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RESEARCH NOTE

Farmers' knowledge and herbicide application adoption in rice production systems in Chhattisgarh Plains of India

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ABSTRACT

Weeds are serious biological constraints in the rice production system. A survey was conducted using a structured questionnaire in two major rice-growing districts of Chhattisgarh Plains. There were 136 respondents. The objectives of the survey were to assess farmers' knowledge of current weed management technologies, farmers' adoption of available technologies and identify challenges faced by farmers to help in order to develop need-based sustainable weed management strategies. The majority of the farmers (68.4%) have reported using their seeds for sowing with 58% of the farmers cleaning the seeds before sowing. A seed rate of 120 kg/ha was being used by 55% of the rice growers. The majority of the respondents (58.8%) were aware of chemical weed management in crops. However, 89.7% of farmers were reportedly unaware of the correct dosage rate (45.6%) and correct application time (44.1%) of post-emergence herbicides. Regarding herbicide application timing, 55% of respondents applied at the 6-8 leaf stage of the weeds; 25% at the 5-6 leaf stage, and 20% were unaware of the time of herbicide application. Likewise, 88.2% of respondents spray the herbicide in a swinging pattern. This study highlighted the urgent need for policy intervention to improve the herbicide application technological knowledge level of rice farmers to improve input use efficiency and produce rice sustainably.

Keywords: Farmers' technological knowledge, Herbicide use, Rice, Technology adoption pattern, Weed management

Rice (*Oryza sativa* L.) is a staple food of more than 60% of the world's population. India and China are the leading rice-producing countries and contribute about 50% of the total rice production in the world (USDA-ERS 2021). Rice is cultivated in India in a very wide range of ecosystems from irrigated to shallow lowlands, mid-deep lowlands, and deep water to uplands. In India, about 44 million hectares (MH) area is engaged in a wide range of agro-ecosystems with a production of 119 million tonnes (MT), which account for 27 and 24% of acreages and production of the world, respectively with a productivity of 2-3 t/ha (USDA-ESMIS 2021). By 2025, about 140 MT of rice is required to feed the population in India and to achieve needed rice production, biotic and abiotic stresses are major hurdles (Choudhary and Dixit 2021). Among biotic stresses, weeds are one of the major yield reducers in rice due to their competition for resources like space, light, moisture, nutrients, *etc*. (Rao *et al.* 2017). The rice yield losses due to weeds range from 14-21% with a monetary loss of 4200 million US$ (Gharde *et al.* 2018). Weeds not only cause direct yield loss but also deteriorate the quality of produce, increase production costs, and act as an alternate host to pests (Mishra *et al.* 2021). Thus, to increase rice productivity using available resources judicially, it is essential to manage weeds that are more adaptive to adverse climatic conditions than rice and may cause complete crop loss under extreme conditions. The adoption of diverse technology is essential for weed management because weed communities are highly responsive to management practices (Rahman 2016). Effective and appropriate weed management technologies development and adoption necessitate a proper understanding of weeds.

It is imperative to understand the adoption pattern of the existing weed management practices by rice growers which are mainly influenced by knowledge, attitude, and perceptions of technologies (Singh *et al.* 2018; Laizer *et al.* 2019). The knowledge of the existing management practices adopted by farmers including first-hand information on weed management and herbicide application technologies used by farmers is needed to improve the available technologies, input use efficiency, and obtain higher rice productivity. Thus, this study was conducted in two districts of Chhattisgarh (Raipur and Dhamtari) to record weed management strategies

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followed by rice farmers as well as the constraints faced by them in the technological adoption and suggest needed policy interventions to bridge the knowledge gap.

Survey and data collection

The household surveys were conducted from June 2015 to February 2017 in Raipur and Dhamtari districts (major rice-growing areas) of Chhattisgarh. The areas surveyed have a normal average annual rainfall of 1140 and 1200 mm, respectively, and about 75-80% of the rain received from June to September months from the South-West monsoon. In these districts, rice is the predominant crop during the rainy season, and chickpea, wheat, lathyrus, and summer rice are other crops during the rest of the year. Farmers' rice fields holding are small in size (<2 acres) with a compartment bunded to collect the rainwater.

Data on rice farming, particularly knowledge, and adoption of weed management practices especially herbicide application techniques were collected through structured questionnaire. In the questionnaire, open and close-ended questions were asked and the response of respondents was recorded. During the data collection, group-wise discussions and personal interviews of 136 respondents (Raipur n=92, and Dhamtari n=44) were organized in both districts.

To achieve the main objective of the study, a multistage sampling procedure [selected two districts of Chhattisgarh (Raipur and Dhamtari) with six blocks (Raipur: Tilda, Dharsinwa, and Abhanpur; Dhamtari: Kurud, Dhamtari, and Magarload) and villages were selected randomly from the blocks] was employed in selecting respondents. Survey data were summarized and descriptive statistics were calculated using Microsoft Excel. For multiple answered questions, the percentages were calculated for each group of similar responses. The percentages of farmers in the two districts, who gave responses to a question were calculated based on the total number of farmers.

Seed purity awareness level among farmers: In the study area, the awareness level of the rice growers largely varied (**Table 1**). The majority of the respondents (68%, n=56) were using rice seeds (varieties: Swarna, Mahamaya, MTU 1010, MTU 1001, *etc*.) produced in their farm for sowing followed by seeds procured from neighbors (16%) and purchases from the market (15%). The seed rate of 120 kg/ha was used by 55% of respondents, followed by 100 kg/ha by 38%, while 7% of the respondents used 80 kg/ha of seed rate, which is 20% lower than recommended by the Agriculture Department. Similarly, 58% of the respondents cleaned the rice seeds before sowing, whereas only 23% of the respondents treated their seeds with brine solution or any other means before sowing. Thus, there was a huge variation among the practices followed by the rice farmers in the study site.

Table 1. Seed use pattern by respondent farmers in the study area

Particulars		% of respondents (n=136)
Source of seeds		
	Self	68
	Neighbor	15
	Purchase from market	16
	Change every year	1
Seed rate (kg/ha)		
	120	55
	100	38
	80	7
Cleaning of seeds before sowing		
	No	42
	Yes	58
Use of seed treatment brine solution or any other means		
	No	77
	Yes	23

Farmer's knowledge of weed management practices: Knowledge is the prerequisite for the adoption of innovative technologies. Respondents of 59% knew herbicides [pre-emergence herbicides: pyrazosulfuron-ethyl (dry- and wet-direct seeded rice, DSR), pendimethalin (dry-DSR), and others; post-emergence herbicides: bispyribac-sodium, penoxsulam, metsulfuron-methyl + chlorimuron-ethyl, fenoxaprop-p-ethyl, 2, 4-D amine salt, *etc*. (dry- and wet-DSR)] to be used in the rice crop grown in the area. Around 50% of the respondents knew about herbicides for the rainy season and only 9% of respondents expressed that they knew herbicides for rainy and winter season crops (2, 4-D amine salt, metsulfuron-methyl, clodinafop-propargyl, sulfosulfuron for wheat and pendimethalin for pulses). On the contrary, 41% of respondents were unaware of the use of herbicides in any of the crops. The respondents who were unaware of herbicides to be used are relying on herbicide retailers and neighbors. About 13% of respondents expressed that they are aware of herbicides to be used based on the weed flora, while the majority (87%) did not know about the selection of herbicides.

Regarding timing of herbicide application, the majority (90%) did not know at what stage of the crop or weed, post-emergent herbicides are to be

applied, while 44% of respondents have reported using post-emergent herbicides late and only 22% of respondents applied at 2-4 leaf stage of weeds. The above findings indicate the existence of a wider herbicide application technologies knowledge level gaps amongst respondents'. Thus, knowledge level needs to be improved to get broad-spectrum weed control while applying herbicides.

In the survey area, about 82% of respondents were unaware of the importance of soil moisture content while applying pre-emergence herbicides (pyrazosulfuron-ethyl and pendimethalin) under dry-DSR conditions. Apart from these, 63% of rice growers have been applying herbicides as sand mix while 37% are using knapsack sprayers. Ninety-three percent of rice growers are unaware of the kind of nozzles to be used for herbicide applications. Still, the respondents were aware of nozzles but were not changing the nozzles while applying herbicides. While applying post-emergence herbicides water level in the field is important, but 52% of respondents said that they are not aware of how much water to be retained in the paddy. There must be >75% of weed foliage above the water level while applying post-emergence herbicides, as the majority of herbicides are absorbed through the foliage. Under dry conditions, plants are under stress, therefore, the herbicides that fall on foliage won't be properly absorbed and translocated, due to reduced stomatal conductance. Likewise, the herbicides that fall on the ground cannot be absorbed by plants thus resulting in poor weed control (Choudhary and Dixit 2018).

After the application of pre-emergence and post-emergence herbicides, some of the weeds are either escaped or not controlled or emerge late. They produce substantial seeds and are sufficient to cause economic damage during subsequent seasons. Those weeds need to be pulled out and only 36% of rice growers in the area remove the weeds before the crop harvest. Weed utilization is one strategy to manage the weeds, but 25% of respondents are unaware of weeds to be used, whereas, 46% of rice growers use weeds in the flowering or maturing stage in compost units, which should be avoided and 29% of respondents using weeds before flowering (**Table 2**).

Adoption pattern of weed management practices: The adoption pattern of any management practice largely depends on the knowledge level of respondents, the better the knowledge higher the adoption (**Table 3**). Fifty-two percent of respondents have been using 120-135 L/acre of water which is 10-20% less than recommended and 36% reportedly used 90-105 L/acre, which is further lesser by 30-40% than the recommended spray volume. Only 12% of the respondents have been using 150-165 L/acre which is at par with the recommendations. Around 54% of respondents use pre-emergence herbicides for weed management, although 50% were reportedly applying herbicides at 5-6 days after sowing (DAS), by the time weeds emerged and efficacy is expected to be comparatively lower. Thirty-five percent of respondents applied at 3-4 DAS, 13% at 1-2 DAS and only 2% at 0-1 DAS. However, it has been suggested to apply pre-emergent herbicides at 0-3 DAS for broad-spectrum weed control in rice (Choudhary and Dixit 2021). Presently, most of the pre-emergence herbicide molecules (pretilachlor + pyrazosulfuron, pretilachlor + bensulfuron, *etc*.) available in the market have a

Table 2. Weed management practices adopted by the respondent farmers in the study area

Particulars	% of respondents (n=136)
Knowledge about herbicides	
No knowledge	41
Rainy season	50
Rainy + winter season	9
Knowledge level of herbicide use as per weed population	
No	87
Yes	13
Knowledge about post-emergence herbicides	
No	90
Yes	10
Timing of post-emergence herbicide application	
No knowledge	34
Late application	44
Timely application	22
Knowledge about soil moisture content while pre-emergence herbicide application	
No	82
Yes	18
Applying method	
Sand	63
Knapsack sprayer	37
Knowledge about nozzle type used for herbicide	
No	93
Yes	7
Do farmers change nozzle for spraying different pesticides	
No	100
Water level in rice field while application of post-emergence herbicides	
No	52
Yes	48
Removal of weed before crop harvest to avoid seed rain (weed seed harvest)	
No	64
Yes	36
Use of weeds as compost materials	
No knowledge-0	25
After flowering-1	46
before flowering-2	29

Table 3. Herbicide application technologies adopted by the respondent farmers in the study area (n=136)

Particular	% of respondents (n=136)
The volume of water used for post-emergence herbicide application (L/acre)	
90–105	36
120–135	52
150–165	12
Use of pre-emergence herbicides	
No	63
Yes	73
Timing of pre-emergence herbicide use	
5–6 DAS	50
3–4 DAS	35
1–2 DAS	13
0–1 DAS	2
Dose of herbicide	
No	35
Yes	65
Application pattern of herbicide spray	
Swinging	88
Straight	12
Stage of weeds at post-emergence herbicides application	
No knowledge-0	20
>7 leaves	42
5-6 leaves	25
<4 leaves	13
Herbicides adoption level/pattern	
Only pre-emergent *fb* hand weeding (HW)	26
Pre-emergence *fb* post-emergence	40
Pre-emergence *fb* early-post-emergence *fb* HW	27
Pre-emergence *fb* post-emergence *fb* HW	7

wider application window of up to 7 DAS. Under the conditions of using recent herbicide molecules, herbicide efficacy can be enhanced. In the survey area, nearly 65% of respondents were well aware of doses of herbicides. It was also observed that around 88% of respondents used a swinging pattern of herbicide application and only 12% followed the suggested "straight pattern" of herbicide application. However, the knowledge level is gradually increasing. The majority of the respondents (42%) were applying herbicides after 7 leaf stage of weeds followed by 5-6 leaf stages (25%), whereas 20% of respondents were not aware of when to apply. Only 13% of respondents have been applying herbicides at the right stage (<4 leaf stage) (Choudhary *et al.* 2021). Seven percent of the respondents practiced pre-emergence followed by post-emergence, supplemented with hand weeding, whereas 40% relied exclusively on herbicides and 26% of respondents practiced pre-emergence followed by hand weeding in the survey area.

The majority of rice farmers have not adopted recommended rice production packages and weed management practices. Farmers were repeatedly using herbicides inappropriately. Thus, immediate policy intervention is required to enhance the weed management technology, knowledge level of rice farmers as well as extension functionaries working in the area by imparting training and demonstrations. Such efforts would strengthen scientific weed management practices adopted in rice by farmers and ultimately help to improve productivity and profitability judiciously.

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