Original Research Article

IMPACT OF WEED MANAGEMENT PRACTICES ON THE WEED DYNAMICS, NUTRIENT UPTAKE PATTERN OF WEEDS AND DIRECT SEEDED RICE

ABSTRACT

Herbicide based weed management is the emerging and effective method for controlling the weed flora of direct seeded rice. Weed growth often has an impact on crop development by interfering with plant nutrients. A two-year weed experiment with twelve treatments was set up at the University of Agricultural Sciences in Bangalore, Karnataka, India to know the effect of weed management practices on weed and nutrient dynamics in direct seeded rice. Significantly lower total weed density and biomass was observed with bispyribac sodium 10 SC 40 g a.i. ha^{-1} as post emergence which recorded statistically at par values with bensulfuron methyl + pretilachlor 6.6 GR 660 g a.i. ha^{-1} as pre-emergence during both the years of study. The allelochemicals used in the study performed well over unweeded control but it was far less when compared with chemical herbicides. Nutrient uptake by the direct seeded rice (82.17, 31.76 and 68.83 kg ha^{-1} NPK in 2020 and 89.38, 38.84 and 75.62 ha^{-1} NPK in 2021, respectively) and grain yield (4.98 t ha^{-1} in 2020 and 4.99 t ha^{-1} in 2021, respectively) was also reported to be higher with bispyribac sodium 10 SC 40 g a.i. ha^{-1} as post emergence which was on par with bensulfuron methyl + pretilachlor 6.6 GR 660 g a.i. ha^{-1} as pre-emergence. As the nutrient uptake by the crop and weeds are negatively correlated, the same treatments have recorded lower nutrient removal by the weeds. Higher weed biomass and rapid nutrient removal by weeds had resulted in poor soil nutritional status in unweeded control compared to all other treatments. Application of bispyribac sodium 10 SC 40 g a.i. ha^{-1} as post emergence or bensulfuron methyl + pretilachlor 6.6 GR 660 g a.i. ha^{-1} as pre-emergence were considered to be best management practices for weed management under direct seeded rice.

Key words: weed management, herbicides, direct seeded rice, nutrient uptake

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1. INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important food crops, providing a staple diet for more than half of the global population. It is a semi-aquatic annual grass native to tropical Asia. It occupies an enviable leading place among all the food crops cultivated around the world and is cultivated on an area of 166.57 million hectares with a production of 513.67 million tonnes and productivity of 4.60 t ha^{-1}. After China, India is the second largest producer and consumer of rice. In India, rice is cultivated on an area of 47 million hectares with a total production of 129.66 million tonnes and a productivity of 4.14 t ha^{-1} during 2021-22 (1). Rice is the most important source of food in India, providing 43 per cent of the calorie requirements for more than two-thirds of the population (2) and 55 per cent of cereal production in the country.

Rice production systems are undergoing a shift from transplanting to direct seeding (3). Direct seeded rice saves water and labour by avoiding puddling, nursery management and transplanting (4). It also improves soil structure, reduces greenhouse gas emission, and early crop harvesting facilitating timely sowing of succeeding crops (5). The establishment of rice crop through dry direct seeding technique is not only simple to use but also has been found effective in sustaining the production of rice.

The popularity of direct seeded rice (DSR) has been increasing under the present context of water and labour scarcity and in the state of Punjab during 2020, adoption of DSR has increased to 5.19 lakh hectares and it resulted in saving of Rs. 10,000 to 12,500 ha^{-1}, which adds up to roughly a saving between Rs 500 to 600 crores cumulatively. Also, there is around 30 per cent water saving on 5.19 lakh hectares paddy area (6).

The major problem in the success of direct-seeded rice in the tropical countries is that of heavy weed infestation due to successive emergence of weeds and crop at the same time (7). Weeds pose a major threat in DSR by competing for nutrients, light, space and moisture with the crop right from the time of emergence and throughout the growing season.

Herbicides are considered to be the most extensively used pesticides globally. With the introduction of herbicides in 19th century, weed control has become less of a chore and more energy efficient. Because of their cost and time effectiveness, chemical weed control has become the most widely used weed control tool all over the world. Over-reliance on herbicide weed

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control has many deleterious effects like herbicide residue build up, soil pollution, decline in soil microbial activity and herbicide resistance. In order to reduce the adverse effects of the chemical herbicides, another group of weed control was gaining importance *i.e.,* allelopathy.

Allelopathy was originally understood to be the biochemical interactions between all types of plants, including the microbes that are normally categorised as part of the plant kingdom (8). Since that time, the phrase has undergone a number of changes, and it is presently defined as any direct or indirect negative or positive impact caused by one plant on another by the synthesis of chemical substances that escape into the environment (9). Allelopathy is any process involving secondary metabolites produced by plants, algae, bacteria, and fungi that affects the growth and development of agricultural and biological systems, according to the International Allelopathy Society. This concept takes into account all biochemical interactions between living things, such as plants, algae, bacteria, and fungi, as well as their surroundings (10). In recent years, the allelochemicals extracted from different plant materials are being used as bioherbicides and it has been an effective tool in combating the adverse effects of toxic manufactured chemical herbicides.

In this present investigation, for the weed management in DSR, different chemical herbicides along with few allelochemicals were tested for their bio-efficacy and their impact on soil and plant nutrition.

2. MATERIALS AND METHODS

A two year (2020 and 2021) field study was conducted in red sandy loam soils of Zonal Agricultural Research Station (ZARS), Gandhi Krishi Vignana Kendra (GKVK), University of Agricultural Sciences, Bengaluru, Karnataka, India (12º 58' N, 77º 33' E). The soil moisture content at field capacity was 19.23 per cent with a bulk density of 1.44 g cc^{-1}. The other physico-chemical properties of the soil were mentioned in **Table 1**.

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Table 1: Physico-chemical properties of soil in the experimental site

Sl. No.	Particulars	Values obtained	Reference
Physical properties			
1	Coarse sand (%)	33.3	International pipette method (11)
2	Fine sand (%)	31.6	
3	Silt (%)	6.9	
4	Clay (%)	28.2	
5	Textural class	Red Sandy loam	
Chemical composition			
1	Soil pH (1:2.5 soil water suspension)	6.20 (Acidic)	Potentiometric method (12)
2	Electrical conductivity (dS m^{-1})	0.35 (Normal)	Conductometric method (12)
3	Organic carbon (%)	0.41 (Low)	Walkely and Black wet oxidation method (12)
4	Available nitrogen (kg ha^{-1})	261.7 (Low)	Alkaline potassium permanganate method (13)
5	Available phosphorus (P_2O_5 kg ha^{-1})	34.62 (Medium)	Bray's method (12)
6	Available potassium (K_2O kg ha^{-1})	268.3 (Medium)	Flame photometer method (12)

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The experimental design was randomized complete block design with twelve treatments and three replications. It includes seven herbicide treatments (T_1: Bensulfuron methyl + Pretilachlor 6.6 G 660 g a.i. ha^{-1} as pre-emergence; T_2: Pyrazosulfuron ethyl 10 WP 40 g a.i. ha^{-1} as pre-emergence; T_3: Oxadiargyl 80 WP 100 g a.i. ha^{-1} pre-emergence; T_4: Bispyribac sodium 10 SC 40 g a.i. ha^{-1} as post emergence; T_5: Quizolofop-p-ethyl 15 EC 37.5 g a.i. ha^{-1} as post emergence; T_6: Cyhalofop-p-butyl 10 EC 100 g a.i. ha^{-1} as post emergence; T_7: Metamifop 10

EC 100 g a.i. ha^{-1} as post emergence), three allelochemical treatments (T_8: *Leucas aspera* plant extract; T_9: *Eucalyptus* leaf extract; T_{10}: *Hyptis saveolensis* plant extract), hand weeding (T_{11}: Hand weeding at 20 and 40 DAS) and T_{12}: Unweeded control. The herbicides were applied using spray volume of 750 L ha^{-1} for pre-emergence and 500 L ha^{-1} for post emergence with knapsack sprayer having flood jet nozzle. The aqueous allelochemical plant extracts were applied at 10 % w/v as post emergence application.

In both the years, 10 t of FYM was applied before sowing. Seeds of aerobic rice variety '*MAS 946-1'* (Sharada) released from University of Agricultural Sciences, Bengaluru were line sown with 30 cm space between the lines and the recommended dose of fertilizer *i.e*., 100-50-50 kg of N, P_2O_5 and K_2O were applied with entire P and K as basal and nitrogen applied in three equal splits.

Weed densities were estimated by taking two 0.25 m^2 quadrate samples at random locations within each plot and then they were converted into weeds per m^2. For weed biomass estimation all the weeds existing in 0.25 m^2 quadrant sample of each plot were cut to the soil surface level, placed in paper bags and dried in a hot air oven at 60 ^oC until a constant dry weight was recorded and the final dry weight was converted to g m^{-2}. The data pertaining to weed was transformed before subjecting to ANOVA (14).

After the harvest, the nutrient content in soil were analyzed for N, P and K. For analyzing nutrient content in plant samples, the crop and weed samples collected at harvest were dried at 60 ^oC in a hot air oven and powdered to a fine level and then the samples are subjected to digestion by di-acid (PK) and tri acid mixture (N) followed by nutrient estimation. The total N, P and K uptake by the crop and weeds were calculated by using the following formula:

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Nutrient concentration (\%)} \times \text{Weight of dry matter (kg ha}^{-1}\text{)}}{100}$$

All the data were analyzed and the results are presented and discussed at a probability level of 5%.

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3. RESULTS AND DISCUSSION

3.1 Weed species

Results revealed that monocots dominated in the weed density followed by dicots and sedges. *Cyperus rotundus, Eleusine indica, Echinochloa colona, Panicum repens* and *Digitaria sanguinalis* dominated in both the years of investigation (**Figure 1a & b**). No much difference was observed with respect to weed species composition in both the years of investigation.

3.2 Weed density and biomass

Herbicides and allelochemicals used in the current investigation differed in their ability to control weeds (**Table 2**). However, significantly lower total weed density and biomass was recorded with bispyribac sodium 10 SC 40 g a.i. ha^{-1} as post emergence which was statistically at par with bensulfuron methyl + pretilachlor 6.6 GR 660 g a.i. ha^{-1} as pre-emergence during both the years of study. All the herbicide treatments including allelochemical treatments significantly lowered the weed density and biomass when compared to unweeded control. Among the allelochemical treatments, *Eucalyptus* leaf extract recorded lower total weed density and biomass comparatively over *Leucas aspera* and *Hyptis suaveolens* plant extract.

Total weed density and biomass is a result of summation of grasses, broad leaf weeds and sedges. In order to record lower total weed density and biomass, all the categories of weeds should record lower respective values and any herbicide which targets all the three categories of weeds will undoubtedly record lower total weed density and biomass. In line with this, herbicide bispyribac sodium and bensulfuron methyl + pretilachlor were reported to control all the categories of weeds *viz*., grasses, broad leaf weeds and sedges. Because of this broad spectrum weed control the respective treatments have recorded lower total weed density and biomass (15-16). Highest weed density and biomass in unweeded control is due to uninterrupted and luxurious growth of weeds assisted by the absence of effective weed management practice (17).

3.3 Nutrient uptake by the crop and grain yield

The nutrient uptake by the crop and yield differed significantly due to application of different herbicides and allelochemicals (**Table 3**). Among herbicide treatments, nutrient uptake by the direct seeded rice (82.17, 31.76 and 68.83 kg ha^{-1} NPK in 2020 and 89.38, 38.84 and

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75.62 ha^{-1} NPK in 2021, respectively) and grain yield (4.98 t ha^{-1} in 2020 and 4.99 t ha^{-1} in 2021, respectively) was higher with bispyribac sodium 10 SC 40 g a.i. ha^{-1} as post emergence which was on par with bensulfuron methyl + pretilachlor 6.6 GR 660 g a.i. ha^{-1} as pre-emergence. *Eucalyptus* leaf extract also recorded a fair nutrient uptake and grain yield among the allelochemical treatments and all treatments were significantly superior over unweeded control.

The nutrient uptake by the crop is affected by so many factors among which crop weed competition plays a crucial role and among different rice growing ecosystems, weeds pose a greater threat in direct seeded rice. The weed biomass had a highly significant negative correlation with the nutrient uptake by the direct seeded rice in both the years (**Figure 2 a & b**) which implies that there is a proportional decrease in the nutrient uptake by the direct seeded rice with increase in weed biomass. The yield of any crop is directly linked with the nutrient uptake and relationship is directly proportional. Hence, the treatment bispyribac sodium 10 SC 40 g a.i. ha^{-1} as post emergence which recorded lower total weed density and biomass has reported higher nutrient uptake and grain yield. Moreover, absence of weeds will always provide favorable conditions for the crop to grow well and absorb more nutrients through minimum competition thereby offering less scope for the robbery of nutrients by weeds ultimately resulting in higher grain production (18). The aqueous allelochemical plant extracts were not as effective as manufactured chemical herbicides but their performance was still appreciable as reflected in the significantly higher grain yields when compared with control.

3.4 Nutrient removal by weeds

The treatment bispyribac sodium 10 SC 40 g a.i. ha^{-1} as post emergence which recorded higher uptake of nutrients by the crop has recorded lower nutrient (nitrogen, phosphorus and potassium) removal by the weeds (24.30, 9.04 and 22.70 kg ha^{-1} NPK in 2020 and 22.99, 7.18 and 21.37 kg ha^{-1} NPK in 2021, respectively) followed by bensulfuron methyl + pretilachlor 6.6 GR 660 g a.i. ha^{-1} as pre-emergence and pyrazosulfuron ethyl 10 WP 40 g a.i. ha^{-1} as pre-emergence (**Table 4**). The highest nutrient removal by the weeds was recorded under unweeded control (93.31, 39.40 and 85.75 kg ha^{-1} NPK in 2020 and 89.36, 37.42 and 78.82 kg ha^{-1} NPK in 2021, respectively) and the same treatment has recorded lowest nutrient uptake by the direct seeded rice. There is inverse relationship between the nutrient uptake by the crop and nutrient removal by the weeds.

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Weeds have competitive advantage over direct seeded rice with higher growth rate and ecological hardiness. The pattern of nutrient removal by weeds revealed that nutrient removal by weeds was minimized wherever efficient weed control was feasible, and the loss of nutrients due to weeds varied with weed intensity and biomass production. There is strong positive correlation between the weed biomass and nutrient removal by the weeds (**Figure 3 a & b**). In unweeded control absence of effective weed management practices allowed the weeds to utilize the available growth resources to the fullest extent leading to uptake of more nutrients from the soil (18).

3.5 Soil nutritional status

Post-harvest nutrient status of the soil differed significantly due to the different weed management practices. The soil available nitrogen, phosphorus and potassium were greater in bispyribac sodium 10 SC 40 g a.i. ha^{-1} as post emergence and bensulfuron methyl + pretilachlor 6.6 GR 660 g a.i. ha^{-1} as pre-emergence (**Table 5**). Significantly lower soil available nitrogen, phosphorus and potassium were reported in unweeded control after the harvest of the crop.

It is a well-known fact that weeds are silent robbers and usually uptake nutrients at a rapid rate than crop plants. Higher weed density in unweeded control along with the ability to grow much faster and denser than the rice crop enables them to absorb more nutrients from the soil thereby reducing the soil nutrient status. Hence, the soil nutrient status was recorded in inverse order of weed density.

4. CONCLUSION

Application of bispyribac sodium 10 SC 40 g a.i. ha^{-1} as post emergence or bensulfuron methyl + pretilachlor 6.6 GR 660 g a.i. ha^{-1} as pre-emergence were found to be effective in controlling weed flora of direct seeded rice. The reduction of weed flora in these treatments has attributed for better nutrient uptake by the crop there by resulting in higher productivity of direct seeded rice.

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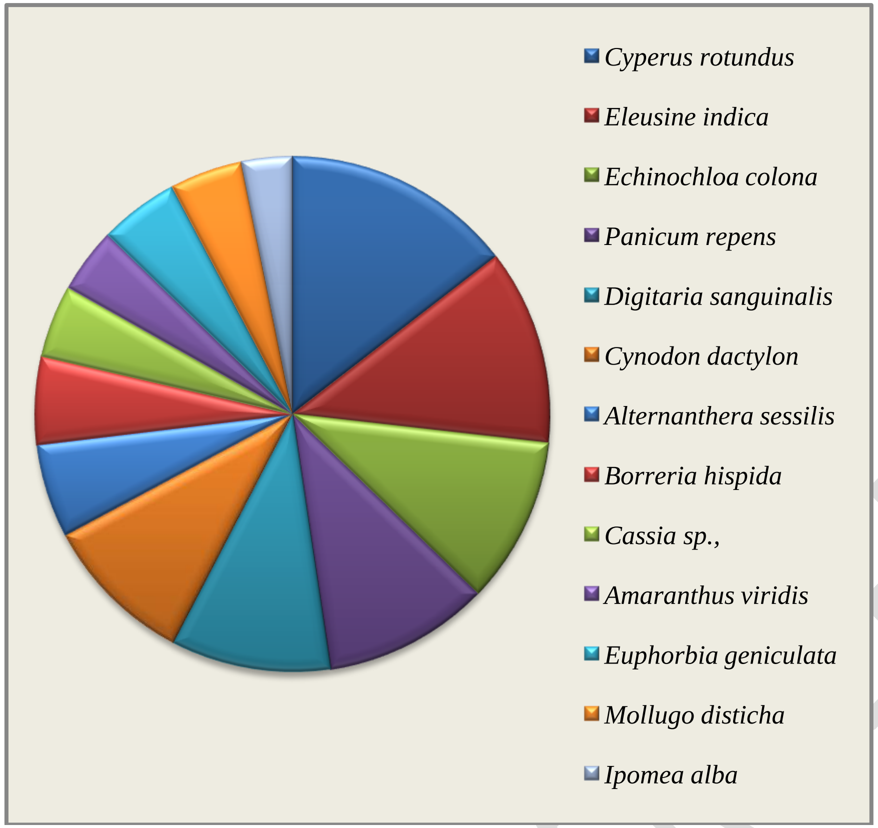

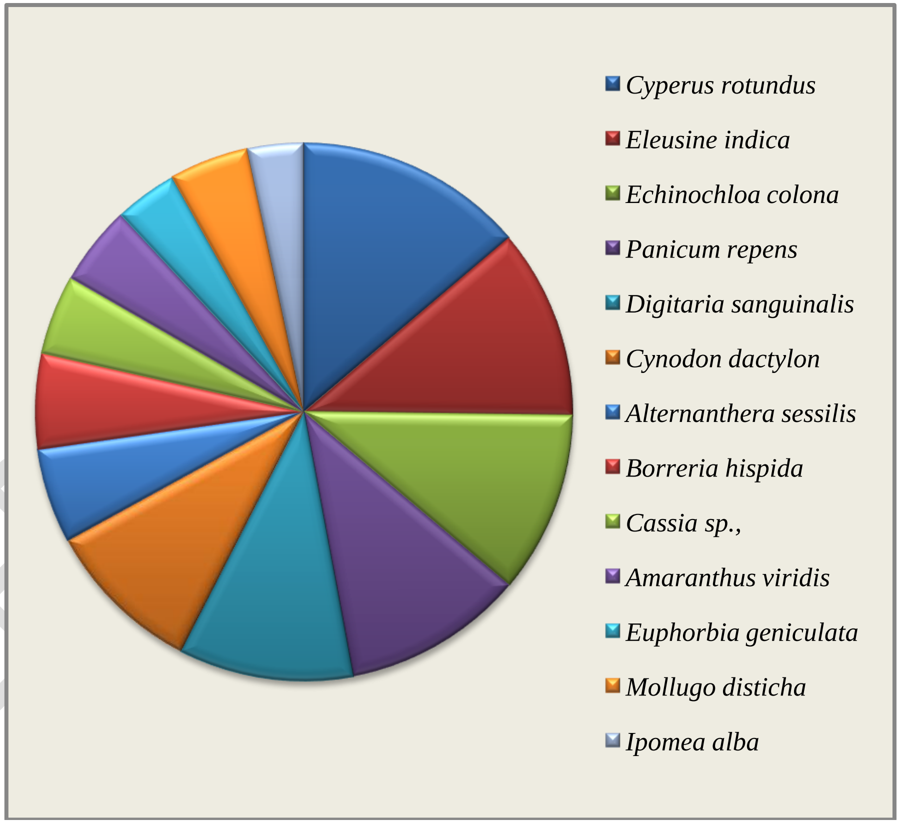

a. 2020 **b. 2021**

Figure 1. Weed species composition of the experimental field during a. 2020 and b. 2021

Table 2. Effect of weed management practices on total weed density and weed biomass at 45 DAS in direct seeded rice in 2020 and 2021

Treatments	Weed density (no. m^{-2})		Weed biomass (g m^{-2})	
	2020	2021	2020	2021
T_1: Bensulfuron methyl + pretilachlor 6.6 GR 660 g a.i. ha^{-1} as pre-emergence	1.36(20.7)	1.30(17.9)	0.96(7.2)	0.94(6.7)
T_2: Pyrazosulfuron ethyl 10 WP 40 g a.i. ha^{-1} as pre-emergence	1.46(26.7)	1.37(21.3)	1.06(9.4)	1.03(8.6)
T_3: Oxadiargyl 80 WP 100 g a.i. ha^{-1} pre-emergence	1.50(29.5)	1.43(24.7)	1.18(13.1)	1.06(9.4)
T_4: Bispyribac sodium 10 SC 40 g a.i. ha^{-1} as post emergence	1.31(18.6)	1.26(16.0)	0.87(5.3)	0.83(4.8)
T_5: Quizalofop-p-ethyl 5 EC 37.5 g a.i. ha^{-1} as post emergence	1.67(45.2)	1.66(43.4)	1.63(40.6)	1.52(30.9)
T_6: Cyhalofop-p-butyl 10 EC 100 g a.i. ha^{-1} as post emergence	1.63(40.6)	1.58(35.9)	1.53(31.7)	1.48(28.4)
T_7: Metamifop 10 EC 100 g a.i. ha^{-1} as post emergence	1.60(37.9)	1.58(35.9)	1.52(31.0)	1.48(28.3)
T_8: *Leucas aspera* plant extract	1.81(63.3)	1.77(57.1)	1.65(43.1)	1.58(36.2)
T_9: *Eucalyptus* leaf extract	1.75(53.9)	1.71(49.2)	1.61(38.5)	1.48(28.5)
T_{10}: *Hyptis suaveolens* plant extract	1.77(57.3)	1.74(53.2)	1.62(39.6)	1.54(32.4)
T_{11}: Hand weeding at 20 and 40 DAS	0.61(2.1)	0.53(1.4)	0.37(0.4)	0.37(0.3)
T_{12}: Unweeded control	2.02(101.9)	1.98(94.0)	2.04(106.5)	1.99(96.8)
C.D. (p=0.05)	0.13	0.10	0.16	0.18

Data within the parentheses are original values; Transformed values - # = log (x+2)

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Table 3. Nutrient uptake and grain yield of direct seeded rice as influenced by the different weed management practices

Treatments	Nutrient uptake (kg ha^{-1})						Grain yield (t ha^{-1})	
	Nitrogen		Phosphorus		Potassium			
	2020	2021	2020	2021	2020	2021	2020	2021
T_1: Bensulfuron methyl + pretilachlor 6.6 GR 660 g a.i. ha^{-1} as pre-emergence	78.67	85.48	30.20	37.24	67.83	73.61	4.79	4.94
T_2: Pyrazosulfuron ethyl 10 WP 40 g a.i. ha^{-1} as pre-emergence	76.02	79.35	28.13	33.42	64.14	69.84	4.65	4.85
T_3: Oxadiargyl 80 WP 100 g a.i. ha^{-1} pre-emergence	68.98	72.99	26.38	28.85	60.66	67.00	4.43	4.62
T_4: Bispyribac sodium 10 SC 40 g a.i. ha^{-1} as post emergence	82.17	89.38	31.76	38.84	68.83	75.62	4.98	4.99
T_5: Quizalofop-p-ethyl 5 EC 37.5 g a.i. ha^{-1} as post emergence	57.99	62.76	21.96	26.67	53.23	62.12	3.76	3.88
T_6: Cyhalofop-p-butyl 10 EC 100 g a.i. ha^{-1} as post emergence	59.26	64.17	22.56	27.34	57.24	64.83	3.83	3.91
T_7: Metamifop 10 EC 100 g a.i. ha^{-1} as post emergence	61.06	66.01	23.05	27.94	59.00	65.09	4.15	4.28
T_8: *Leucas aspera* plant extract	52.81	57.03	20.00	24.36	46.01	53.88	2.07	2.21
T_9: *Eucalyptus* leaf extract	56.61	61.19	21.30	26.06	51.23	60.31	3.30	3.67
T_{10}: *Hyptis suaveolens* plant extract	53.91	58.22	20.57	25.13	48.27	56.50	2.63	3.04
T_{11}: Hand weeding at 20 and 40 DAS	85.35	90.59	32.60	39.74	71.39	77.49	5.06	5.21
T_{12}: Unweeded control	24.27	26.24	7.91	9.69	20.53	24.59	0.67	0.70
C.D. (p=0.05)	8.28	11.63	3.77	4.43	5.90	7.45	0.40	0.32

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Table 4. Nutrient removal by the weeds as influenced by the different weed management practices

Treatments	Nutrient removal (kg ha^{-1})					
	Nitrogen		Phosphorus		Potassium	
	2020	2021	2020	2021	2020	2021
T_1: Bensulfuron methyl + pretilachlor 6.6 GR 660 g a.i. ha^{-1} as pre-emergence	25.67	24.34	9.50	7.95	25.32	23.02
T_2: Pyrazosulfuron ethyl 10 WP 40 g a.i. ha^{-1} as pre-emergence	32.79	30.98	12.67	9.67	30.01	28.2
T_3: Oxadiargyl 80 WP 100 g a.i. ha^{-1} pre-emergence	36.15	34.11	14.17	10.95	33.46	31.43
T_4: Bispyribac sodium 10 SC 40 g a.i. ha^{-1} as post emergence	24.30	22.99	9.04	7.18	22.70	21.37
T_5: Quizalofop-p-ethyl 5 EC 37.5 g a.i. ha^{-1} as post emergence	49.82	46.86	19.26	16.16	47.48	44.53
T_6: Cyhalofop-p-butyl 10 EC 100 g a.i. ha^{-1} as post emergence	47.09	44.31	17.04	15.12	44.68	41.92
T_7: Metamifop 10 EC 100 g a.i. ha^{-1} as post emergence	41.29	38.91	16.46	12.91	38.73	36.36
T_8: *Leucas aspera* plant extract	56.99	53.55	23.46	18.90	54.84	51.42
T_9: *Eucalyptus* leaf extract	50.80	47.78	19.70	16.54	48.49	45.48
T_{10}: *Hyptis suaveolens* plant extract	52.44	48.37	20.98	16.78	49.14	46.09
T_{11}: Hand weeding at 20 and 40 DAS	22.23	20.99	8.86	6.40	21.22	19.59
T_{12}: Unweeded control	93.31	89.36	39.40	37.42	85.75	78.82
C.D. (p=0.05)	8.65	9.20	3.67	2.77	8.58	6.83

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Table 5. Post harvest soil available major nutrient status (kg ha^{-1}) of direct seeded rice as influenced by different weed management practices

Treatments	Soil available nutrients (kg ha^{-1})					
	Nitrogen		Phosphorus		Potassium	
	2020	2021	2020	2021	2020	2021
T_1: Bensulfuron methyl + pretilachlor 6.6 GR 660 g a.i. ha^{-1} as pre-emergence	230.23	236.72	28.62	30.70	213.95	226.12
T_2: Pyrazosulfuron ethyl 10 WP 40 g a.i. ha^{-1} as pre-emergence	227.74	231.08	26.66	28.60	211.78	222.12
T_3: Oxadiargyl 80 WP 100 g a.i. ha^{-1} pre-emergence	222.51	230.35	26.15	28.06	209.23	221.06
T_4: Bispyribac sodium 10 SC 40 g a.i. ha^{-1} as post emergence	231.71	241.66	29.68	31.85	219.75	229.78
T_5: Quizalofop-p-ethyl 5 EC 37.5 g a.i. ha^{-1} as post emergence	215.80	226.15	23.45	25.16	205.34	216.21
T_6: Cyhalofop-p-butyl 10 EC 100 g a.i. ha^{-1} as post emergence	218.00	228.51	24.61	26.41	206.92	217.91
T_7: Metamifop 10 EC 100 g a.i. ha^{-1} as post emergence	221.15	228.90	25.26	27.10	208.92	220.39
T_8: *Leucas aspera* plant extract	211.02	223.02	22.19	23.80	198.84	211.91
T_9: *Eucalyptus* leaf extract	215.62	225.62	23.08	24.76	202.08	215.39
T_{10}: *Hyptis suaveolens* plant extract	212.29	224.39	22.92	24.59	200.41	213.60
T_{11}: Hand weeding at 20 and 40 DAS	238.63	247.75	32.28	34.64	223.01	235.81
T_{12}: Unweeded control	207.43	215.83	18.98	20.36	200.37	205.64
CD (p=0.05)	10.56	15.68	3.77	4.26	9.26	12.87

UNDER PEER REVIEW

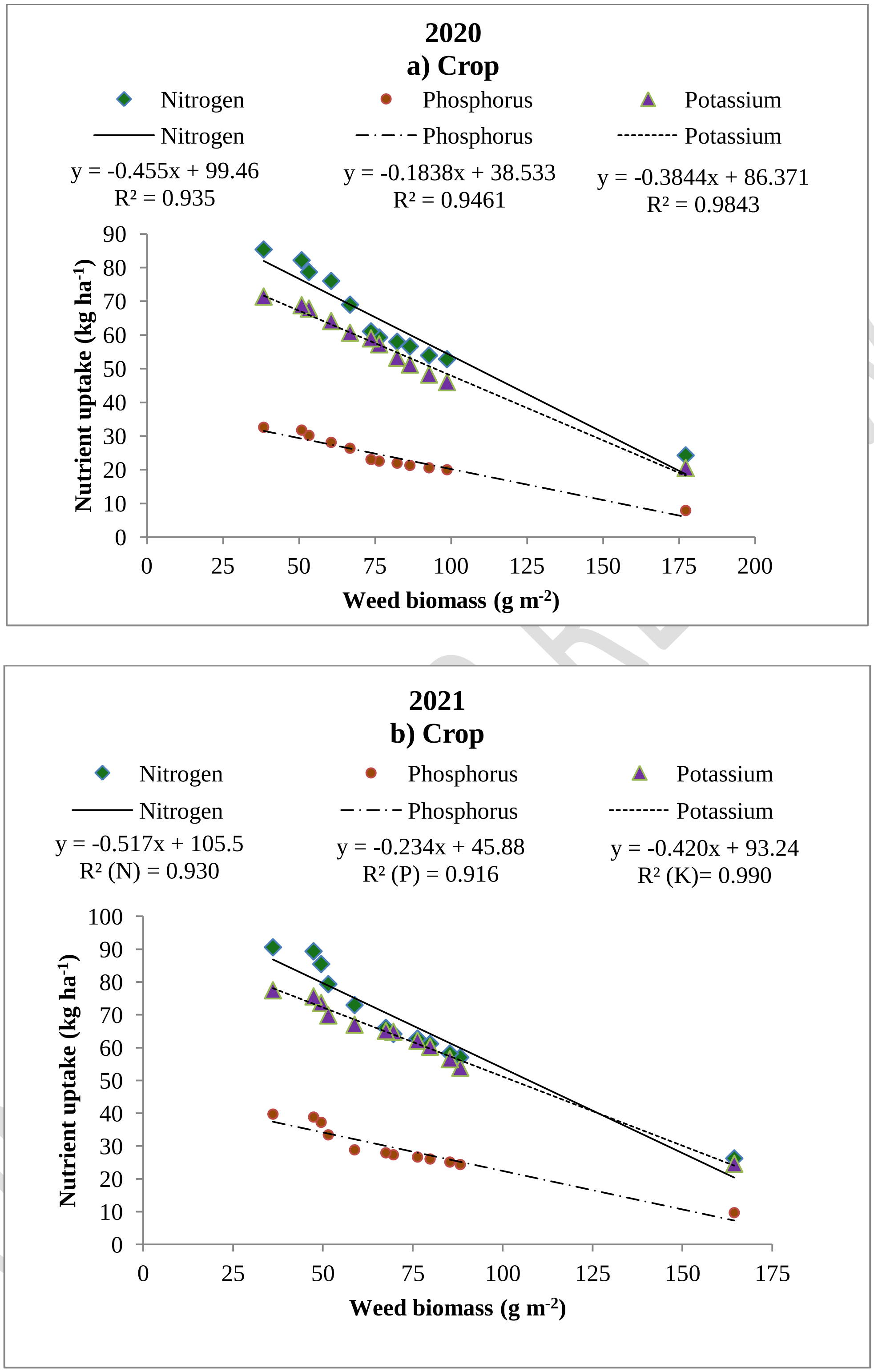

Figure 2. Relationship between weed biomass and nutrient uptake by the direct seeded rice during a. 2020 and b. 2021

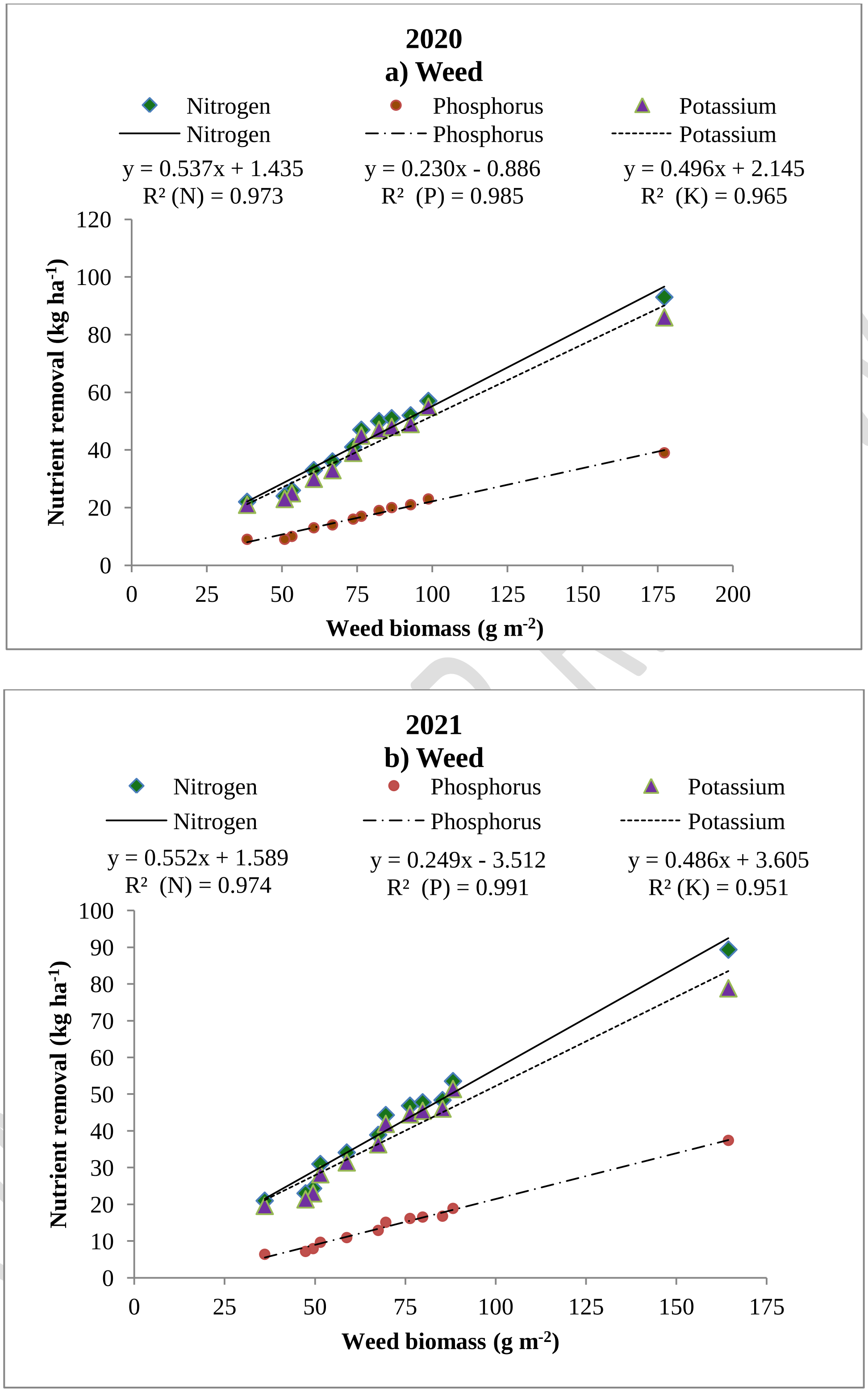

Figure 3. Relationship between weed biomass and nutrient uptake by weeds during a. 2020 and b. 2021