Aerobic Rice Weed Management Optimization through Agro Techniques O. Sativa L.

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Abstract

One of the most widely grown crops, rice (Oryza sativa L.) is crucial to the world's food supply. Historically, rice fields have been flooded for the primary purpose of weed suppression. However, non-flooded or decreased water management practises used in aerobic rice farming systems have received attention because to their potential advantages, which include water saving and increased resource use efficiency. The lack of floods, a traditional method of weed control, makes weed management in aerobic rice systems very difficult. The purpose of this research is to examine and improve agrotechniques for weed control in aerobic rice production utilising Oryza sativa L as the model species.

Keywords: Oryza sativa L., Aerobic Rice Cultivation, Agro Techniques, Weed.

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1. Introduction

Rice (Oryza sativa L.) is a crucial staple crop that provides food and money for millions of people across the globe, notably in Asia. In order to grow rice successfully, farmers have historically depended on flooded or paddy systems, which use vast quantities of water. Alternative rice farming techniques, however, have attracted interest in recent years due to rising worries about water shortages, competition for water resources, and the need for sustainable agricultural practises. Aerobic rice farming is one such method; it entails taking care of rice plants under non-flooded or decreased water situations.[1-2]

Compared to flooded systems, aeroponic rice farming has various potential benefits. It encourages water conservation by using far less water than conventional techniques do, making it a desirable choice in areas with a water shortage. Since methane generation is constrained in non-flooded settings, aerobic rice systems have also been demonstrated to contribute to lower methane emissions. Aerobic rice production also improves nutrient usage efficiency and opens the door to growing rice in arid regions with little water resources.[3-4]

However, weed control is a major difficulty when growing rice aerobically. In flooded environments, the submergence of weeds in water reduces their development and the amount of rice plants they may outcompete. Aerobic rice systems, in contrast, have no such benefit, and instead foster an environment where weed growth is encouraged. Maximising rice output and keeping crop quality in check both depend on efficient weed management. Therefore, it is crucial to maximise productivity and minimise yield losses by using agro methods for weed control in aerobic rice production.[5-7]

A thorough familiarity with diverse agro methods is necessary for the development and execution of suitable weed control strategies in aerobic rice systems. Cultural practises, mechanical interventions, chemical applications, and biological methods are all examples of these methods. [8-9]

Sustainable rice production may be ensured by the integration and optimisation of various methods for controlling weeds while reducing their negative effects on the environment. Therefore, the purpose of this research is to investigate and enhance agro methods for weed control in aerobic rice production using Oryza sativa L.[10]

2. Material And Methods

Experimental site

University of Agricultural Sciences (UAS), Lucknow was the site of the outdoor tests.

Soil and its characteristics

The experimental plot had a flat terrain. The composite soil samples were taken at the experimental site and analysed for physico-chemical characteristics prior to the design of the experiment. The soil was a moderately fertile red sandy loam. The available nitrogen, phosphorus, and potassium levels, as well as the electrical conductivity and organic matter, were all around average in the soil. Table displays the analysis outcomes and procedures used.

Table 1: ZARS, UAS (B) Experimental Site Soil Physicochemical Properties

Particulars	**Values**	**Status**
I. Physical properties		
1. Coarse sand (per cent)	33.1	
2. Fine sand (per cent)	36.3	
3. Silt (per cent)	8.6	
4. Clay (per cent)	22.0	
5. Soil type	Red sandy loam	
II. Chemical properties		

1. pH (1:2.5)	6.71	Neutral
2. EC (1:2.5) (dSm-1)	0.36	Normal
3. Organic carbon (per cent)	0.58	Medium
4. Available N (kg ha-1)	362	Medium
5. Available P2O5 (kg ha-1)	43	Medium
6. Available K2O (kg ha-1)	289	Medium

Important characteristics of the crop cultivars tested

- **MAS 946-1**

Marker Assisted Selection (MAS) 946-1, bred from a hybrid between IR-64 and Azucena at the University of Agricultural Sciences in Bengaluru, was the rice utilised in the study. High producing, semi-tall (100-105 cm), resistant to drought and blast disease, aerobic soil condition cultivar. This plant type is an upright kind that matures in 130–135 days and produces medium-fine grains.

Methods for Gathering Biometric Information

- **Weed dry matter yield**

during 30, 60, and 90 days following planting, as well as during harvest, 0.25 m2 of the field was sampled to collect data on the total dry matter (g m-2) of grasses, wide leaved weeds, and sedges. After weeding and oven drying at 650C for 48 hours, the final, constant weight was reported in grammes m-2.

Data collected on crop development

1. **Rice Growth parameters**

Plant height (cm)

The height of the plant was measured in centimetres from the bottom of the soil to the base of the fully opened leaf in the case of young plants, and from the bottom of the soil to the tip of the longest panicle in the case of mature plants. 30-day, 60-day, 90-day, and harvest measurements were taken. The average was calculated and shown in centimeters.

Accumulation and dispersion of dry matter (g hill-1)

The above-ground fraction of the plant's dry matter accumulation was measured at 30, 60, and 90 DAS, as well as during harvest. Leaf, stem, and panicle samples were gathered from each of the five hills, then dried in a hot air oven at 600 degrees Celsius until a consistent dry weight was achieved. The weight, in grammes, of each individual dried plant component was recorded. The total dry weight hill-1 and the percentage split between plant sections at different phases of plant development were calculated using these fundamental data.

2. Rice Yield parameters at harvest

1. Number of productive tillers hill^{-1}

At harvest season, we randomly selected five hills and tallied the number of fruitful tillers in hill-1, averaging the results.

2. Panicle length (cm)

From randomly selected five panicles from 5 plants, panicle linear length was measured by using a scale, averaged and expressed in cm.

3. Panicle weight (g hill^{-1})

The electronic balance was used to record the combined weight of the panicles over all five hills, and the average weight (in g) of panicle hill-1 was then determined.

4. Grains per panicle

The grains in five randomly chosen panicles were counted by hand, and an average was calculated.

5. Total no. filled and unfilled grains panicle^{-1}

Five panicles from randomly selected five plants were used for counting the filledand unfilled grains.

6. Sterility percentage

Sterility percentage was calculated from the unfilled and total grains by using theformula.

$$\text{Sterility percentage} = \frac{\text{Unfilled grains}}{\text{Total grains}} \times 100$$

7. Test weight/ 1000 grain weight (g)

A thousand grains were manually counted and the weight was recorded as testweight in grams.

8. Grain yield (kg ha^{-1})

Plants were threshed and winnowed from the net plot, and then dried and weighed. The yield was converted from net plot yield to kilogrammes per hectare.

9. Straw yield (kg ha^{-1})

Straw was harvested from each treatment's net plot area, sun-dried for 10 days, weighed, and then converted to kilogrammes per hectare.

Statistical analysis and interpretation of data

Fisher's technique of Analysis of variance (ANOVA) was used to analyse the experimental data on plant and weed development characteristics, as stated by Panse and Sukhatme (1967). In cases where the F test yielded a significant result when comparing treatment means, the crucial difference (CD) was calculated. Otherwise, the NS (Non-significant) indicator was shown against the CD values in the observation. All the data was analysed both separately for each year and together for the two years. The pooled values at the 5% probability level are used for the majority of the presentation and discussion of the findings.

- **Correlation coefficient analysis**

The nature and extent of the association between yield and growth, yield components, nutrient absorption, weed density, and weed dry weight were investigated using a correlation analysis. Panse and Sukhatme (1967) detailed a method for calculating correlation coefficients (r) and applying tests of significance..

3. Results

Weed population and dry weight as a function of weed control techniques

- **Weed dry weight (g m-2)**

The level of weed competition with crop plants may be gauged by measuring the dry weight of the weeds. Variations in weed control led to substantial changes in the proportion of grassy, broad-leaved, sedge, and total weeds present in aerobic rice at various phases of development. The information is tabulated below.

Dry weight of grassy, broad leaved, sedges, and total weeds were all significantly lower at 30, 60, and 90 days after sowing when treated with stale seedbed technique fb bispyribac sodium 10% SC @ 30 ml a.i. ha-1 as early PoE + one IC @ 40 days after sowing.

Table 2: The effects of weed control strategies on the dry weight (g/m2) of weeds at 60 DAS in paddy (combined data for 2020 and 2021).

Weed management practices	Grassy weeds	Broad leaved weeds	Sedges	Total weeds
T1:	3.64(12.76)	3.54(12.08)	2.38(5.16)	5.52(30.00)
T2:	3.70(13.23)	3.67(13.02)	2.47(5.61)	5.69(31.86)
T3:	2.16(4.19)	1.81(2.79)	1.45(1.63)	3.02(8.61)
T4:	2.28(4.74)	1.94(3.33)	1.51(1.79)	3.21(9.86)
T5:	4.27(17.71)	3.78(13.82)	2.62(6.39)	6.20(37.91)
T6:	4.03(15.84)	3.74(13.52)	2.56(6.08)	5.99(35.43)
T7:	2.39(5.25)	2.05(3.71)	1.57(1.96)	3.38(10.92)
T8:	2.30(4.81)	2.01(3.56)	1.54(1.89)	3.28(10.26)
T9:	2.43(5.40)	2.11(3.97)	1.61(2.11)	3.46(11.48)
T10:	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)
T11:	7.22(51.57)	6.74(45.16)	3.45(11.49)	10.42(108.22)
S.Em.±	0.03	0.03	0.03	0.04
CD (P=0.05)	0.09	0.11	0.10	0.13

Table 3: The effects of weed control strategies on the dry weight (g/m2) of weeds at 90 DAS in paddy (combined data for 2020 and 2021).

Weed management practices	Grassy weeds	Broad leaved weeds	Sedges	Total weeds
T1:	4.29(17.90)	4.32(18.24)	2.94(8.14)	6.69(44.3)
T2:	4.67(21.27)	4.58(20.50)	3.07(8.92)	7.15(50.7)
T3:	3.62(12.61)	3.31(10.46)	2.33(4.92)	5.34(28.0)
T4:	3.79(13.85)	3.34(10.63)	2.46(5.56)	5.53(30.0)

T5:	4.89(23.41)	4.70(21.63)	3.38(10.91)	7.51(56.0)
T6:	4.78(22.49)	4.66(21.19)	3.13(9.29)	7.31(53.0)
T7:	3.82(14.08)	3.37(10.88)	2.56(6.04)	5.61(31.0)
T8:	3.80(14.00)	3.35(10.72)	2.52(5.85)	5.57(30.6)
T9:	3.92(14.86)	3.39(11.03)	2.60(6.24)	5.71(32.1)
T10:	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.0)
T11:	11.20(125.2)	11.48(131.3)	6.66(44.24)	17.35(300.8)
S.Em.±	0.05	0.04	0.04	0.08
CD (P=0.05)	0.17	0.13	0.13	0.23

Biometric Studies of Rice Production

- **Parameters affecting aerobic rice growth**

Tables detail the effects of weed control on the height, number of tillers, leaf area, and total dry matter production of aerobic rice plants at various phases of development. Weed control methods have a considerable impact on aerobic rice growth metrics. Maximising the transfer of photosynthates to the sink and increasing total dry matter synthesis inside the plant are both crucial for increasing grain yield in any agricultural plant. The sum of the dry matter accumulation in all plant sections is known as the total dry matter production, and it is influenced by factors such as moisture, nutrients, and light intensity.

When comparing weedy check (4.45 g plant-1) with stale seedbed approach, total dry matter output was considerably greater with the former. The pattern was also seen at 90 DAS (151.30 and 39.16 g plant-1 vs. 45.73 and 14.13 g plant-1, respectively) and harvest (151.30 and 39.16 g plant-1 vs. 14.13 and 45.73 g plant-1). Leaf area (184 Reduced weed competition is mostly responsible for the improved growth characteristics seen in plots planted using the stale seedbed method and treated with fb bispyribac sodium.

Table 4: Effect of weed control on paddy plant height (in centimetres) throughout growth stages (data from 2020 and 2021 combined)

Weed management practices	30 DAS	60 DAS	90 DAS	at harvest
T1:	21.90	41.33	55.10	55.38
T2:	21.85	40.17	54.63	54.93
T3:	22.47	47.15	58.87	59.17
T4:	22.33	46.75	58.48	58.98
T5:	20.73	38.70	53.47	53.97
T6:	21.02	39.20	54.10	54.40
T7:	22.12	46.40	57.62	57.99
T8:	22.18	46.58	58.03	58.42
T9:	22.05	46.11	57.38	57.58
T10:	22.62	47.55	59.67	60.18
T11:	20.55	24.98	29.32	30.05
S.Em.±	0.31	0.55	0.59	0.98
CD (P=0.05)	0.92	1.64	1.76	2.90

Table 5: The effect of weed control on paddy's total dry weight (g plant-1) over stages (pooled data, 2020 and 2021).

Weed management practices	30 DAS	60 DAS	90 DAS	at harvest
T1:	6.05	36.80	115.04	125.53
T2:	5.60	34.61	98.30	120.89
T3:	7.40	45.73	128.74	151.30
T4:	7.07	42.88	123.21	150.39
T5:	4.77	27.08	87.29	109.86
T6:	5.14	29.24	92.42	110.10

T7:	6.71	42.06	121.98	149.79
T8:	6.79	42.33	122.78	149.84
T9:	6.57	41.90	121.89	149.60
T10:	8.09	46.78	132.42	154.37
T11:	4.45	14.13	38.45	39.16
S.Em.±	0.10	0.70	1.55	1.76
CD (P=0.05)	0.29	2.07	4.59	5.21

- **Aerobic rice yield and yield factors**

Variations in weed management considerably altered both production and yield characteristics.

The weedy check yielded 430 kilogrammes per hectare of land per year, whereas the stale seedbed approach yielded a whopping 5838 kilogrammes per hectare of land in grain and 9904 kilogrammes of straw. Number of productive tillers hill-1 (41.58), panicle length (24.98 cm), panicle weight hill-1 (3.15 g), total number of grain panicle-1 (118.63), 1000 grain wt. (26.12 g), and harvest index (0.37) were all better than in the weedy check (1.62, 10.28 cm, 1.34 g, 47.35 cm, 16.25 g, and 0.36, respectively), which could explain the higher rice grain yield. The aforementioned yield gain may be traced back to improved growth characteristics like more leaf area and more even distribution of dry matter throughout the plant. Reduced weed competition in crops shifted the resource utilisation equilibrium in favour of crops, leading to increased growth and production.

Table 6: Paddy yield metrics affected by weed control strategies (combined data for 2020 and 2022).

Weed management practices	**No. productive tillers hill-1**	**Panicle length (cm)**	**Panicle weight hill-1 (g)**	**Filled grain panicle -1**	**unfilled grain panicle -1**	**Total No. grain panicle -1**	**Chaffyness (%)**
T1:	23.40	20.50	2.16	89.42	12.63	100.90	12.50
T2:	21.92	19.43	2.05	85.35	15.18	98.35	15.43

T3:	41.58	24.98	3.15	107.25	11.72	118.63	9.86
T4:	40.75	24.70	3.03	106.25	12.22	116.83	10.42
T5:	20.83	17.43	1.76	82.53	13.90	94.80	14.63
T6:	21.75	18.15	1.85	83.47	13.92	95.10	14.63
T7:	40.15	24.23	2.82	104.83	12.87	116.08	11.06
T8:	40.32	24.53	2.92	105.23	13.15	116.53	11.26
T9:	39.45	23.78	2.70	104.62	12.68	115.75	10.93
T10:	42.55	25.42	3.22	107.03	13.18	120.10	10.96
T11:	1.62	10.28	1.34	28.08	20.90	47.35	43.20
S.Em.±	0.52	0.38	0.06	1.36	0.26	1.29	NA
CD (P=0.05)	1.55	1.13	0.19	4.02	0.77	3.83	NA

Table 7: The effects of weed control strategies on rice, straw yield (kg ha-1), yield characteristics, and weed index (%) in paddy (combined data for 2020 and 2021)

Weed management practices	1000 grain wt. (g)	Grain yield	Straw yield
T1:	21.80	4625	8242
T2:	21.00	4583	8123
T3:	26.12	5838	9904
T4:	25.58	5817	9842
T5:	19.74	4235	8014
T6:	20.15	4312	8056
T7:	25.12	5781	9802
T8:	25.35	5800	9786

T9:	24.41	5699	9853
T10:	26.83	6068	9973
T11:	16.25	430	805
S.Em.±	0.55	71.02	145.60
CD (P=0.05)	NS	209.53	429.54

- **The Impact of Weed Control Methods on Crop and Weed Nutrient Absorption**

Tables detail the effects of various weed control strategies on the nitrogen, phosphate, and potassium taken up by rice at harvest and by weeds at various growth stages, respectively.

Realising a crop's full production potential in the field requires optimal nutrient delivery in each crop or cropping system. Improved nutrient absorption and subsequent productivity increases are necessary for optimal nutrient utilisation. Since weeds often outcompete rice plants in terms of growth and development, they often deplete soil nutrients before crop plants can use them for their own growth and production. Weeds have an advantage over rice since they are more aggressive and C4 plants, whereas rice is C3. Weeds are capable of rapid photosynthesis, sustained rapid growth, and high environmental adaptability. Noda et al. (1968) found that crops grown in unweeded areas absorbed the same number of nutrients as those grown in weed-free plots. Nutrient loss owing to weeds was shown to follow a predictable pattern, with losses being reduced in areas where weeds could be effectively managed. The rate of growth in nutrient intake (nitrogen, phosphorus, and potassium) by weeds and plants was correlated with the amount of dry matter produced.

Table 8: Effect of weed control on nutrient absorption by weeds and crop in paddy (kg ha-1) (averaged data for 2020 and 2021).

Weed management practices	Weeds uptake at harvest			Crop uptake at harvest		
	N	P	K	N	P	K
T1:	22.97	4.29	16.68	93.67	25.53	91.76
T2:	25.83	3.73	17.07	88.26	23.48	87.76
T3:	8.44	1.67	5.48	131.86	43.34	129.21
T4:	9.40	1.82	6.01	129.80	41.51	127.63
T5:	35.53	3.90	16.99	74.15	19.25	78.66
T6:	32.63	3.91	15.38	80.90	21.21	82.17
T7:	12.09	1.89	6.33	125.49	39.20	124.57
T8:	11.81	1.85	6.24	127.93	40.32	125.84

T9:	14.35	2.52	7.50	123.65	37.48	121.42
T10:	0.00	0.00	0.00	137.24	45.57	135.22
T11:	200.57	52.97	187.56	8.32	1.83	7.54
S.Em.±	0.33	0.07	0.24	1.83	0.56	1.79
CD (P=0.05)	1.00	0.23	0.73	5.41	1.65	5.28

link between rice crop nutrient absorption (nitrogen, phosphorous, and potassium) and grain production per hectare. Weed control methods had substantial effects on the amounts of nitrogen, phosphorus, and potassium that the weeds absorbed at various phases of crop development. N, P, and K uptake in stale seedbeds treated with fb bispyribac sodium 10% SC @ 30 ml a.i. ha-1 as early PoE + one IC @ 40 DAS was 0.15 kg ha-1, 0.029 kg ha-1, and 0.097 kg ha-1, respectively, at 30 DAS. Nitrogen uptake was 2.40 tonnes per hectare per year (DAS), phosphorus uptake was 0.47 tonnes per hectare per year (DAS), and potassium uptake was 1.56 tonnes per hectare per year (DAS), and potassium uptake was 5.04 tonnes per hectare per year (DAS), and at harvest, nitrogen uptake was 8.44 tonnes per hectare per year (DAS), phosphorus uptake was 1.67 tonnes per hectare per year (DAS), and potassium uptake was 5. This may be attributable to the improved growth and development of the rice crop as a consequence of the enhanced weed control implemented at an earlier stage. Madhukumar's (2011) and Ramana Murthy and Reddy's (2013) results are consistent with these findings.

Table 9: Effect of weed control on the dry weight (g/m2) of weeds in harvested paddy (pooled data, 2020 and 2021).

Weed management practices	Grassy weeds	Broad leaved weeds	Sedges	Total weeds
T1:	4.66(21.25)	4.56(20.31)	3.10(9.13)	7.32(53.11)
T2:	4.83(22.88)	4.69(21.53)	3.18(9.61)	7.54(56.33)
T3:	3.91(14.78)	3.23(9.95)	2.50(5.73)	5.56(30.46)
T4:	4.02(15.66)	3.36(10.83)	2.63(6.44)	5.78(32.92)
T5:	5.12(25.75)	4.75(22.03)	3.53(11.94)	8.07(64.57)
T6:	4.99(24.50)	4.71(21.70)	3.36(10.77)	7.80(60.43)
T7:	4.07(16.06)	3.55(12.07)	2.69(6.71)	5.94(34.85)
T8:	4.06(15.98)	3.51(11.81)	2.67(6.62)	5.91(34.41)
T9:	4.08(16.19)	3.60(12.48)	2.76(7.10)	6.34(39.63)
T10:	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)
T11:	11.53(132.8)	13.44(180)	7.10(49.99)	19.06(362.8)
S.Em.±	0.03	0.04	0.02	0.06
CD (P=0.05)	0.10	0.13	0.08	0.19

1.63 and 8.61 g m-2, 90 days after sowing (12.61, 10.46, 4.92, and 28.0), and harvest (14.78, 9.95, 5.73, and 30.46 g m-2). After 30 DAS (0.14 g m-2), 60 DAS (4.74 g m-2), 90 DAS (13.85), harvest (15.66 g m-2), and at harvest (10.83 g m-2), we applied straw mulch at 6 t ha-1 fb bispyribac sodium 10% SC at 30 ml a.i. ha-1 as PoE. Aerobic rice weed dry weight has been increasing with weed density throughout all growth phases. Stale seedbed method and post-emergence herbicidal spray contributed to the decrease in weed dry weight in these plots.

The effect of weed control on the correlation between yield and yield and growth components in aerobic rice

Table displays the results of a correlation analysis using Karl Pearson's coefficient (r) between rice grain yield and growth, yield, and weed characteristics under the effect of various weed control strategies for aerobic rice. Plant height at maturity (r=0.97), tillers per hill (r=0.99), leaf area at 90 days after sowing (r=0.96), and total dry matter at maturity (r=0.99**) were positively correlated with rice grain production. Numerous tillers per hill, panicle length, panicle weight, 1000 grain weight, and total number of grains per panicle were all positively correlated with grain yield (r=0.94**, 0.97**, 0.86**, 0.91**, and 0.99**, respectively). Total nitrogen uptake (r=0.98**), phosphorus uptake (r=0.94**), and potassium uptake (r=0.98**) all had a strong positive connection with one another. Total weed density at maturity was substantially and inversely linked with grain yield (r=-0.97**), as was weed biomass at maturity (r=-0.95**).

Table 10: Relationship between weed control practices and production, growth components, and yield in aerobic rice

Sl. No.	Parameters (x)	Correlation coefficient(r)
Rice grain yield versus growth parameters		
01	Plant height	0.97**
02	Total dry matter accumulation	0.99**
Rice grain yield versus yield attributes		
01	No.of productive tillers	0.94**
02	Panicle length	0.97**
03	Panicle weight	0.86**
04	Total grain weight	0.99**
05	1000 grain weight	0.91**
Rice grain yield versus nutrient uptake		

01	Nitrogen	0.98**
02	Phosphorus	0.94**
03	Potassium	0.98**
Rice grain yield versus weed density and dry weight		
01	Weed dry weight	-0.95**

4. Conclusion

Aerobic rice yield and its constituent parts differed greatly between weed control strategies. In a weedy check, grain yield was only 430 kilogrammes per hectare while straw yield was only 805 kilogrammes per hectare; the number of productive tillers per hill was 41.58; the length of the panicle was 24.98 centimetres; the weight of the panicle per hill was 3.15 grammes; the total number of grains per panicle was 118.63; the weight of one thousand grains was 26.12 grammes; and the harvest index was 0.37. The crop's harvest-time intake of nitrogen, phosphate, and potassium was affected by the weed control techniques used. Stale seedbed technique fb bispyribac sodium 10% SC @ 30 ml a.i. ha-1 as early PoE + one IC @ 40 DAS significantly increased total nitrogen (131.86 kg ha-1), phosphorus (43.34 kg ha-1), and potassium (129.21 kg ha-1) uptake by rice crop at harvest compared to the weedy check. Weed control techniques had substantial effects on the availability of nitrogen, phosphorus, and potassium to the plants at harvest. Compared to the weedy check (200.57, 52.97, 187.56 kg NPK ha-1, respectively), stale seedbed method using bispyribac sodium 10% SC @ 30 ml a.i. ha-1 as early PoE + one IC @ 40 DAS resulted in significantly reduced nitrogen phosphorus and potassium.

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