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Associated weed flora of rice (*Oryza sativa* L.) under different establishment methods & their management in rice-wheat cropping system

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Abstract
Rice (*Oryza sativa* L.) crop is the backbone of livelihood for millions of rural households and plays vital role in the country's food security, so the term "rice is life" is most appropriate in Indian context. Due to intensive cultivation of rice–wheat sequence, the weed flora simplified with grasses. For future productivity gain in rice in India, high-yielding varieties that might have resistance to multiple stresses (abiotic and biotic stress) particularly in the wake of climate change need to be explored. The present study was conducted during the *kharif* season of 2020-21 & 2021-22 at the crop research center of G. B. Pant University of Agriculture & Technology, Pantnagar, U. S. Nagar (Uttarakhand). The Purpose of the study was to examine the effect of weed control treatments on growth and productivity of rice under different mode of establishment. The experiment was laid out in split plot design taking 3 establishment methods *i.e.* Mechanical Transplanting (TP),Wet direct seeded rice (WDSR) & Dry direct seeded rice (DSR) as main plot and 4 weed management practices i.e. Weedy check (T1), Mechanical Weeding (T2), Chemical weeding (T3) & Weed free (T4)as sub plot treatment. Rice crop, in general, faces the problem of both grassy and non-grassy weeds. Therefore, it is, necessary to control weeds so as to reduce the competition for nutrients, moisture, radiant energy, and to obtain higher fertilizer and water use efficiency. Important weeds which are commonly associated with rice are composed of *Caesulia axillaris*, and *Ludwigia spp.* among the broad leaved weeds, and *Cyperus rotundus*, *Leptochloa chinensis*, *Elusine indica* and *Echinochloa colona* among the grassy weeds. Results showed that the diversity of grassy & non grassy weeds are more in case of DSR followed by WDSR method of establishment. T4 produced significantly better control over the T2 and T3 management practices. However the T2 & T3 also gave the significant control of weeds over the weedy check. So, this approach can minimize the crop weed competition a step forward in sustainable agriculture.

Keywords: DSR, WDSR, transplanting, weed, management, competition and sustainable

Introduction
Rice (*Oryza sativa* L.) is the most prominent crop of India as it is the staple food for most of the people of the country. It is estimated that 40% of the world's population consume rice as their major source of food; and 1.6 billion people in Asia take rice as their mainstay food (1st Indian rice congress-2020-first circular). The rice-wheat system has been practiced by farmers in Asia for more than 1000 years. It has since expanded and is currently estimated at 23.5 million ha. The rice-wheat system covers 13.5 million ha in South Asia: India (10.0), Pakistan (2.2), Bangladesh (0.8) and Nepal (0.5). It represents 32% of the total rice area and 42% of the total wheat area in these countries. https://www.pakissan.com/. This crop is the backbone of livelihood for millions of rural households and plays vital role in the country's food security, so the term "rice is life" is most appropriate in Indian context. India occupies an important position both in area and production of rice. By the adoption of improved production technologies such as high-yielding varieties/hybrids, expansion of irrigation potential, and use of chemical fertilizer, supply of rice in the country has kept pace with the increase in demand. Demand for rice is expected to further increase in future as population is continuously increasing, so production of rice also needs to be increased. There is a need to further increase rice productivity because land area under rice cultivation is declining. Major constraints for productivity and sustainability of rice-based systems in the country are the inefficient use of inputs (fertilizer, water, labor), increasing scarcity of water and labor especially for rice cultivation, new emerging challenges from climate change, rising fuel prices, increasing cost of cultivation, and socioeconomic changes such as migration of labor, urbanization, less liking for agricultural work by youths, and concerns from environmental pollution.

The only way to sustain rice production for meeting the increasing population demand is to increase the productivity per unit of area of rice with enhanced resource use efficiency. For future productivity gain in rice in India, high-yielding varieties that might have resistance to multiple stresses (abiotic and biotic stress) particularly in the wake of climate change need to be explored. Crop production techniques in rice that could increase factor productivity by efficient utilization of inputs (water, fertilizers, pesticides, etc.) reduce cultivation cost, enhance profit, and provide safe environment must be explored. Encouraging resource conservation technologies and cultivation of climate-resilient high-yielding varieties through demonstrations and making seed available to the farmers will be important to sustain rice production in India.

Diverse weed flora

Diverse weed flora and excessive weed pressure is an important issue in the way to sustainable agriculture. Due to intensive cultivation of rice–wheat sequence, the weed flora simplified with grasses. Weeds compete with the main plants for light, water and nutrients and in turn decrease overall land productivity of the system as a whole. Being major biotic constraint to sustainable agriculture in Asia, weeds causing complete grain yield losses, in some cases. Dry direct seeded rice is advocated to have higher water productivity as no puddling operations are involved here. But the chances of yield loss are higher in dry direct-seeded rice than in puddled transplanted rice as the initial flush of weeds is not controlled by flooding in dry direct-seeded rice. Changes in establishment method, technology and weed management practices in dry direct-seeded rice resulted in diverse weed composition. Weeds are the main factor responsible for the yield declines in any eco-system.

The current rice production system, which uses transplanted rice, is expensive in terms of inputs, cash, and labour (Mankotia *et al*., 2009) [4]. Transplanting, the most common method of establishment, has a negative impact on the soil environment for succeeding wheat and other upland crops. Because rice seedling transplanting is an expensive operation, direct seeding should be used instead, which could reduce labour requirements by more than 20% in terms of working hours and other input requirements while increasing or maintaining economic productivity and alleviating soil degradation (Nazir *et al*., 2020) [5]. Direct seeded rice production in India has a 2-12 percent higher grain yield than transplanted rice production (Husain *et al*., 2003) [2]. Direct seeding eliminates the need for seedbed preparation, seedling uprooting, and transplanting, as well as the associated costs and energy. In addition, direct seeded rice matures 8-10 days earlier (Gill *et al*., 2006a) [1]. Wet direct seeding can help you save money on labour, nursery management, and transplanting. Wet direct seeded rice in continuous standing water produced 3-17% more than transplanted rice while using 25-48% less water (Tabbal *et al*., 2002) [8].

Rice is grown both directly and through transplantation. Weed competition is greater in direct seeded rice. Weed competition has been reported to reduce yields by 34% in transplanted rice, 45% in direct seeded low land rice, and 67% in upland rice. During the first three weeks of direct seeded rice, weed competition is at its peak. The critical period for weed-free conditions in transplanted rice is reported to be 30-35 days, whereas the weed-free period in direct seeded low and upland conditions ranges from 40-60 days.

Weeds, both grassy and non-grassy, plague rice crops in general. As a result, weed control is required to reduce competition for nutrients, moisture, and radiant energy while also increasing fertiliser and water use efficiency. *Caesulia axillaris* and *Ludwigia* are two broad-leaved weeds commonly associated with rice, while grassy weeds include *Cyperus rotundus*, *Leptochloa chinensis*, *Elusine indica*, and *Echinochloa colona*.

Weed infestation is a major impediment to increasing rice yield (Nazir *et al*., 2020) [5]. Weed flora in rice crops changes as rice establishment methods change from traditional manual seedling transplanting to dry direct seeding, wet direct seeding, and rice intensification. Weed and weed competition are greater in direct seeded rice than in transplanted rice because the land is exposed until the initial seedling establishment (Shendage *et al*., 2019) [6]. Weed flora interacts more competitively with applied plant nutrients than crop flora because weeds absorb nutrients faster and more efficiently than crop plants. Nutrient management practises have the potential to influence weed communities in two ways: directly through seed immigration and indirectly through changes in competitive capacities.

Both manual and mechanical weed removal methods are effective, but they are both expensive due to the extra labour and time required for weed removal (Kewat and Pandey, 2001) [3]. Chemical weed control methods appear to be simpler, less time consuming, and less expensive, as well as providing a weed-free environment during crop plant establishment. As a result, herbicides have emerged as a promising and effective tool for weed control. Many pre-emergence herbicides were used in rice for effective weed control, such as Bispyribac sodium, Pretilachlor, and pendimethalin (Singh *et al*., 2010) [7], but these herbicides only provided effective weed control during the initial growth period (up to 30 days after sowing). Because rice has a long growing season, numerous weed flushes have emerged in later stages and are competing with the crop for growth resources. As a result, post-emergence herbicides are critical for effective weed management during the critical crop-weed competition period.

Rice wheat cropping system (RWCS) is a major agricultural production system. Both crop components of this cropping system require more water, labour, time, nonrenewable energy, heavy farm machinery, and costs for successful cultivation. Rice is grown by transplanting to achieve high yields while controlling weeds. Land preparation for transplanted rice is not only time consuming and costly, but it also degrades soil properties due to the formation of a compacted hard soil surface. Rice establishment technologies such as dry and wet seeding can be used to reduce the water and labour requirements of rice transplanting cultures without sacrificing yield. Weeds, on the other hand, pose a significant threat to direct seeded rice culture. High yield in direct seeded crops is more dependent on effective weed management. Direct seeded systems may face a threat from changes in competing weeds, with an increase in difficult-to-control species. Ischaemum rugosum, Echinochloa crus-galli, E. Colona, and Leptochloa chinensis are among them. The transition from TPR to DSR had an impact on wheat weed dynamics as well.

Materials and Methods

The experiment was carried out during *Kharif* season of 2020-21 and 2021-22 at Norman E. Borlaug Crop Research Centre of G. B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India, located at 29°N latitude, 79.3 ° E longitude and an altitude of 243.8 m above mean sea level. The research centre falls under foothills of "Shivalik" ranges of "Himalaya" a narrow belt called "*Tarai*" of Uttarakhand state. The mean annual rainfall is about 1400 mm, of which 80-90 per cent is received during June to September and rest in winter season. The average maximum temperature varied from 29.8 to 36.8°C. The soil of the experimental site was sandy loam with near neutral pH (7.2), medium soil organic carbon (0.69%), low available nitrogen (195.7 kg/ha) and medium available phosphorus (19.9 kg/ha) and potassium (202.6 kg/ha). The experiment was carried out in split plot design taking 3 establishment methods *i.e.* Mechanical Transplanting (TP),Wet direct seeded rice (WDSR) & Dry direct seeded rice (DSR) as main plot and 4 weed management practices i.e. Weedy check (T1), Mechanical Weeding (T2), Chemical weeding (T3) & Weed free (T4)as sub plot treatment.

Species wise weed counts was recorded in each plot by using a quadrate of 0.5 m x 0.5 m (0.25 m^2) size and was expressed as number of weeds (m^2). Individual species wise counts was grouped into grasses, sedges and broad-leaved weeds and was expressed as no m^2. Total weed density by adding the count of all weeds was also obtained.

Table 1: Weed flora of the experimental field during 2020-21 and 2021-22

S. No.	Weed flora	Density m^{-2}								Mean		Relative Density (%)	
		30 DAA		60 DAA		90 DAA		At harvest					
		2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021
Grasses													
1	*Echinochloa colona*	27.81	22.79	45.75	42.30	49.46	50.91	47.51	44.42	42.63	40.11	18.12	17.17
2	*Leptochloa chinensis*	9.47	9.73	20.47	18.76	34.69	34.07	32.18	31.64	24.20	23.55	10.28	10.09
3	*Eluesine indica*	5.38	4.74	19.66	17.14	26.00	28.77	23.20	24.40	18.56	18.76	7.89	8.03
	Sub-total	42.66	37.26	85.88	78.20	110.15	113.75	102.89	100.46	85.40	82.42	36.29	35.29
Sedges													
4	*Fimbristylis miliacea*	19.82	19.23	46.91	43.33	59.63	51.54	59.39	42.96	46.44	39.27	19.73	16.81
5	*Cyperus rotundus*	35.38	39.07	46.61	37.56	49.83	50.44	47.16	48.94	44.75	44.00	19.01	18.84
	Sub-total	55.20	58.30	93.52	80.89	109.46	101.98	106.55	91.90	91.18	83.27	38.75	35.66
Broad leaved weeds (BLW)													
6	*Caesulia axillaris*	21.07	13.43	29.30	33.43	44.95	45.05	40.98	40.22	34.08	40.08	14.48	17.16
7	*Ludwigia parviflora*	13.62	12.27	20.93	18.27	31.54	27.79	32.58	25.95	24.67	27.75	10.48	11.88
	Sub-total	34.69	25.70	50.86	51.70	76.49	72.84	73.56	66.17	58.74	67.83	24.96	29.05
	Grand Total									235.32	233.51	100.00	100.00

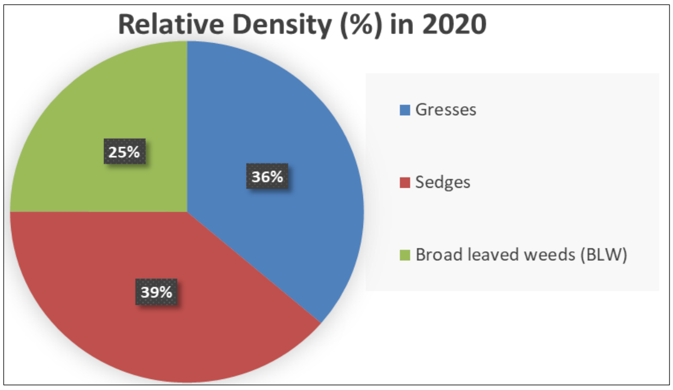

Fig 1: Relative Density of weed flora in 2020-21

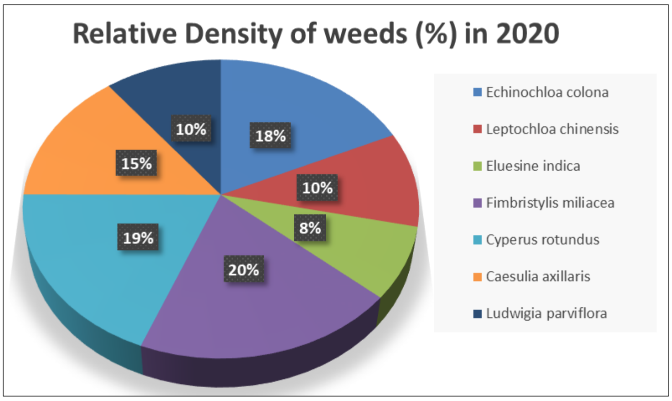

Fig 3: Species wise relative density of weed flora in 2020

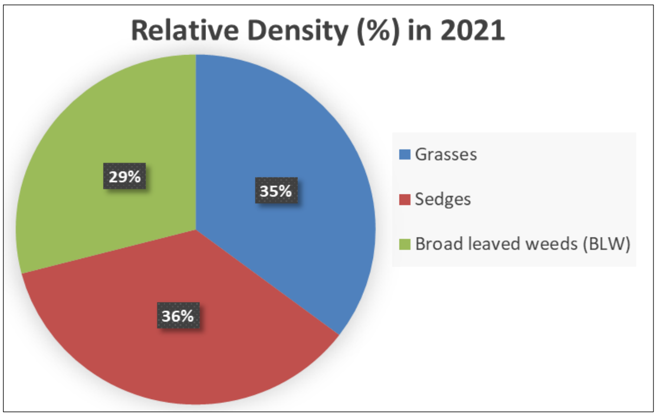

Fig 2: Relative Density of weed flora in in 2021-22

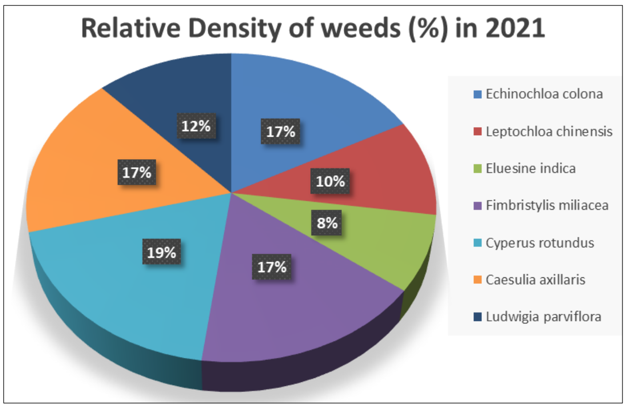

Fig 4: Species wise relative density of weed flora in 2021

Results and Discussion

Associated weed flora

Important weeds which are commonly associated with rice are composed of *Caesulia axillaris*, *C. fimbristylis* and *Ludwigia spp.* among the broad leaved weeds, and *Cyperus rotundus*, *Leptochloa chinensis*, *Elusine indica* and *Echinochloa colona* among the grassy weeds.

Results showed that the diversity of grassy & non grassy weeds are more in case of DSR followed by WDSR method of establishment. T4 produced significantly better control over the T2 and T3 management practices. However the T2 & T3 also gave the significant control of weeds over the weedy check.

Conclusion

It is, necessary to control weeds so as to reduce the competition for nutrients, moisture, radiant energy, and to obtain higher fertilizer and water use efficiency. So, this approach of adopting suited establishment method with batter weed management practices can minimize the crop weed competition a step forward in sustainable agriculture.

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