. During survey, ten different types of weedy rice were found in cultivated fields under transplanted and direct seeded rice fields. These different types of weedy rice are locally known as *Sada* or *Sadwan*. Two wild types were found in ponds / ditches and tanks; and these are called as *Pasai Dhan* by local people (Table 2). The species of wild rice reported from different parts of India are given (Table 3).

Table 2. Percentage of weedy rice in the areas adjoining Jabalpur (M.P.)

S No.	Name of village	Density of weedy rice/m^2 on farmers' fields	* Weedy rice (%)
1.	Raipura	13.6	32.69
2.	Budhagar	16.0	39.41
3.	Darshani	10.0	31.94
4.	Pondi	9.0	27.28
5.	Kakar dehi	12.8	27.49
6.	Singh-pura	21.0	31.09
7.	Majholi	13.0	20.06
8.	Majholi - Tola	13.0	25.80
9.	Boria	18.6	27.45
10.	Boria Road	14.6	44.28
11.	Nagana	12.0	33.19
12.	Timiri	8.0	25.16
13.	Aga Solndha	14.0	31.68
14.	Udna	13.6	29.2
15.	Patan	10.0	38.25
16.	Gughuri	9.0	16.13
17.	Shahpura	20.0	34.12
18.	Bharraw	12.0	23.48
19.	Bharraw Tola	8.0	11.32
20.	Sadafal	5.0	15.86
21.	Ghunsaur	19.0	33.28
		On NRCWS farm	
1		0.17-0.55	0.78-2.40

* Figures are determined on the basis of population of cultivated rice

Table 3. Species of wild rice reported from different parts of India

S No.	State	Place	Species / Types
1.	Assam	Jorhat	*Oryza meyeriana, rufipogon*
		In Lower Brahmputra valley zone	*O. collina ,O.mintla*
			O.sativa var sativa,O. sativa var plena
2.	Himachal Pradesh	Palampur	*Oryza sativa var. fatua*
3.	Jharkhand	Ranchi	*O. nivara, O. spontanea*
			O. rufipogon
4.	Kerala	KAU, Thrissur	*O. rufipogon*
5.	Orissa	Bhubaneshwar	
		West Central Table Land Zone N.W.	*O. rufipogon*
		North Central & NE Plateau	*O. nivara*
		South Eastern Ghat zone	*O.officinalis*
6.	West Bengal	B.C.K.V. Kalyani	*O.rufipogon,O. minuta*
		V.B. Sriniketan	*O.rufipogon ,O. meyeriana*
			O.rufipogon sub. Sp. Nivara

Types of weedy rice

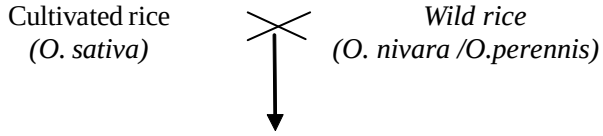
On the basis of variations in morphological features, the collected samples of wild rice were grouped into 12 types. Out of them 10 types were found on the rice fields of farmers near by Jabalpur (MP), while 2 types were found in the water reservoirs (ponds / tanks/ ditches) (Fig. 1- a to l).

The morphological characteristics of the different groups of wild rice are as fallows :

1. Tall and erect plant, black spikelets with robust and greenish white awn, highly shattering type, anther yellowish white and stigma white (Fig. 1-a)
2. Tall and erect plants, brown spikelets with small and white awns, anthers yellow, and stigma white (Fig. 1-b)
3. Dwarf spreading habit, straw colored spikelets with robust and straw white awns, early maturing and highly shattering type (Fig. 1-c)
4. Tall and erect habit, brown spikelets with robust awns anthers whitish yellow and stigma white (Fig. 1-d)
5. Tall and erect plant, greenish – straw coloured spikelets with straw white awns, anthers yellowish white (Fig. 1-e)
6. Tall and semi erect habit, spikelets straw coloured, awnless, anthers yellow and stigma white (Fig. 1-f)
7. Dwarf and erect plant, black colored spikelets, awnless, anthers yellow and stigma white (Fig. 1-g)
8. Dwarf and erect plants, brownish spikelets, awnless, anthers yellow and stigma purple (Fig. 1-h)
9. Tall and erect plants, brown spikelets with red awns, highly shattering and medium duration of maturity (Fig. 1-i)
10. Tall and erect plants, red spikelets, without awns, anthers yellow and stigma whitish purple (Fig. 1-j)
11. Weak culms, spreading, lodging, rooting at lower nodes, spikelets straw colored with red awns which turn into black at maturity, grains long and reddish (Fig. 1-k)
12. Thin culm, lodging type, emergent on water, procumbent on shores, long panicle, spreading, straw colored thin long spikelets with white awns, highly shattering type (Fig. 1-l)

The distinguishing vegetative and ecological characters of weedy rice types are presented in Table 4. The awnless types resemble the cultivated types but they were differentiated by their shattering nature. These morphological types would be attributed to crosses between cultivated rice and wild-rice as well as the back crosses with hybrids in both ways in due course of time (Sampath and Rao 195, Negi and Saini 1956, Richharia 1960, Nezu *et al.* 1960, Oka and Chang 1961, Sampath 1962). These are known as *O. sativa f. spontanea* after Roschevicz (1931) and after Sampath and Govindaswami (1958). Several ecospecies and ecotypes are also developed in due course. However, delimiting a species or ascertaining its correct name has been a controversial due to differences of opinion among the Taxonomists. The genetic barrier between the cultivated and wild species has been incomplete and introgressive hybridization has added a weedy form. The mutations are also responsible for development of weedy rice. Some of these forms closely resemble the cultivated rice, but shatter their spikelets on maturity. The development of weedy rice in nature is given as under.

Development of weedy rice in nature



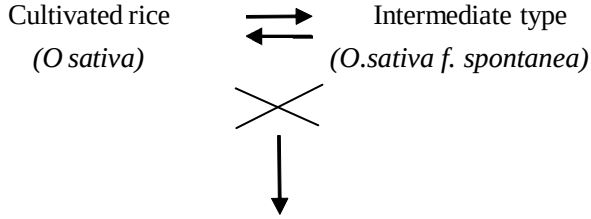
Intermediate form (weedy rice)

O. sativa var. fatua

or

O. sativa f. spontanea

Back- Cross both ways



Several morphologically different types of weedy rice

Fig. 1 : Weedy-rice types i-j, wild rice types k-l

Table 4. Some vegetative and ecological characters of weedy rice types found in Jabalpur M.P.

Characters	Group number of different types of weedy rice											
	1	2	3	4	5	6	7	8	9	10	*11	*12
Plant size												
Perennial												
Weak perennial (P)												
Annual with (A)	(A)	(A)	(A)	(A)	(A)	(A)	(A)	(A)	(A)	(A)	(A)	(A)
Perennating												
Capacity												
Annual-A												
Rhizome – Present												
Absent	A	A	A	A	A	A	A	A	A	A	A	A
Habit												
Erect-E	E	E	E		E		E		E	E		
Semi erect – SE				SE		SE		SE		SE		
Semi open-SO											O	O
Open-O												
Culm	112.52	80.46	116.3	142.9	131.62	134.7	102.38	136.49	94.30	82.64	67.48	150.36
Height – H cm												
Thick – T	T	T	T	T	T	T						
Medium – M							M	M	M	M	M	
Slender - S												S
Legule												
Acuminate and bipartite AB	AB	AB	AB	AB		AB	AB	AB	AB	AB	AB	AB
Acute A												
Orbiculate – O												
Truncate – T												
Truncate ciliate – TC					TC							
Peduncle – Length cm	30.7	31.95	41.14	32.10	32.17	32.82	29.20	31.57	33.1	27.62	38.0	29.3
Exsertion – Length cm	1.64	1.85	5.58	1.20	3.30	4.40	1.62	4.70	11.8	5.78	9.0	7.24
Panicle	26.1	21.95	29.52	24.2	22.2	27.39	21.34	21.21	24.5	17.42	18.2	18.52
Length of primary rachis cm												
Spike lets – Length cm	0.78	0.67	0.80	0.79	0.70	0.79	0.74	0.60	0.9	0.80	0.70	0.62
Width cm	0.32	0.30	0.42	0.32	0.30	0.33	0.32	0.30	0.4	0.38	0.20	0.20
Sterile lemma - size	S	S	S	S	S	S	S	S	S	S	S	S
Short – S												
Medium – M												
Long - L												
Fertile lemma – tuberculations									S			S
Smooth – S												
Linearly tuberculated – T	T	T	T	T	T	T	T	T		T	T	
Irregularly corrugated - C												
Fertile lemma – hairs	H	H	H	H	H	H	H	H		H	H	H
Sparsely hairy – H												
Almost glabrous (G)												
Glabrous - G									G			
Spikelet colour												
Black – B	B						B				B	
	1	2	3	4	5	6	7	8	9	10	*11	*12
Straw colour – S			S		S	S						S
Red – R									R	R		

Brown – Br		Br		Br								
Red brown - Rb								Rb				
Awn												
Colour- White straw – W	W	W	W	W	W							W
Red - R								R			R/B	
Absent – A						A	A		A	A		
Short and slender – S		S		S								
Long and robust – R	5.61	5.58	4.86	5.24	7.80			4.66			5.1	9.06
Palea Tip												
Elongated – E	S	S	S	S	S	S	S	S	S	S	S	S
Short – S												
Anther colour												
Pale white – W	W		W	W	W							
Yellow - Y		Y				Y	Y	Y	Y	Y		Y
Brown – B											B	
Stigma colour												
Purple – P									P		P	P
White – W	W	W	W	W	W	W	W	W		W		
Habitat												
Growing in wet ground – W	W	W	W	W	W		W	W	W	W		
Pond, ditches P												
Growing in damp soil											P	P
Insulation												
Growing in open sunshine – O	O	O	O	O	O	O	O	O	O	O	O	O
Growing in partial shade – *P*									*P*		*P*	*P*
Growing in shade – S												
No. of tillers / plant	5.0	8.8	24.0	31.9	33.18	23.00	6.38	35.00	2.00	5.26	20.00	17.00
Flag leaf length cm	24.62	21.8	51.32	38.3	28.52	39.35	28.36	36.74	34.5	26.00	24.34	15.66
Grain colour												
Pale-white – PW						PW						PW
Creamy white – CW			CW	CW	CW		CW					
Brown – Br		Br								BR		
Red – R	R							R	R		R	
Red with shade – Rb of brown												
Purple (almost black) P												
Grain surface – Fine – F												F
Coarse – C	C	C	C	C	C	C	C	C	C	C	C	
Shattering												
Very high – VH	VH		VH					VH			VH	VH
High – H		H		H	H	H	H		H	H		

Impact assessment on rice yield

Rice productivity analysis at the district level indicated that 155 districts in the country are falling in the low productivity category and 94 districts under very low productivity group. Bihar, Orissa, Maharastra are under low productivity and M.P. is under very low productivity group. In Madhya Pradesh, the average yield of rice is 9.79 q/ha. The profitability of rice, based on yield sensitivity shows that rice cultivation in Madhya Pradesh is non profitable at cost A_2 (Operation Cost) and at cost C_2 (Total Cost).The trend analysis of production and productivity of last decades in M.P. has positive non-significant growth rate apart from use of high yielding varieties, fertilizers, irrigation and improved technological inputs.

One of the main reasons for low productivity in M.P. is the weed problem particularly the increasing population

of weedy rice which grows spontaneously with the cultivated rice. Other weed species can be identified at early stage and they are removed by weeding at 20 to 30 day stage or controlled by herbicides. But weedy rice can not be identified at the critical stage of weeding i.e. at 20 to 30 days after sowing or planting. It could be identified at the time of panicle emergence and need additional weeding to remove this weed. The selective herbicides also can not control the weedy rice. Hence, the cost of weeding is increased and till this period, it causes significant damage to the crop by creating the competitive stress on the crop. Even after weeding at panicle emergence, some of the seeds mature earlier and shatter at the time of weeding and some of weedy rice plants still escaped. Hence, the population of weedy rice is built up for the next year. The population increases in exponential progression and it results in drastic reduction in seed yield during subsequent years. If the weedy rice is not controlled, the yield of rice may reduce drastically in coming years. The estimated reduction in rice yield could be 5-10% in first year; the shattered grains may lead to the development of weedy rice in the next year. Considering a very marginal population of 10-20% in second year and 40% in third year and so on due to uncontrolled weedy rice production there may be drastic reduction in rice production. Considering the present rice production of 91.5 m tones, the reduction in first, second and third years may be 9.15, 18.30 and 36.60 m tones, respectively. Presently, where the weedy rice infestation is higher; the cultivators leave that field or grow the purple leaved rice which has low productivity. According to the official estimates, the demand for rice in India is projected at 128 million tones for 2012 which will require a productivity level of 30 q/ha against the present average yield of 19.30 q/ha. This production level will be difficult to achieve in view of the infestation of weedy rice. Contrary to this, the present production level will be reduced.One of the major reasons for low productivity (12.28 q/ha) in 155 districts and very low productivity (8.26 q/ha) in 94 districts of the country could be the infestation of weedy rice. The presence of weedy rice to the extent of 11-44% noted at the panicle emergence *vis-â-vis* reduction in rice yield to the same magnitude as these weedy rice utilize the resources and space depriving the rice crop. Apart from lowering the yield and quality of rice, the cost of cultivation will be increased in future due to increased population of the weedy rice. Therefore, for increasing the production level of rice, it is necessary to make in-depth study about the location specific weedy rice infestation and conduct research for finding necessary measures for efficient control of weedy rice.

Until recently, India had no problem of weedy rice, due to the fact that transplanted rice was the main planting method. With the opening of new industries and lucrative remunerations, people have moved from rural to urban areas, reducing considerably the labour formerly used for planting and weeding. It is the reason, in addition to the decreasing irrigation water availability, that farmers have been compelled to shift from transplanting to the direct-seeding method. Current agronomic practices will continue to contribute to make weedy rice the most troublesome weed in rice in the twenty first century. Weedy rice has become a perennial problem for various reasons, including absence of technology transfer and appropriate communication technologies, lack of awareness, and poor farmer attitude. The lack of interaction and communication among scientists on environmentally sound and integrated technologies to control weedy rice has resulted in less attention being paid to capacity-building in the sphere of weedy rice management in Asia.

Given the importance of the problem, FAO conducted activities to assist developing countries to reduce weedy rice infestations in rice. FAO began with the organization of a global workshop on the subject, held in Varadero, Cuba (FAO 1999), with the participation of specialists from 17 countries. The deliberations from the workshop pointed out the need to adopt an integrated management approach, where sources of weedy rice are reduced using several management strategies. Keeping in view the predicted pace of weedy rice infestation in India there is an urgent need to implement programmes and projects aiming at creating awareness among farmers and researchers about problem of weedy rice and ways of its prevention and management.

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