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RESEARCH ARTICLE

Competition for nutrients between weeds and black rice as influenced by date of rice transplanting and weed management treatments in system of rice intensification (SRI)

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ABSTRACT

Heavy weed infestation is a major problem in System of Rice Intensification cultivation method of rice (SRI) due to wider spacing and lack of flooding in the field. Yield losses due to weed infestation amounts to 25-47%. Thus, a field experiment was conducted to study the competition for nutrients between weeds and black rice (*Oryza sativa* L.) as influenced by the date of transplanting and integrated weed management in SRI. The experiment was conducted in the experimental farm of SAS, Nagaland University during *Kharif* season 2019 and 2020. A split plot design was used with three dates of rice transplanting in main plots and five methods of weed management in sub plots. The transplanted black rice with pre-emergence application (PE) of pretilachlor 0.75 kg/ha at 3 days after transplanting (DAT) followed by (*fb*) handweeding at 40 DAT recorded maximum decrease in weeds biomass and nutrient depletion by weeds with significant increase in the weed control efficiency, nutrient uptake and yield of black rice.

Keywords: Black rice, Nutrient uptake, SRI, Pretilachlor, Transplanted rice, Weed management

INTRODUCTION

Black rice (*Oryza sativa* L. *indica*), a special variety of rice contains high amount of anthocyanin pigments in compared to red and white rice that is responsible for its violet or dark purple color in the aleurone layer (Hou *et al.* 2013). Black rice which is called as 'Chakhao', in Manipuri dialect meaning delicious rice is cultivated mostly by Meitei farmers of Manipur. Black rice has been consumed for centuries in Asian countries. Glycemic Index (GI) value of black rice is low which is good for a diabetic patient. Black rice is significantly rich in vitamins, anthocyanin levels, carbs, lipids, proteins, dietary fibers and minerals (Biswas 2018, Panda *et al*. 2022). There are many distinct kinds of black rice and the history of black rice is extensive. Most Asian nations, including India, China, Thailand and others, grow black rice. There are over 200 different types of black rice on the planet. China is the world's leading producer of black rice, accounting for 62% of global output (Panda *et al*. 2022). Now, black rice is consumed and grown in many countries. However, China alone constitute 62% of the total global production standing 1st in which is followed by India, Indonesia, Sri Lanka, Thailand (Amagliani *et al*. 2016). In India, it was cultivated in Odisha, but nowadays mainly developed in North-eastern states of India like Manipur and Assam. Currently, Manipur is the leading producer of black rice in India. Out of the various agronomic practices, timely transplanting is the most important factor as it indirectly decides the soil temperature, weather conditions and several biotic and abiotic stresses a young seedling of rice has to face during different phenological stages. Timely transplanting ensures higher yield attributing parameters and grain yield (Khalifa 2009). Optimizing the transplanting time is crucial for rice crop because of the differences in the growth duration, photo- and thermo-sensitiveness, and vegetative lag period of different varieties (Dixit *et al*. 2004). Heavy weed growth is a major problem in system of rice intensification due to wider spacing and non-flooded condition in the field. Weeds grow faster than the rice and thus absorb the available nutrients earlier, resulting in lack of nutrient for growth of the crop plants (Rao 2022). Prevention of weed competition and provision of weed free environment at critical period of rice growth is necessary for successful rice

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production (Murali and Gowthami 2017, Rao *et al*. 2017). Hence, a field experiment was carried out to study the effect of transplanting date and weed management methods on competition for nutrients between weeds and black rice.

MATERIALS AND METHODS

The field experiment was carried out during 2019 and 2020 at the experimental research farm of the SAS, Nagaland University, Medziphema, Nagaland, India. The farm is geographically situated at $20^0$45'43'' N latitude and $93^0$53'04'' E longitude at an altitude of 310 m above mean sea level. The climate of the region is sub-tropical having hot and humid summers and cold winters. The initial fertility status of soil was ascertained by collecting soil samples randomly from each experimental plot taken at a depth of 0-15 cm. The soil is clayey loam in texture, acidic in reaction (4.85pH), high in OC (1.21%), low in available N (253.12 kg/ha), low in available P (18.43 kg/ha) and medium in available K (142.62 kg/ha). A split plot design with three replications was used to carry out this experiment. The treatments of the main plots consist of dates of transplanting rice: D_1- on15th June, D_2- 30th June and D_3- 15th July and the sub-plots treatments comprised of W_1- weedy check, W_2- weeding with conoweeder (conoweeding) at 20 and 40 days after transplanting (DAT), W_3- pre-emergence application (PE) of pretilachlor at 0.75 kg/ha followed by (*fb*) hand weeding at 40 DAT, W_4- pretilachlor at 0.75 kg/ha PE *fb* conoweeder at 40 DAT and W_5-pretilachlor 0.75 kg/ha PE *fb* post-emergence application (PoE) of bispyribac-Na 25 g/ha. The experimental plot size was 4 m ×3 m. Cultivar used was Chakhao Poireiton.

Well decomposed FYM 7 t/ha was uniformly broadcasted over the field and incorporated thoroughly during the final land preparation. Transplanting of 12 days old rice seedlings was done as per the treatment on 15th June, 30th June and 15th July using one seedling/hill with 25 cm × 25 cm spacing. The recommended dose of fertilizer at 50 kg/ha N, 30 kg/ha P and 20 kg/ha K in the form of urea, single super phosphate (SSP) and muriate of potash (MOP) were applied in all the plots irrespective of the treatment for both the years. Based on the treatment, pre-emergence (PE) herbicide pretilachlor at 0.75 kg/ha and post-emergence (PoE) herbicide bispyribac-Na at 20 g/ha were applied at 3 DAT and 20 DAT, respectively, in respective plots.

The weed samples collected in each quadrat were washed, sundried and oven dried at 105^0 C for 48 hrs. The weight of the weed samples was recorded at 60 DAT after it attained a constant weight and weed dry weight (biomass) was noted. Weed control efficiency was calculated based on the data recorded at 60 DAT as per standard formula. Weed samples were drawn from each plot at 60 DAT of crop and randomly selected plant samples were collected treatment wise for determination of N, P and K content in weed and crop. Collected weeds, straw and grains were dried and grinded thoroughly and analyzed as per standard procedure of modified Kjeldahl method for N, Vanadomolybdo-phosphoric yellow colour method (Jackson 1973) for P and flame photometric method for K as suggested by Jackson (1973). The nutrient depletion and uptake were further calculated by using the formula and expressed in kg/ha,

$$\text{Weeds nutrient depletion (kg/ha)} = \frac{\text{Nutrient (\%) in weeds} \times \text{weed biomass (kg/ha)}}{100}$$

$$\text{Rice nutrient uptake (kg/ha)} = \frac{\text{Nutrient content (\%)} \times \text{biological yield (kg/ha)}}{100}$$

Data obtained from various studies were statistically analyzed in split plot design using the technique of Analysis of Variance as described by Gomez and Gomez (1984). The significance differences were tested by 'F' test. Critical difference of different groups of treatments and their interactions at 5 per cent probability level were calculated whenever 'F' test was significance.

RESULTS AND DISCUSSION

Biomass of grasses, sedges and broad-leaved weeds

Significant difference in biomass of grasses, sedges and broad-leaved weeds were observed amongst the date of transplanting treatments at 60 DAT (**Table 1**). Early transplanting of black rice on 15th June recorded significantly lowest weed biomass while the highest was observed with 15th July transplanting date, during the both the years. Higher weed biomass with late transplanting could be due to higher density of weeds and its dominance in utilizing the limited resources as also observed by Bera *et al*. (2016) and Ghandor *et al*. (2017).

Among weed management treatments, pretilachlor 0.75 kg/ha PE at 3 DAT *fb* handweeding at 40 DAT recorded significantly lowest biomass of all the categories of weeds during both the years which may be attributed to the broad spectrum and season long weed control provided by application of herbicides and hand weeding. Similar results were also observed by Kashid (2019) and Akter *et al.* (2020). Weedy check recorded significantly highest weed biomass in both the years due to favourable conditions available for establishment of all the categories of weeds as also reported by Gangireddy *et al.* (2019) and Yogananda *et al.* (2019).

The interaction effect between transplanting date and integrated weed management were found to be significant in both the years of study except for biomass of grasses (**Table 2**). Transplanting of black rice on 15th June with combined application of pretilachlor 0.75 kg/ha PE at 3 DAT *fb* hand weeding at 40 DAT recorded significantly minimum weed biomass while significantly maximum was observed with the combination of 15th July transplanting date and weedy check.

Weed control efficiency

The differences in weed control efficiency due to date of transplanting and weed management treatments were found to be significant (**Table 1**). The highest weed control efficiency was recorded when rice was transplanted on 15th June and it was at par with the other two date of transplanting in the year 2019 while significantly lowest weed control efficiency was observed under 15th July transplanting date in the year 2020. Cono weeding at 20 and 40 DAT recorded lower weed control efficiency among weed management treatments and significantly highest weed control efficiency was recorded with pretilachlor 0.75 kg/ha PE at 3 DAT *fb* hand weeding at 40 DAT due to lower weed density and biomass production of weeds because of effective control of weed growth with this treatment. The results are in corroboration with those of Jadhav *et al.* (2016) and Ansari *et al.* (2017).

Nutrient depletion by weeds

Variation in NPK depletion by weeds due to date of transplanting and weed management treatments were found to be significant in both the years (**Table 1**). Maximum and minimum NPK depletion by weeds was recorded when the crop was transplanted on 15th July and 15th June respectively. Kumar *et al.* (2017) also reported minimum depletion with early transplanting due to the reduced weed density and biomass. Maximum depletion of NPK was observed in weedy check was due to higher weed density and biomass as reported by Kumar *et al.* (2020). Pretilachlor 0.75 kg/ha PE at 3 DAT *fb* hand weeding at 40 DAT recorded minimum nutrient depletion by weeds and was followed by pretilachlor 0.75 kg/ha PE at 3 DAT *fb* bispyribac-Na 25 g/ha PoE at 20 DAT which were found to be at par with the rest of the treatments. A similar decrease in depletion of NPK

Table 1. Biomass of grasses, sedges, broad-leaved weeds, weed control efficiency and NPK depletion by weeds at 60 DAT as influenced by date of rice transplanting and weed management treatments

Treatment	Grasses (g/m^2)		Sedges (g/m^2)		Broad-leaved weeds (g/m^2)		Weed control efficiency (%)		Nitrogen (kg/ha)		Phosphorus (kg/ha)		Potassium (kg/ha)	
	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
Date of rice transplanting														
15th June	2.25 (5.86)	2.45 (6.81)	6.12 (50.8)	6.02 (50.0)	5.48 (42.0)	5.34 (41.5)	71.81	72.4	13.18	13.19	2.99	3.03	11.87	11.89
30th June	3.04 (10.6)	3.26 (11.8)	6.76 (59.4)	6.71 (59.4)	6.41 (54.2)	6.25 (52.9)	70.19	70.6	16.76	16.81	3.82	3.86	15.04	15.09
15th July	3.43 (13.7)	3.60 (14.9)	7.75 (73.1)	7.68 (72.5)	7.43 (72.3)	7.34 (72.3)	68.68	69.1	21.65	21.91	4.98	5.06	19.32	19.48
LSD (p=0.05)	0.28	0.40	0.40	0.40	0.59	0.46	1.83	1.39	3.13	2.50	0.55	0.43	1.05	1.39
Weed management treatment														
Weedy check	5.39 (29.5)	5.60 (31.6)	14.21 (201.8)	14.26 (203.3)	13.87 (193.8)	13.99 (197.4)	0.00	0.00	58.14	59.51	13.50	13.89	51.93	53.03
Cono weeding at 20 and 40 DAT	2.73 (7.3)	2.98 (8.53)	5.61 (32.2)	5.65 (32.3)	5.51 (30.5)	5.38 (28.9)	83.9	84.1	9.34	9.29	2.10	2.12	8.41	8.42
Pretilachlor 0.75 kg/ha at 3 DAT *fb* HW at 40 DAT	1.55 (2.1)	1.83 (3.04)	4.15 (17.2)	3.88 (15.0)	3.39 (11.7)	3.10 (9.9)	92.9	93.7	3.98	3.56	0.84	0.77	3.62	3.27
Pretilachlor 0.75 kg/ha at 3 DAT *fb* cono weeder at 40 DAT	2.59 (6.5)	2.76 (7.40)	5.50 (30.3)	5.41 (29.9)	5.14 (26.5)	5.00 (25.1)	85.4	85.9	8.35	8.26	1.86	1.84	7.51	7.39
Pretilachlor 0.75 kg/ha at 3 DAT *fb* bispyribac-Na 25 g/ha at 20 DAT	2.26 (4.91)	2.35 (5.41)	4.92 (24.0)	4.79 (22.9)	4.29 (18.4)	4.08 (16.7)	89.0	89.8	6.16	5.92	1.34	1.30	5.59	5.33
LSD (P=0.05)	0.44	0.35	0.35	0.37	0.43	0.43	1.62	1.41	3.42	2.88	0.66	0.65	1.37	1.20

Original values were subjected to square root transformation. Figures in parenthesis are the original values; DAT = days after transplanting with application of herbicides at initial stage followed by mechanical/hand weeding/post emergence application of herbicides at later stage were also reported by Hassan and Upasani (2015) and Nazir *et al.* (2022).

Interaction of date of transplanting and integrated weed management on NPK depletion by weeds (**Table 2**) were found to be significant during both the years. Transplanting of black rice on 15th June along with application of pretilachlor 0.75 kg/ha PE at 3 DAT *fb* handweeding at 40 DAT recorded lower depletion of potassium by weeds while transplanting on 15th July in combination with weedy check recorded significantly highest potassium depletion by weeds.

NPK uptake by black rice: NPK uptake was significantly influenced by different dates of transplanting and weed management treatments (Table 3). Transplanting rice on 15th June recorded significantly highest uptake of NPK by rice and it was followed by 30th June while transplanting on 15th July recorded significantly lowest uptake of NPK by rice. Higher NPK uptake by rice in 15th transplanting date might be attributed to relatively early crop establishment, stronger root growth and longer growth period which in turn results in increased absorption of nutrients and moisture from the soil. The results are in agreement with the findings of Kabat and Satapathy (2011) and Kumari and Prasad (2021).

Among tested weed management treatments, significantly highest uptake of NPK by rice was recorded with pretilachlor 0.75 kg/ha at 3 DAT *fb* handweeding at 40 DAT, followed by pretilachlor 0.75 kg/ha at 3 DAT *fb* bispyribac-Na 25 g/ha at 20 DAT. The concentration of a certain nutrient in plant tissue and yield determine the nutrient uptake (Pandey 2009). The higher NPK uptake by black rice could be attributed to higher content in grain and straw and higher yield with the above treatments. Similar findings were reported by Goswami *et al.* (2017) and Sanodiya and Singh (2021). Pretilachlor 0.75 kg/ha PE *fb* conoweeder at 40 DAT and conoweeding at 20 and 40 DAT were at par with each other in both the years in case of potassium uptake. Weedy check recorded significantly minimum NPK uptake by black rice.

Grain and straw yield of black rice: Grain and straw yield of black rice were significantly influenced by different transplanting date and weed management treatments (**Table 3**). Transplanting black rice on 15th June significantly increased the rice grain and straw yield during both the years of 2019 and 2020. Significantly lowest rice grain and straw yield were recorded when black rice was transplanted on 15th July. Increase in grain yield by 39% and 24% and straw yield by 14.6% and 6.5% over 15th July and 30th June, respectively was recorded when black rice was transplanted on 15th June. This might be attributed to availability of optimal time for growth and development which allowed the crop to store greater amount of photosynthates in the grain as well as due to improved yield attributes exhibited by early transplanted crop compared to later planted crop (Singh *et al.* 2021 and Yumnam *et al.*2021).

Table 2. Interaction effect of date of transplanting and weed management treatments on biomass of sedges, broad-leaved weeds and NPK depletion by weeds at 60 DAT

Treatment	Sedges(g/m^2)		Broad-leaved weeds (g/ m^2)		Nitrogen (kg/ha)		Phosphorus (kg/ha)		Potassium (kg/ha)	
	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
D_1W_1	13.4(181.0)	13.48(181.3)	12.32(151.3)	12.46(154.7)	47.18	48.25	10.89	11.27	42.39	43.35
D_1W_2	4.51(20.0)	4.70(21.7)	4.76(22.5)	4.66(21.4)	6.18	6.43	1.34	1.43	5.56	5.86
D_1W_3	3.39(11.1)	3.18(9.7)	2.49(5.9)	2.18(4.4)	2.22	1.98	0.47	0.42	2.07	1.81
D_1W_4	4.81(22.7)	4.59(20.7)	4.37(18.8)	4.21(17.4)	5.93	5.57	1.30	1.19	5.36	5.02
D_1W_5	4.44(19.2)	4.13(16.7)	3.47(11.7)	3.21(9.9)	4.36	3.75	0.95	0.83	3.97	3.43
D_2W_1	14.24(202.3)	14.35(205.8)	13.61(184.7)	13.65(185.7)	56.85	57.92	13.20	13.53	50.86	51.82
D_2W_2	5.26(27.3)	5.39(28.7)	5.52(30.3)	5.36(28.4)	8.82	8.86	1.96	1.99	7.98	8.01
D_2W_3	4.24(17.7)	4.01(15.7)	3.44(11.5)	3.12(9.5)	4.04	3.74	0.85	0.80	3.68	3.40
D_2W_4	5.18(26.4)	5.11(25.7)	5.05(25.2)	4.87(23.3)	7.85	7.67	1.72	1.69	7.03	6.87
D_2W_5	4.86(23.2)	4.67(21.4)	4.44(19.3)	4.22(17.6)	6.22	5.87	1.35	1.28	5.65	5.36
D_3W_1	14.93(222.3)	14.96(223.3)	15.68(245.3)	15.88(251.7)	70.38	72.38	16.41	16.86	62.53	63.91
D_3W_2	7.06(49.3)	6.86(46.7)	6.24(38.7)	6.11(36.9)	13.03	12.57	3.01	2.95	11.67	11.41
D_3W_3	4.81(22.8)	4.46(19.5)	4.24(17.7)	3.99(15.7)	5.68	4.96	1.21	1.09	5.13	4.60
D_3W_4	6.49(41.7)	6.54(42.4)	6.00(35.6)	5.92(34.7)	11.26	11.53	2.55	2.63	10.14	10.29
D_3W_5	5.47(29.5)	5.56(30.5)	4.98(24.3)	4.81(22.7	7.89	8.14	1.73	1.80	7.14	7.19
LSD (p=0.05) (D×W)	0.61	0.63	0.75	0.75	5.93	4.99	1.15	1.12	2.37	2.08
LSD (p=0.05) (W×D)	0.57	0.56	0.81	0.66	4.63	3.76	0.84	0.72	1.64	1.96

Original values were subjected to square root transformation. Figures in parentheses are the original values

Among the weed management treatments tested, rice grain and straw yield were significantly lowest under weedy check while significantly highest rice grain and straw yield were obtained with pretilachlor 0.75 kg/ha PE *fb* hand weeding at 40 DAT during both the years and it was followed by pretilachlor at 0.75 kg/ha PE *fb* bispyribac-Na 25 g/ha PoE. Weed infestation reduced 44% grain yield in weedy check due to crop-weed competition compared to pretilachlor at 0.75 kg/ha PE *fb* handweeding at 40 DAT. Higher rice grain and straw yield with application of herbicides along with handweeding might be due to prevention of weed competition and providing a weed free environment at critical period resulting in more crop growth and yield attributes and ultimately yield. Similar observations were made by Kashyap *et al.* (2020) and Paul *et al.* (2019).

Rice grain yield was influenced significantly by the interaction of transplanting date and weed management treatments during both the years of study (**Table 4**). Significantly highest rice rain yield was obtained with black rice transplanted on 15th June along with application of pretilachlor at 0.75 kg/ha (PE) *fb* hand weeding at 40 DAT while treatment of 15th July transplanting in combination with weedy check recorded significantly lowest rice grain yield.

Table 4. Black rice grain yield as influenced by interaction of date of transplanting and weed management treatments

Treatment*	Black rice grain yield (kg/ha)		
	2019	2020	Pooled
D_1W_1	1340.20	1410.03	1375.12
D_1W_2	1917.11	2015.63	1966.37
D_1W_3	2527.54	2655.04	2591.29
D_1W_4	2068.23	2168.36	2118.30
D_1W_5	2297.54	2411.67	2354.61
D_2W_1	1181.91	1303.69	1242.80
D_2W_2	1487.86	1592.39	1540.13
D_2W_3	2106.44	2232.96	2169.70
D_2W_4	1528.16	1629.83	1579.00
D_2W_5	1803.99	1921.25	1862.62
D_3W_1	968.34	1078.59	1023.47
D_3W_2	1375.70	1487.83	1431.76
D_3W_3	1738.30	1847.13	1792.71
D_3W_4	1492.69	1595.03	1543.86
D_3W_5	1630.81	1746.34	1688.57
LSD (p=0.05) (D×W)	191.73	215.79	140.61
LSD (p=0.05) (W×D)	186.49	213.37	128.32

*Please refer material and methods for the full forms of treatments

Relation between nutrient depletion by weeds and black rice grain yield

Linear regression equations were developed among nutrient depletion and grain yield.The equations showed strong negative correlation between nutrient depletion by weeds and rice grain yield among different dates of rice transplanting and integrated weed management treatments. Higher nutrient depletion by weeds resulted to higher competition for nutrients uptake by rice and ultimately results in lower rice grain yield and thus the negative correlation. The linear regression equations are as follows.

Nitrogen depletion by weeds and rice grain yield among dates of rice transplanting

$y= -0.0134x +39.986$, $R^2=0.9076$ (2019)$y= -0.0141x+42.732$, $R^2=0.9102$ (2020)

Table 3. Effect of date of transplanting and weed management treatments on NPK uptake (kg/ha), grain and straw yield of black rice

Treatment	Nitrogen uptake (kg/ha)		Phosphorus uptake (kg/ha)		Potassium uptake (kg/ha)		Grain yield (kg/ha)		Straw yield (kg/ha)	
	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
Date of transplanting										
15th June	50.97	53.49	16.56	17.35	67.57	69.09	2030	2132	4063	4120
30th June	42.12	44.70	13.99	14.92	61.74	63.63	1622	1736	3800	3882
15th July	37.41	40.08	12.47	13.31	56.83	59.01	1441	1551	3532	3634
LSD (p=0.05)	2.71	3.08	0.87	1.22	3.46	3.01	133	152	242	226
Weed management treatments										
Weedy check	28.62	30.00	10.05	10.66	51.35	50.55	1163	1264	3287	3188
Cono weeding at 20 and 40 DAT	39.75	42.25	13.36	14.25	59.05	61.39	1593	1699	3636	3754
Pretilachlor 0.75 kg/ha at 3 DAT *fb* hand weeding at 40 DAT	55.92	59.12	17.81	18.88	71.97	74.49	2124	2245	4301	4419
Pretilachlor 0.75 at 3 DAT *fb* cono weeder at 40 DAT	43.73	46.62	14.44	15.19	61.83	64.20	1696	1798	3780	3897
Pretilachlor 0.75 kg/ha at 3 DAT *fb* bispyribac-Na 25 g/ha at 20 DAT	49.48	52.46	16.02	16.98	66.03	68.92	1911	2026	3988	4134
LSD (p=0.05)	2.84	2.60	0.90	0.84	3.69	3.77	111	125	237	219

DAT = days after transplanting

Nitrogen depletion by weeds and rice grain yield among integrated weed management

y= -0.0555x +111.34, R^2=0.762 (2019) y= -0.0558x+118.04, R^2=0.7568 (2020)

Phosphorus depletion by weeds and rice grain yield among date of transplanting

y= -0.0031x +9.2765, R^2=0.9038 (2019) y= -0.0033x+9.8939, R^2=0.906 (2020)

Phosphorus depletion by weeds and rice grain yield among integrated weed management

y= -0.0033x +9.8939, R^2=0.906 (2019) y= -0.0131x+27.623, R^2=0.7565 (2020)

Potassium depletion by weeds and rice grain yield among date of transplanting

y= -0.0118x +35.47, R^2=0.9094 (2019) y= -0.0123x+37.656, R^2=0.9144 (2020)

Potassium depletion by weeds and rice grain yield among integrated weed management

y= -0.0495x +99.378, R^2=0.7619 (2019) y= -0.0496x+105.12, R^2=0.7571 (2020)

Relation between nutrient uptake by black rice and its grain yield

In our study it was also noticed that more uptake of nutrients (NPK) by black rice resulted in higher black rice grain yield. Linear regression equations were developed among different nutrient uptake and rice grain yield. The linear regression equations are as follows.

Nitrogen uptake by black rice and its grain yield among date of transplanting

y= 0.0228x +4.8061, R^2=0.9979 (2019) y= 0.0229 x+4.6612, R^2=0.9992 (2020)

Nitrogen uptake by black rice and its grain yield among integrated weed management treatments

y= 0.0285x +4.8543, R^2=0.9979 (2019) y= 0.0297x+7.6193, R^2=0.9978 (2020)

Phosphorus uptake by black rice and its grain yield among date of transplanting

y= 0.0068x +2.7394, R^2=0.9947 (2019) y= 0.0068 x+2.8694, R^2=0.9919 (2020)

Phosphorus uptake by black rice and its grain yield among integrated weed management treatments

y= 0.0081x +0.6131, R^2=0.999 (2019) y= 0.0084x+0.0879, R^2=0.9997 (2020)

Potassium uptake by black rice and its grain yield among date of transplanting

y= 0.0176x +32.235, R^2=0.9712 (2019) y= 0.0168 x+33.596, R^2=0.975 (2020)

Potassium uptake by black rice and its grain yield among integrated weed management treatments

y= 0.0212x +26.025, R^2=0.9911 (2019) y= 0.0243x+20.097, R^2=0.9987 (2020)

It can be concluded that black rice could be transplanted on 15th June along with application of pretilachlor 0.75 kg/ha PE at 3 DAT *fb* hand weeding at 40 DAT to minimize NPK depletion by weeds with effective weed management and increase the productivity of black rice.

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