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Weed control by application of sodium bispiribak 400 g/l herbicide in direct seed planting system

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Abstract
This study aims to determine the efficacy of sodium bispiribak 400 g/l herbicide against weeds in lowland rice cultivation with direct seed planting systems. The experiment was carried out for 5 months, from July 2020 to November 2020. The experimental design used was a randomized block design with 4 replications and 6 treatments. The treatments consisted of a of the sodium bispiribak 400 g/l herbicide at a dose of 11.25 g/ha; 15 g/ha; 18.75 g/ha; 22.5 g/ha; manual and control weeding (no weed control). The test results showed that sodium bispiribak 400 g/l herbicide from a dose of 11.25 g/ha to 22.5 g/ha could control *Ludwigia octovalis*, *Marsilea crenata*, *Monochoria vaginalis*, *Fimbristylis miliacea*, *Cyperus iria*, and other weeds. Sodium bispiribak 400 g/l Herbicide starting at a dose of 11.25 g/ha to 22.5 g/ha does not cause poisoning in rice plants. Herbicide treatment Sodium bispiribak 400 g/l from a dose of 11.25 g/ha to 22.5 g/ha gave rice yields that were not different from manual weeding.

Keywords: herbicide efficacy, sodium bispiribak 400 g/l, weeds, lowland rice direct seed planting system

Introduction

Rice (*Oryza sativa* L) is a source of food for nearly half of the world's population. Indonesia has the highest ranking as a country that consumes rice in the world besides Korea, Japan, Malaysia and Thailand (Ishaq *et. al.*, 2016) [7]. Indonesia has a total production of milled dry unhulled rice (GKG) of rice in 2018 of 56.54 million tons with rice production of 32.42 million tons (Badan Pusat Statistik, 2018) [1]. The National Development Planning Agency stated that the total population of Indonesia reached 243 million people in 2015. Meanwhile, the population growth rate increased by 1.18% in 2011-2015 and will increase by 0.82% in 2025-2030. rice consumption of 139 kg per capita per year so that the need for rice in 2030 is estimated to reach 59 million tons (Haryono *et. al.*, 2012) [6]. This shows that Indonesia needs to increase rice production for the future.

The direct seed planting system is a method of planting rice plants by planting seeds directly on the land without any nursery and transplanting. The advantage of the Tabela system is that it can reduce the labor required because it is not needed for making nurseries and transplanting plants. Rice plants grown through the Tabela system can shorten the production period because rice plants will reach a faster generative stage because rice plants do not experience a period of stagnation (Balai Penelitian dan Pengembangan Pertanian, 2015) [3]. However, the Direct Seed Planting system has various weaknesses, including requiring more seeds, increasing weed populations and being prone to rats (Mamondol, 2017) [10].

One of the causes of low rice productivity is the competition between rice and weeds. Weeds need more attention because weeds can harm the staple plants around them (Sindel and Coleman, 2010). Weeds are nuisance plants that can reduce rice yields if they are not controlled effectively (Pane and Jatmiko, 2009) [11]. This is the same as mentioned by Pranasari *et al.* (2012) [6], that weeds have various negative impacts on plant growth and production. Weeds are one of the biotic factors that cause crop yield losses. Losses caused by the presence of weeds on agricultural land are often associated with the ability of weeds as competitors or competitors for the main crop (Sembodo, 2010).

Weeds compete with major crops in terms of uptake of nutrients, water, space and light. According to Pitoyo (2006), the decline in rice yield due to weeds ranges from 6-87%, and the data on the decline in rice yields nationally due to weed disturbances, namely around 15-42% for lowland rice and 47-84% for upland rice. Competition between weeds and rice can reduce rice yields by 10-40% on irrigated land, depending on weed species and density, soil type, water supply, and climatic conditions (Pane and Jatmiko, 2009) [11]. One of the dominant weeds in rice is Echinochloa cruss-galli. According to Guntoro, *et al.* (2009), the population of Echinochloa cruss-galli as much as 4 plants per pot can reduce grain weight by 48.0% and reduce the weight of filled grain by 46.2%. In addition to decreasing production, according to Guntoro, *et al.* (2013) [4] farmers' income has also decreased due to large control costs due to the presence of weeds in lowland rice cultivation. This proves that the weed problem is very serious in lowland rice cultivation.

The rate of yield loss due to weeds in rice varies according to the rice cropping system. The loss of rice production due to competition with weeds is around 34% in transplanted rice, 45% in direct planted rice in irrigated and rainfed lowland rice, and 67% in upland rice (Pane and Jatmiko, 2009) [11]. According to Somowiyarjo (2011), losses due to weeds in lowland rice and upland rice are 15-40% and 47-87%, respectively. In addition, at the world level, the percentage of losses due to weeds on various commodities is estimated at 12%.

According to Pane and Jatmiko (2009) [11], there are 14 types of weeds which are the results of an inventory of weeds found in paddy fields. As for the weeds, namely *Echinochloa cruss-galli*, *Leptochloa chinensis*, *Paspalum distichum*, *Ischaemum rugosum*, *Fimbristylis miliaceae*,

Cyperus difformis, Cyperus iria, Scirpus juncoides, Monochoria vaginalis, Limnocharis flava, Ludwigia octovalvis, Ludwigia adcendens, Salvinia molesta, and *Marsilea crenata*. These weeds are common weeds in lowland rice cultivation, although there are still many other weeds that have the potential to interfere with rice plants.

There are many control methods that can be used in weed control activities, one of which is chemical control. Chemical control is a method that is widely used by farmers. Selection of herbicides suitable for weed control in rice is very important. The selection was made by taking into account the efficacy of herbicides against weeds and the presence or absence of titotoxicity in plants. Other factors to consider include safety to the environment (non-target organisms), price and availability.

One of the herbicides that can be used for weed control in tablea rice cultivation is the sodium bispiribak 400 g/l herbicide. The herbicide sodium bispiribak is a pyrimidunyloxybenzonic herbicide. The herbicide sodium bispiribak is systemic and is applied post-growth which can be absorbed by the leaves and roots of weeds (William, 2002). The mechanism of action of sodium bispiribak is absorbed through the surface of the leaves and roots then translocated throughout the plant body to inhibit the activity of the enzyme Acetolactate synthase (ALS) which causes death in weeds. The entry of this type of herbicide can inhibit the protein formation process so that plants become stressed and then die. Symptoms that arise in the form of plants experiencing defiolation, leaf fall, brown leaves until experiencing drought.

Research methods

The experiment was carried out in the paddy fields of SPLPP, Faculty of Agriculture, Padjadjaran University, Ciparay Unit, Baleendah District, Bandung Regency, West Java at an altitude of about 625 m above sea level with Inceptisol soil type. The experiment was carried out for 5 months and started from July to November 2020.

The materials used in this study were Ciherang variety of lowland rice (Oryza sativa L.) seeds, basic fertilizers used by Urea, TSP and KCl, Tabas 400 SC herbicide (sodium bispiribak 400 g/l). Meanwhile, the tools used in the experiment were the knapsack semiautomatic sprayer, weed survey tool, measuring cup, oven, analytical scale, and meter.

The research method used was an experimental method with a randomized block design consisting of 6 treatments, each of which was repeated 4 times. Data processing is done with a variety analysis method. To determine the difference in the effect between treatments, the smallest significant difference (LSD) test was used at the 5% real level. The complete treatment is presented in Table 1.

Table 1: Experiment Treatment

No.	Treatment	Dose (g/ha)
A	Sodium bispiribak 400 g/l	11.25
B	Sodium bispiribak 400 g/l	15
C	Sodium bispiribak 400 g/l	18.75
D	Sodium bispiribak 400 g/l	22.5
E	Manual weeding	-
F.	Control (no weeding)	-

Observation

1. Weed Dry Weight

The dry weight of the target weeds was taken from 2 sample plots of 0.5 mx 0.5 m in each plot. Weed dry weight sampling is done by cutting fresh weeds to the ground level, then weeds are collected according to species. Furthermore, the weeds are dried in an oven at 800C for 48 hours or until they reach a constant dry weight and then weighed. Observations were made at 3 and 6 weeks after application.

2. Height of Rice Plants

Plant height was measured from the base of the stem to the tip of the top leaf. Observations were made on 12 samples of plants taken randomly, measured at the age of 1, 3 and 5 weeks after application.

3. Number of Paddy Puppies per Clump

The number of pups is done by counting all the pups that grow normally and the leaves are fully open. Observations were made on 12 samples of plants taken at random, measured at 3 MSA and 6 weeks after application.

4. Dry Grain Milled Rice

Observation of the yield of dry milled rice paddy rice (14% moisture content) was carried out on ubinan plots measuring 2.5 x 2.5 m.

5. Phytotoxicity

Phytotoxicity levels were visually assessed against the plant population in the ubinan plots, observed at 1, 2 and 3 weeks after herbicide application. The score for poisoning between 0 - 4 is as follows: 0 = No poisoning, 0 - 5% the shape and/or color of the leaves and or the growth of the oil palm plant is not normal. 1 = mild poisoning,> 5 - 20% leaf shape and/or color and/or growth of oil palm plants is not normal. 2 = moderate poisoning,> 20 - 50% the shape and/or color of the leaves and or the growth of the oil palm plant is not normal. 3 = severe poisoning,> 50 - 75% of the shape and/or color of the leaves and or the growth of the oil palm plant is not normal. 4 = very severe poisoning,> 75% of the shape and / or color of the leaves and/or growth of the oil palm plant is not normal

Results and Discussion

Weed Dry Weight

Ludwigia octovalis

The results of observations of the dry weight of *Ludwigia octovalis* weeds are presented in Table 2. The results of statistical analysis on the dry weight of *Ludwigia octovalis* weeds are in Appendix 5.In Table 3 it can be seen that the dry weight of Ludwigia octovalis weed treatment of sodium bispiribak 400 g/l herbicide starting at a dose of 11.25 g/ha to 22.5 g/ha gave the lowest average dry weight of *Ludwigia octovalis* weed and was significantly different from manual weeding treatment at observation 3 and 6 weeks after application. This situation shows that the Sodium bispiribak 400 g/l herbicide from a dose of 11.25 g/ha to 22.5 g/ha is effective in controlling Ludwigia octovalis weeds until the age of 6 weeks after application. This is in line with the research of Kurniati (2018) [9], that the Sodium bispiribak 400 g/l herbicide is effective in controlling broad leaved weeds *Ludwigia hyssopifolia, Monochoria vaginalis, Spenochlea zeylanica*, and golongan sedges such as *Fimbristylis miliacea, Cyperus diffomis, Cyperus iria*.

Table 2: Dry weed weight of *Ludwigia octovalis* (g/0.25 m^2)

No.	Treatment	Observation time (Weeks After Application)	
		3	6
A	Sodium bispiribak 400 g/l dose 11.25 g/ha	2.83 bc	2.92 c
B	Sodium bispiribak 400 g/l dose 15 g/ha	2.18 cd	1.22 cd
C	Sodium bispiribak 400 g/l dose 18.75 g/ha	0.67 cd	0.6 d
D	Sodium bispiribak 400 g/l dose 22.5 g/ha	0.26 d	0.5 d
E	Manual weeding	5.24 b	8.24 b
F	Control (no weeding)	13.63 a	23.35 a

Note: The average value marked with the same letter in the same column shows no significant difference at the 5% level according to the Duncan Test.

Marsilea crenata

The results of statistical analysis of the average dry weight of *Marsilea crenata* weeds are shown in Table 3. From this table it can be seen that the dry weight of *Marsilea crenata* weeds in the herbicide treatment Sodium bispiribak 400 g/l from a dose of 11.25 g/ha to 22.5 g/ha gave a low average dry weight value and was significantly different from manual and control weeding treatments at 3 and 6 weeks after application. The control treatment produced the highest dry weight and was significantly different from other treatments. These results indicate that the Sodium bispiribak 400 g/l herbicide from a dose of 11.25 g/ha to 22.5 g / ha is effective in controlling Marsilea crenata weeds until the age of 6 weeks after application. According to Yadav *et. al*. (2009) reported that the sodium bispiribak herbicide at a dose of 16-60 g/ha had a control power of 61-88% which was applied 15 days after planting.

Table 3: *Marsilea crenata* dry weight (g/0.25 m^2)

No.	Treatment	Observation time (Weeks After Application)	
		3	6
A	Sodium bispiribak 400 g/l dose 11.25 g/ha	1.17 c	1.40 c
B	Sodium bispiribak 400 g/l dose 15 g/ha	0.85 c	0.86 c
C	Sodium bispiribak 400 g/l dose 18.75 g/ha	0.87 c	0.87 c
D	Sodium bispiribak 400 g/l dose 22.5 g/ha	0.59 c	0.59 c
E	Manual weeding	4.32 b	5.99 b
F	Control (no weeding)	12.74 a	15.08 a

Note: The average value marked with the same letter in the same column shows no significant difference at the 5% level according to the Duncan Test.

Monochoria vaginalis

The results of statistical analysis on the average dry weight of weeds are shown in Table 4 showing that the herbicide treatment Sodium bispiribak 400 g/l starting at a dose of 11.25 g/ha to 22.5 g/ha gave the most average dry weight of *Monochoria vaginalis* weeds. small and significantly different from the treatment of manual and control weeding at the observation 3 and 6 weeks after application. The control treatment gave the highest average dry weight of *Monochoria vaginalis* weed and was significantly different from other treatments except by manual weeding (Table 5). This shows that the treatment Sodium bispiribak 400 g/l herbicide from a dose of 11.25 g/ha to 22.5 g/ha is effective in controlling *Monochoria vaginalis* weeds in lowland rice cultivation until the age of 6 weeks after application. This is in line with the research of Kurniadie *et. al.* (2020) [8] that the application of the Sodium bispiribak 400 g/l herbicide is effective in controlling the *Monochoria vaginalis.*

Table 4: Dry weight of *Monochoria vaginalis* weeds (g/0.25 m^2)

No.	Treatment	Observation time (Weeks After Application)	
		3	6
A	Sodium bispiribak 400 g/l dose 11.25 g/ha	0.69 b	1.13 b
B	Sodium bispiribak 400 g/l dose 15 g/ha	0.76 b	0.46 b
C	Sodium bispiribak 400 g/l dose 18.75 g/ha	0.00 b	0.00 b
D	Sodium bispiribak 400 g/l dose 22.5 g/ha	0.00 b	0.00 b
E	Manual weeding	3.54 a	8.07 a
F	Control (no weeding)	6.35 a	8.97 a

Note: The average value marked with the same letter in the same column shows no significant difference at the 5% level according to the Duncan Test.

Fimbristylis miliacea

The results of statistical analysis of the average dry weight of *Fimbristylis miliacea* weeds are shown in Table 5. The results of observations of the dry weight of *Fimbristylis miliacea* weeds show that the herbicide treatment of sodium bispiribak 400 g/l starting from a dose of 11.25 g/ha to 22.5 g/ha gives The average dry weight of *Fimbristylis miliacea* weed was low and significantly different from the control at observation 3 and 6 weeks after application. This shows that the herbicide treatment Sodium bispiribak 400 g/l from a dose of 11.25 g/ha to 22.5 g/ha is effective in controlling the weed *Fimbristylis miliacea* until the age of 6 weeks after application. This is in line with the research of *Hardini et. al.* (2020) [5] stated that the application of the sodium bispiribak herbicide is effective in controlling sedges in lowland rice plantations.

Table 5: Dry Weight of *Fimbristylis miliacea* Weeds (g/0.25 m^2)

No.	Treatment	Observation time (Weeks After Application)	
		3	6
A	Sodium bispiribak 400 g/l dose 11.25 g/ha	0.99 b	1.3 c
B	Sodium bispiribak 400 g/l dose 15 g/ha	0.42 b	0.59 c
C	Sodium bispiribak 400 g/l dose 18.75 g/ha	0.07 b	0.44 c
D	Sodium bispiribak 400 g/l dose 22.5 g/ha	0.17 b	0.64 c
E	Manual weeding	1.29 b	4.26 b
F	Control (no weeding)	4.53 a	8.56 a

Note: The average value marked with the same letter in the same column shows no significant difference at the 5% level according to the Duncan Test.

Cyperus iria

The results of statistical analysis on the average dry weight of *Cyperus iria* weeds are shown in Table 6. In this table, it can be seen that the dry weight of Cyperus iria weeds in the herbicide treatment Sodium bispiribak 400 g/l from a dose of 11.25 g/ha to 22.5 g/ha with manual weeding treatment was not significantly different and both were significantly different from the control treatment. This shows that the Sodium bispiribak 400 g/l herbicide is effective in controlling *Cyperus iria* weeds.

Table 6: Dry weight of *Cyperus iria* weeds (g/0.25 m^2)

No.	Treatment	Observation time (Weeks After Application)	
		3	6
A	Sodium bispiribak 400 g/l dose 11.25 g/ha	0.76 bc	0.66 b
B	Sodium bispiribak 400 g/l dose 15 g/ha	0.00 c	0.00 b
C	Sodium bispiribak 400 g/l dose 18.75 g/ha	0.00 c	0.00 b
D	Sodium bispiribak 400 g/l dose 22.5 g/ha	0.00 c	0.00 b
E	Manual weeding	0.75 b	1.09 b
F	Control (no weeding)	1.90 a	4.63 a

Note: The average value marked with the same letter in the same column shows no significant difference at the 5% level according to the Duncan Test.

Other Weed Species

Weed dry weight of other species is the dry weight of several weed species (excluding dominant species) found at the time of observation in the observed squares. Weeds of other species include *Leptochloa synensis, Sphenoclea zeylanica, Limnocharis flava, Echinochloa crus-gall, Leersia hexandra.* and *Pistia stratiotes.*

Based on the results of observations and analyzes carried out at 3 and 6 weeks after application, it is known that the average dry weight of weeds of other species in the herbicide treatment Sodium bispiribak 400 g/l from a dose of 11.25 g/ha to 22.5 g/ha is not different. real with manual weeding treatment (Table 7.). In observing the dry weight of other weeds, the control treatment gave the highest dry weight and was significantly different from other treatments both at 3 and 6 weeks after application. This may indicate that the herbicide treatment Sodium bispiribak 400 g/l from a dose of 11.25 g/ha to 22.5 g/ha is effective in controlling weeds of other species until the age of 6 weeks after application.

Table 7: Dry weeds of other species (g/0.25 m^2)

No.	Treatment	Observation time (Weeks After Application)	
		3	6
A	Sodium bispiribak 400 g/l dose 11.25 g/ha	0.16 b	2.92 bc
B	Sodium bispiribak 400 g/l dose 15 g/ha	0.07 b	1.61 c
C	Sodium bispiribak 400 g/l dose 18.75 g/ha	0.03 b	1.39 c
D	Sodium bispiribak 400 g/l dose 22.5 g/ha	0.14 b	1.19 c
E	Manual weeding	0.31 b	5.58 b
F	Control (no weeding)	1.46 a	10.45 a

Note: The average value marked with the same letter in the same column shows no significant difference at the 5% level according to the Duncan Test.

Rice plants

Phytotoxicity of Rice Plants

Observations on phytoxicity in lowland rice plants 1, 3, and 5 weeks after application showed that the application of sodium bispiribak 400 g/l herbicide from a dose of 11.25 g/ha to 22.5 g/ha did not cause poisoning symptoms in lowland rice plants. with a scale of 0 (Table 8). This is in line with the research of Yadav, *et. al.* (2009) [15], the application of the sodium bispiribak herbicide up to a dose of 60 g / ha did not cause phytotoxicity in rice.

Table 8: Rice poisoning rate

No.	Treatment	Observation time (Weeks After Application)		
		1	3	5
A	Sodium bispiribak 400 g/l dose 11.25 g/ha	0	0	0
B	Sodium bispiribak 400 g/l dose 15 g/ha	0	0	0
C	Sodium bispiribak 400 g/l dose 18.75 g/ha	0	0	0

D	Sodium bispiribak 400 g/l dose 22.5 g/ha	0	0	0
E	Manual weeding	0	0	0
F	Control (no weeding)	0	0	0

Rice Plant Height

The results of the analysis due to treatment of rice plant height are presented in Table 9. From the data in the table, it can be seen that all treatments, including control, gave no different plant heights in the observation 3 and 6 weeks after application. According to Sujitno *et. al.* (2011) [13] that plant height is influenced by genetic traits and environmental conditions for plant growth.

Table 9: Effect of application Sodium bispiribak 400 g/l herbicide on the Height of Rice Plants

No.	Treatment	Plant height (cm)	
		3 WAA	6 WAA
A	Sodium bispiribak 400 g/l dose 11.25 g/ha	58.86 b	68.03 a
B	Sodium bispiribak 400 g/l dose 15 g/ha	62.24 ab	70.73 a
C	Sodium bispiribak 400 g/l dose 18.75 g/ha	63.63 a	72.46 a
D	Sodium bispiribak 400 g/l dose 22.5 g/ha	59.97 ab	70.09 a
E	Manual weeding	60.56 ab	68.79 a
F	Control (no weeding)	61.1 ab	68.53 a

Note: The average value marked with the same letter in the same column shows no significant difference at the 5% level according to the Duncan Test. WAA = Weeks after Application

Number of Paddy Seedlings per Clump

The number of tillers is one component of rice plant growth that can be observed to see the response of plant growth to treatments other than plant height. Rice tillers are an indicator of rice plant growth which indicates healthy or sick plants (Makarim and Suhartatik, 2008). The results of observations at 1 week after application of the number of rice tillers per clump showed that all treatments, both treatment of sodium bispiribak 400 g/l herbicide, from 11.25 g/ha to 22.5 g/ha, as well as no weeding and control. showed a difference in the number of tillers (Table 10). However, at observations 3 and 5 weeks after application, the control treatment gave the lowest number of pups and was significantly different compared to other treatments. On the other hand, manual weeding treatment produced the number of tillers that were not different from the treatment of sodium bispiribak 400 g/l herbicide, starting from 11.25 g/ha to 22.5 g/ha. This situation shows that the herbicide treatment Sodium bispiribak 400 g/l from a dose of 11.25 g/ha to 22.5 g/ha can produce the same number of rice plant tillers as manual weeding.

Table 10: Effect of herbicide application Sodium bispiribak 400 g/l on the number of tillers of rice per clump

No.	Treatment	Number of Tillers		
		1 WAA	3 WAA	5 WAA
A	Sodium bispiribak 400 g/l dose 11.25 g/ha	11,21 a	19,47 b	25,61 b
B	Sodium bispiribak 400 g/l dose 15 g/ha	12,67 a	19,29 b	27,35 b
C	Sodium bispiribak 400 g/l dose 18.75 g/ha	11,11 a	21,25 b	29,98 b
D	Sodium bispiribak 400 g/l dose 22.5 g/ha	11,69 a	19,71 b	28,88 b
E	Manual weeding	10,15 a	20,81 b	28,05 b
F	Control (no weeding)	8,98 a	13,94 a	18,18 a

Note: The average value marked with the same letter in the same column shows no significant difference at the 5% level according to the Duncan Test. WAA = Weeks after Application

Dry Grain Milled Rice

The results of the analysis of lowland rice yields due to treatment can be seen in Table 11. In Table 14 it can be seen that the control gives the smallest results, namely 2440.75 g/6.25 m^2 or equivalent to 3.90 tonnes/ha (dry grain milled rice) and significantly different from all other treatments, including manual weeding treatment. The herbicide treatment Sodium bispiribak 400 g/l from a dose of 11.25 g/ha to 22.5 g/ha gave rice yields that were not different from manual weeding. The small yield of rice in the control treatment was due to competition with weeds that were not carried out. control.

Table 11: Effect of application of the Sodium bispiribak 400 g/l herbicide on Milled Rice Dried Grain

No.	Treatment	Dry Grain Milled Rice	
		g/6,25 m^2	Tonnes/ha
A	Sodium bispiribak 400 g/l dose 11.25 g/ha	2657.75 a	4.25
B	Sodium bispiribak 400 g/l dose 15 g/ha	3402.75 a	5.44
C	Sodium bispiribak 400 g/l dose 18.75 g/ha	3539.50 a	5.66
D	Sodium bispiribak 400 g/l dose 22.5 g/ha	3420.25 a	5.47
E	Manual weeding	3319.00 a	5.31
F	Control (no weeding)	2440.75 b	3.90

Note: The average value marked with the same letter in the same column shows no significant difference at the 5% level according to the Duncan Test.

Conclusion

1. Sodium bispiribak 400 g/l herbicide from a dose of 11.25 g/ha to 22.5 g/ha could control *Ludwigia octovalis*, *Marsilea crenata*, *Monochoria vaginalis*, *Fimbristylis miliacea*, *Cyperus iria*, and other weeds.
2. Sodium bispiribak 400 g/l Herbicide starting at a dose of 11.25 g/ha to 22.5 g/ha does not cause poisoning in rice plants.
3. Herbicide treatment Sodium bispiribak 400 g/l from a dose of 11.25 g/ha to 22.5 g/ha gave rice yields that were not different from manual weeding.

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