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Floristic composition and distribution of weeds in different crop ecosystems of Raipur (Chhattisgarh), India

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Abstract
The present communication pertains to major weeds of different crop ecosystems of Raipur in India. The study was based on extensive and intensive fields surveys made during different months of rainy and dry season 2020-2022. Surveys were made in five important crops ecosystems of total four developmental blocks of Raipur district during both Kharif and Rabi seasons of the year. Vegetation data were collected followed by quadrat methods and analyzed for density, frequency, diversity and importance value index (IVI) for each crop ecosystems. Interspecific association was also analyzed for ten dominant weed species followed by Cole's index. During this period, a total of 80 weed species were reported of which 50 species were recorded from the transplanted Kharif rice fields, while 60 weed species were recorded from the Rabi crop fields. The five dominant weed families in the study area were Cyperaceae, Poaceae, Onagraceae, Asteraceae and Fabaceae.

Keywords: Crop ecosystem floristic composition kharif and rabi crops transplanted rice weeds

Introduction
Farmers have long realized the interference of weed with crop productivity as weeds are regarded as old as agriculture itself and that eventually led to the co-evolution of agro-ecosystems and weed management (Ghersa *et al*. 1994, 2000) [1-2]. Worldwide yield loss due to weeds in rice field was found to be 15% (De Datta, 1990) [3]. Weed competes with crops for natural and applied resources and reduces both quantity and quality of agricultural productivity (Rao and Nagamani 2010, Rao *et al*. 2015) [4-5]. It has also been reported that weeds are notorious yield reducers that are, in many situations, economically more important than insects, fungi and other pest organisms in agricultural fields (Savary *et al*. 1997, 2000) [6-7]. In India, weeds are one of the major biological constrains that limit crop productivity and reduce crop yields by 30.5% that amounts to 22.7% in winter and 36.5% in summer and Kharif season (Bhan *et al*.1999) [8]. It has been reported that reduction of rice yield due to weed competition ranged from 9-51% and uncontrolled weed growth may cause 75.8, 70.6, 62.6% yield reduction in dry seeded rice, wet seeded rice and transplanted rice, respectively (Mani *et al.* 1968) [9].
The information on the presence, composition, abundance, importance and ranking of weed species is needed to formulate appropriate weed management strategies to produce optimum yields of rice (Begum *et al.* 2005) [10]. A through survey is necessary to address the current weed problems in cropping systems as it will help in developing target-oriented research programmes (Boldt and Devine 1998) [11]. Specific sound knowledge on the nature and extent of infestation of weed flora is essential to plan the control measures and formulate target oriented research programme. Transplanted Kharif rice and different Rabi crops like black gram/green gram, pea, mustard, potato and different winter vegetables are the dominant agricultural crops of Raipur in India. The soil is drained by a number of perennial tributaries of the Shivnath River and pH ranges from 4.5 to 6.0. However, detailed information regarding the status and distribution of weeds are rare from the study area. Therefore, the present study was undertaken.

Methodology
Study area
The study was conducted in Raipur in India. It is situated between 22° 33' N to

21°14'N Latitude and 82° 6' to 81° 38'E Longitude. It occupies the south eastern part of the upper Mahanadi River valley and the bordering hills in the south and the east. The district is located on the Chhattisgarh plain, the areas near the hills being split off when the district was trifurcated.

Raipur district comprised of total four developmental blocks. Repeated field survey was done followed by interaction with the farmers and agricultural officers prior to selection of study sites. Finally, five dominant crop ecosystems namely transplanted Kharif rice, mustard, mixed winter vegetables, green/black gram and potato were selected in study area and all the four developmental blocks were surveyed. GPS reading were recorded for each sampling sites. Both quadrat and line transect methods (Akwee *et al.* 2010) [12] were used to collect data from study area. Quadrats of 1×1 m size were plotted in random systematic design for collection of data by following the method as described by Kent and Coker (1994) [13]. All the plant species enumerated in the quadrat, were identified and counted.

Ecological analysis of weed flora was done following quantitative measures as density, frequency dominance and their relative values were used to calculate the importance value index (IVI). Similarity coefficient of different weed community of different crop ecosystems was calculated using Sorenson Index (Janson and Vegelius, 1981) [14] to compare of species affiliation among weed Communities between crop ecosystems.

The inter-specific association among the dominant weed species occurring in the different crop ecosystem of entire study area was computed (Sutomo and Putri, 2011) [15], to find out the inclination and repulsion effects among the weed species.

Results and Discussion

Weed flora in transplanted Kharif rice

Based on pooled data (2020-22), a total of 54 weed species were recorded in the transplanted Kharif rice crop ecosystem of Raipur district during the study; of which 16 were sedges, 10 grasses and 28 Broad-leaved weed (BLW) species (Table 1). Among the weed groups, highest density was recorded for BLW (626.21/m^2), followed by sedge (517.12/m^2) and grass (225.26/m^2) (Figure 1). Species richness was the maximum in BLW (28), followed by sedges (16) and grasses (10) (Figure 2). Among the weed flora recorded from rice fields *Fimbristylis miliacea* was the most widely distributed species with a frequency value of 73.12%, followed by *Rotala rotundifolia* (50%) and *Isachne himalaica* (47.54%). During the study, high value of IVI was recorded for *Eleocharis acicularis* (32.74) followed by *Cyperus iria* (24.56), *I. himalaica* (24.47), *Fimbristylis miliacea* (22.84) and *Rotala rotundifolia* (19.40) (Table 1). In the present study, a significant difference was found in the weed types in rice fields of entire Raipur district ($F_{2,\,872}$= 97.04, p<0.01). *F. miliacea* was the most common, widely distributed and the most serious weed with highest frequency, field uniformity and highest density values in the rice fields of different parts of the country (Baki 1993, Begum *et al.* 2005) [16, 10]. It has also been observed that the change of cultivation practice from transplanting to direct-seeding has no influence on *F. miliacea* (Tomita *et al.* 2003) [17]. In fact, because of the tremendous size of the soil seed bank accumulated over years of transplanting, *F. miliacea* would remain as a dominant weed species in direct-seeded rice areas (Azmi and Mashhor 1996) [18].

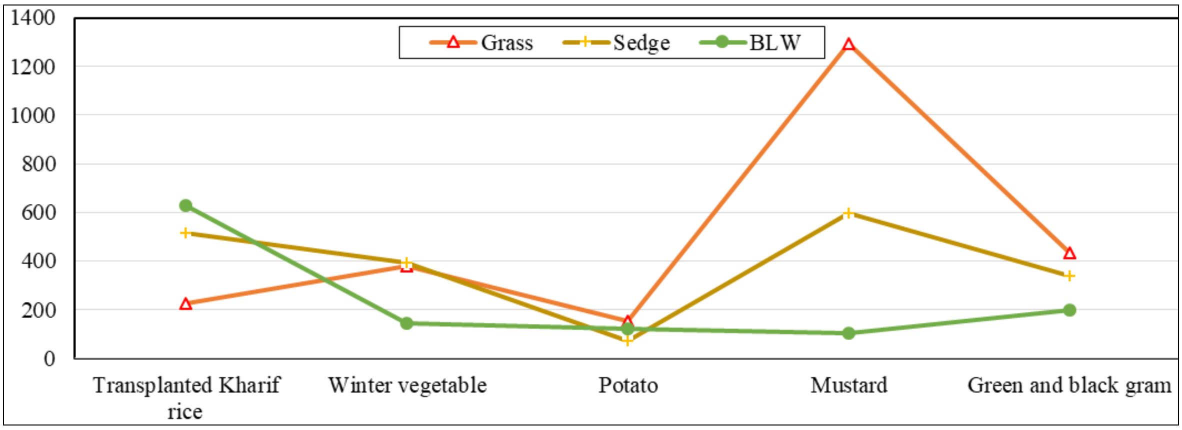

Fig 1: Graph analysis of weed density (no./m^2) in different crop ecosystems of Raipur (CG) in India

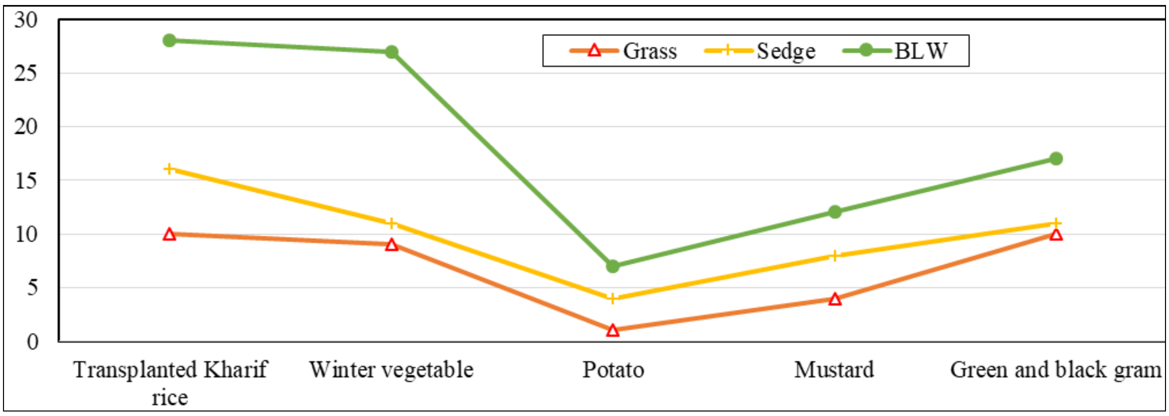

Fig 2: Graph analysis of weed species richness in different crop ecosystems of Raipur (CG) in India

Table 1: Consolidated account of different parameters of weed species in different crop ecosystems of Raipur in India

Parameters	Transplanted Kharif rice	Winter vegetable	Potato	Mustard	Green and black gram
Density (no./m²)					
Grass	225.26	378.6	152.62	1294.6	435.6
Sedge	517.12	393.4	71.2	598.7	336.8
BLW	626.21	144.0	121.6	104.7	196.5
Species richness					
Grass	10	9	1	4	10
Sedge	16	11	4	8	11
BLW	28	27	7	12	17
Species with highest IVI					
Five most dominant species (IVI)	*Eleocharis acicularis* (32.74)	*Cynodon dactylon* (39.16)	*Colocasia esculenta* (54.73)	*Cynodon dactylon* (59.93)	*Cynodon dactylon* (54.79)
	Cyperus iria (24.56)	*Ageratum houstonianum* (25.26)	*Ageratum houstonianum* (51.33)	*Cyperus compressus* (49.05)	*Cyperus compressus* (35.60)
	Isachne himalaica (24.47)	*Fimbristylis bisumbellata* (22.87)	*Cynodon dactylon* (48.51)	*Paspalum conjugatum* (26.54)	*Cyperus brevifolius* (14.79)
	Fimbristylis miliacea (22.84)	*Cyperus compressus* (19.20)	*Cyperus haspan* (24.16)	*Fimbristylis littoralis* (26.03)	*Ludwigia perennis* (14.57)
	Rotala rotundifolia (19.40)	*Cyperus brevifolius* (17.20)	*Hygrophilla auriculata* (23.19)	*Eragrostis unioloides* (19.42)	*Fimbristylis littoralis* (14.48)

Weed flora in major Rabi crops

Out of the four major Rabi crops, 46 weed species were recorded in different mixed winter vegetables, 12 species from potato fields, 24 species in mustard and 48 weed species were recorded in the green gram/ black gram crop ecosystem in Raipur district (Table 1). Pumpkin, tomato, brinjal, radish, cauliflower, cabbage, garlic, bean etc. were cultivated as mixed winter vegetable crops in Rabi season in all the four developmental blocks of Raipur, district. Among the weed groups, highest density was recorded for grasses in potato (152.62/m^2) followed by mustard (1294.6/m^2) and green gram/black gram cultivated fields (435.6/m^2). However, in winter vegetables, highest density was recorded for sedge (393.4/m^2). Among the weeds *Cynodon dactylon* had the highest IVI value 59.93 followed by *Colocasia esculenta* (54.73), *Ageratum houstonianum* (51.33), *Cyperus compressus* (49.05) and *Paspalum conjugatum* (26.54) in different Rabi season crop ecosystems of Raipur district, (CG) (Table 1). These were the most dominant weed species with high density and wide distribution. Similar findings were reported in West Bengal, where *C. dactylon* was the dominant weed species in different winter crops like rapeseed mustard, wheat and potato fields (Duary *et al.* 2015) [19]. Pramanick *et al.* (2012) [20] also reported that, *C. dactylon* and *F. littoralis* were the most dominant and well distributed species in potato fields of West Bengal. Besides these, *F. littoralis*, *F. miliacea* and *F. bisumbellata* were reported as dominant species amongst the five dominant weed species from mixed winter vegetables, mustard, green gram and black gram cultivated fields with the exception of potato fields.

In the present study, a significant difference in weed types (sedge, grass and BLWs) was found among different crop ecosystems in all the developmental blocks (Table 2). All the three weed types were found to be significantly different among four developmental blocks in transplanted rice and green gram/black gram crop ecosystems, while BLWs and grass were not significantly different in winter vegetables (Table 3).

Table 2: Differences among weed types (Sedge, grass and broad-leaved weed) in different crop ecosystems in four developmental blocks of Raipur district, Chhattisgarh (one-way ANOVA)

Crop ecosystem	Developmental blocks	F value	df (Degrees of freedom)	Result
Kharif rice	Dharshiwa	39.9	2, 108	<0.01
	Tilda	63.25	2, 106	<0.01
	Arang	70.84	2, 112	<0.01
	Avanpur	90.08	2, 116	<0.01
Winter vegetable	Dharshiwa	14.06	2, 32	<0.01
	Tilda	12.08	2, 38	<0.01
	Arang	5.47	2, 34	<0.01
	Avanpur	5.36	2, 42	<0.01
Potato green gram/ Black gram	Dharshiwa	16.40	2, 30	<0.01
	Tilda	15.20	2, 28	<0.01
	Arang	6.35	2, 32	<0.01
	Avanpur	6.40	2, 38	<0.01

However, weed species diversity differed significantly among all the crop ecosystems of different developmental blocks of the entire study area (Table 4). On the other hand, there was a difference in the weed types among transplanted rice fields of Raipur district ($F_{2, 872}$ = 97.04, p<0.01).

Similarity analysis

Similarity analysis among the weed communities of different crop ecosystems of Raipur district recorded that the highest similarity (0.78%) was among the weed communities of mixed winter vegetable crop fields and greengram/black gram crop fields followed by Mustard and greengram/black gram (0.66%), rice and greengram/black gram (0.58%) and mustard and mixed winter vegetables (0.56%) (Table 5). However, only 0.28% similarity could be found among the weed communities of potato and green gram/black gram cultivated fields of the study area.

Table 3: Difference of weed types in Kharif rice, mixed winter vegetables, green gram/ black gram cultivated fields among different developmental Blocks of Raipur district (one-way ANOVA)

Crop ecosystem	Weed types	F value	df (Degrees of freedom)	Result
Kharif rice	Sedge	17.6	3, 264	<0.01
	Broad-leaf	84.8	3, 264	<0.01
	Grasses	10.4	3, 264	<0.01
Winter vegetable	Sedge	6.34	3, 58	<0.01
	Broad-leaf	0.58	3, 58	NS*
	Grasses	1.22	3, 58	NS*
Greengram/ blackgram & mustard	Sedge	9.38	3, 70	<0.01
	Broad-leaf	4.14	3, 70	<0.01
	Grasses	2.78	3, 70	<0.05

NS*= Non significant

Table 4: Difference of weed species diversity among different Developmental blocks of Raipur district in different crop ecosystem (one-way ANOVA)

Crop ecosystem	F Value	df (Degrees of freedom)	Result
Kharif rice	15.56	3, 248	< 0.01
Mixed winter vegetables	6.72	3, 54	< 0.01
Greengram, blackgram and mustard	6.24	3, 66	< 0.01

Table 5: Similarity index of weed communities among different crop ecosystems of Raipur in India

Crop ecosystems	Rice	Mixed winter vegetables	Potato	Mustard	Greengram/ black gram
Rice	***				
Mixed winter vegetables	0.56	***			
Potato	0.33	0.36	***		
Mustard	0.40	0.46	0.32	***	
Greengram/ blackgram	0.55	0.62	0.26	0.54	***

Interspecific association

The positive and negative association was analyzed for the ten most dominant (Highest IVI value) weed species found in different crop ecosystems of Raipur district. Out of ten of positively associated weed pairs, *Fimbristylis miliacea* showed high degree of positive association with *Elocharis acicularis* (0.290±0.001; p<0.01). Similarly, significant positive association was recorded between *Rotala rotundifolia* and *Isachne himalaica* (0.352±0.002), *Cynodon dactylon* and *Ageratum houstonianum* (0.268±0.008), *Fimbristylis miliacea* and *Cyperus iria* (0.232±0.001) and so on (Table 6). Barua and Gogoi (1995) [21] studied the association among different weed groups in sugarcane cultivated areas in Assam. Positive association between various species pairs can be attributed to their similar requirement for growth and development (Sundriyal 1991) [22] and the competition between them in fairly stable habitat is not to eliminate one by the other from the area (Smith and Cottam 1967) [23].

Table 6: Chi-square ($\chi 2$) values (*, p<0.05; **, p<0.01) showing association and Cole's index showing degree of association of different weed pairs in different crop fields of Raipur district, Chhattisgarh.

Name of the species	Cole's index ± Standard error	Chi- square Value
Positive association		
Cynodon dactylon x *Ageratum houstonianum*	0.268±0.008	60.46**
Cyperus compressus x *Cynodon dactylon*	0.564±0.013	24.65**
Fimbristylis miliacea x *Cyperus iria*	0.232±0.001	56.93**
Fimbristylis miliacea x *Eleocharis acicularis*	0.290±0.001	69.61**
Isachne himalaica x *Eleocharis acicularis*	0.178±0.001	21.54*
Isachne himalaica x *Fimbristylis miliacea*	0.422±0.006	28.57**
Rotala rotundifolia x *Eleocharis acicularis*	0.218±0.001	37.12**
Rotala rotundifolia x *Isachne himalaica*	0.352±0.002	65.67**
Schoenoplectiella juncoides x *Fimbristylis miliacea*	0.517±0.011	24.68**
Schoenoplectiella juncoides x *Isachne himalaica*	0.323±0.004	27.88**
Negative association		
Eleocharis acicularis x *Ageratum houstonianum*	0.741±0.021	26.06**
Eleocharis acicularis x *Cynodon dactylon*	0.722±0.010	42.64**
Fimbristylis miliacea x *Cynodon dactylon*	0.334±0.003	38.64**
Fimbristylis littoralis x *Fimbristylis miliacea*	0.336±0.003	35.75**
Isachene himalaica x *Ageratum houstonianum*	0.517±0.015	17.76*
Rotala rotundifolia x *Ageratum houstonianum*	0.478±0.013	17.72*
Rotala rotundifolia x *Cynodon dactylon*	0.704±0.007	66.13**
Schoenoplectiella juncoides x *Ageratum houstonianum*	0.827±0.026	26.26**
Schoenoplectiella juncoides x *Cynodon dactylon*	0.558±0.015	21.25*

However, out of nine negatively associated weed pairs, broad-leaved weed *Rotala rotundifolia* showed high degree of negative association with *Cynodon dactylon* (0.704±0.007; p< 0.01) followed by *E. acicularis* and *C. dactylon*

(0.722±0.010), *F. miliacea* and *C. dactylon* (0.334 ± 0.003) and *F. littoralis* and *F. miliacea* (0.336±0.003) (Table 6). Interspecific association is that if species are independent to each other, they will occur together more or less by chance, while if they are not dependent they will occur together more often or less often than can be expected by chance, which is expressed in terms of Coles index (Brey, 1956) [24]. The positive association between species is due to habitat suitability, requirement of shade by herbaceous species and requirement of light, space and nutrition (Mishra and Mishra 1981) [25]. Several factors might have attributed to the negative associations of the weeds of rice fields as well as different winter crop ecosystems in the present study area, and the major factor might be the divergence of niches. Higher degree of negative associations between different *Fimbristylis* species with other sedges, BLW weeds and grass species were recorded in both the cropping season (monsoon and post monsoon) in Raipur district, Chhattisgarh. The other important factors might be topography, site condition, microclimate, differential growth pattern, allelopathy and management and other biotic pressures (Barua and Gogoi 1995) [21]. Whatever may be, these species had wider ecological and sociological amplitude in the weed communities of different crop fields of Raipur district, Chhattisgarh.

Overall, the study revealed that, grasses were the most dominant weed groups in different winter crop ecosystems of Raipur in India and *C. dactylon* was one of the most dominant and well distributed species followed by different BLW species and sedge. Similar findings had been reported by Tiwari *et al.* (2014) [26] from Bilaspur district, Chattisgarh where they found Poaceae as the dominant family followed by BLW families like Asteraceae, Fabaceae, Amaranthaceae and Cyperaceae (sedge). The dominance of sedge was slightly lesser in winter crop ecosystems as compared to the transplanted Kharif rice in Raipur in India. As the different winter crops were cultivated in upland situation in the post-monsoon season of the year, therefore, the dominance of sedges were comparatively lesser in Rabi crops. While, it was higher in transplanted Kharif rice in the study area, as all experimented rice fields were inundated about 5-10 cm in water. In rice, water and weeds are often considered to be closely interlinked. Bhagat *et al.* (1999) [27] reported that weed species respond differently to changing water regimes and the dominance of grass species was favoured by saturated and below saturated conditions, whereas aquatic broad-leaved weeds and sedges grow rapidly when soil was submerged with water (Bhagat *et al.* 1999, Juraimi *et al.* 2011) [27, 28]. This may be the most important factor for grass dominance over sedge and broad-leaved weeds in different winter crop ecosystems of Raipur (CG) in India.

Different crop ecosystems are infested by various problematic weeds for which modern technology should be used to address the issue and ensure increased crop productivity in a sustainable way, with the minimum of environmental degradation and loss of diversity of many important plant species. Weed control must be done to increase the crop productivity but there are some weeds and some situations in which more may be lost than gained by their destruction (Hillocks, 1998) [29].

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