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Research Article

Testing the efficacy of the herbicide tolerant rice mutant (Robin) under direct seeded cultivation

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Abstract
In the recent years of labour and water scarcity, most of the rice cultivating areas all over the world are in a desperate need to save the resources and to find suitable alternatives so as to budge from transplanted rice cultivation. Direct seeded rice (DSR) cultivation is one of the best alternative. The vast spectrum of weeds present in this DSR ecology causes a voluminous decrease in the crop yield. In order to curtail the weeds, chemical management using broad spectrum herbicides which can control all classes of weeds is the efficient and economic way. On using broad-spectrum herbicide it may cause crop injury. In this regard TNAU has developed a novel herbicide (Imazethapyr) tolerant rice mutant (HTM Robin) through EMS mutagenesis of Nagina 22 cultivar. Robin mutant was tested across the location against the herbicide Imazethapyr and found to be tolerant and was registered at NBPGR, New Delhi. In this study the efficacy of this herbicide tolerant mutant was tested under chemical weed management. The genotypes CO51, HTM, Nagina 22 were raised in the weed free and control plots. Certain traits such a total number of tillers, number of productive tillers, grain yield/plant, straw yield/plant, number of filled grains/panicle, plant height, panicle length, 1000 grain weight, spikelet fertility were observed in the weed free and the control plots. Significant difference was observed for certain traits between the weed free and control plots. There was a vast reduction in the dry weight of the weeds in the herbicide sprayed plot when compared to the control plot. The weed control efficiency of the herbicide was found to range (Imazethapyr) from 74-92%.

Key words
Rice, Herbicide Tolerant Mutant (Robin), Weed control efficiency

INTRODUCTION

Rice is one of the important cereal crops considered key in achieving world's food security (Lobell *et al.,* 2011). In India, rice is grown in an area of about 43.5 million hectares (Mha) with a total production of 106 million tonnes (Mt) (www.indiastat.com),(2016). Of the total rice area, 49.5% (22 Mha) is under irrigated, 13.5% (6 Mha) is under upland and 32.4% (14.4 Mha) is under rainfed lowland ecosystems. More than 60% of the rice supply comes from irrigated rice cultivation which consumes more than 50% of fresh water resources for field preparation and irrigation.

India ranks top in exploiting ground water for irrigation and increased use of water for irrigation (113 times increase) led to decline in ground water availability by 0.5 - 1.0 my^{-1} in majority states of the country. Depleting water resources is going to affect rice production severely in India, a major cultivator, producer and consumer of rice in the world. Puddling alone utilizes 30% of water required for rice cultivation (1300-1500 mm) which is favourable in rice–rice cropping systems as puddling reduces soil permeability, creates hardpans and reduces water losses through percolation. Next to water, availability of labour for different agricultural operations is predicted to affect rice production significantly. Rapid economic growth coupled with booming industrial revolution has increased the demand of labor in non-agricultural sectors (Kumar and Ladha, 2011) and hence percentage of population engaged in agriculture as well as availability of agricultural labor has declined across the world. Hence, declining water and labor availability warrants a change in conventional puddled and transplanted system of rice cultivation.

Dry direct seeded rice (DSR) is one of the potential alternative systems of rice cultivation which can help in saving water, labour, reduced emission of methane and increase net profit to farmers (Kumar and Ladha, 2011). Direct-seeding of rice has the potential to provide several benefits to farmers and the environment over conventional practices of puddling and transplanted rice (PTR). Despite its several advantages, DSR is still in its infancy in India. Weed management poses challenge to the scientific community in developing successful DSR cultivation technology. The yield loss due to weeds ranges from 20-85% in India. The weed flora consists of both the broad-leaved and the grassy weeds. Thus crops need to survive the crop-weed competition for nutrients.

Manual weeding under DSR is quite difficult and hence DSR requires herbicide tolerance technology for effective weed management. Commercially available herbicide tolerance technologies have been developed through transgenic methods and hence not allowed for commercial cultivation in India. In this context, discovery of herbicide "Imazethapyr" resistant Nagina 22 namely "Robin" and mapping of SSR markers linked to herbicide tolerance in Robin has paved way for utilizing this trait in rice cultivation and breeding (Shoba *et al.,* 2017). Before putting this trait into breeding applications, testing its efficacy under direct seeded rice cultivation is necessary for product development and delivery. With this background, the present study was undertaken to test the performance of Imazethapyr resistant Robin mutant along with its wild type Nagina 22 under control and herbicide sprayed conditions.

MATERIALS AND METHODS

Three different genotypes *viz*., CO51, a high yielding short duration variety, Nagina 22 , an upland Aus cultivar and a mutant of Nagina 22 namely, Robin exhibiting resistance against Imazethapyr were used in this study. All the three genotypes were established under direct seeded cultivation at Paddy Breeding Station (PBS) during Summer 2020. Each genotype was raised in three plots (size 6.16 m^2) and maintained normally upto 21 days after sowing. Imazethapyr (Commercial Name: Pursuit 10% SL) herbicide was sprayed at the rate of 3ml/lit along with the appropriate adjuvant (Commercial Name: Outright) 3ml/lit with the help of a backpack sprayer. Two plots for each genotype were sprayed with the herbicide and the other plot was the control (unsprayed).

The Observations namely, spectrum of weeds, dry weight of weeds (g/plot) were recorded as detailed below.

Spectrum of weeds: Weed species were identified and grouped as grassy, broad-leaved or sedge weeds.

Dry weight of the weeds (g/plot): Weeding was done in both the control and herbicide sprayed plots on 90 DAS. Weed biomass was recorded.

The weed control efficiency (WCE) was worked out by using the formula suggested by Mani *et al.,*(1973) and it is expressed in percentage.

$$\text{WCE (\%)} = \frac{\text{Dry wt. of the weeds in unweeded control} - \text{Dry wt. of weeds in treated plot}}{\text{Dry weight of the weeds in unweeded control}} \times 100$$

Effect of herbicide on the growth of main crop was also studied by recording the following observations *viz*., Plant height (cm), Total number of tillers/plant, Number of productive tillers/plant, Panicle length (cm), Number of filled grains/panicle, 1000 seed weight(g), Spikelet fertility(%), Grain yield/plant(g) and Straw yield/plant(g). All the observations were recorded in ten different plants in each genotype. Student t-test was performed to test the difference between the treatments.

RESULTS AND DISCUSSION

Performance of CO51, Nagina 22 and HTM Mutant-Robin under control and herbicide sprayed conditions are given in Table 1. CO51 and N22 exhibited high level of susceptibility to Imazethapyr spray (**Fig. 1A and 1B**) and showed 100% mortality **(Table 1)**

The herbicide tolerant mutant "Robin" exhibited high level of resistance aginst Imazethapyr spray (**Table 1; Fig. 1C**). The major weed species in the experimental field consisted of *Echinochloa crus-galli, Cynodondactylon, Chloris barbata* and *Brachiaria reptans* under grasses, *Cyperus rotundus* under sedges and *Basilicum polystachyon, Bergia ammannioides, Eclipta prostrata* and *Alternanthera paronychioides* under broad leaved weeds. Similar spectrum of weeds in direct seeded rice was earlier reported by Rao *et al.,*(2007). Imazethapyr offered broad spectrum control against all the classes of weeds (**Table 2**).

Significant differences were observed for certain traits such as plant height, umber of productive tillers, filled grains per panicle, grain yield per plant and straw yield per plant in the control and the sprayed plot of the herbicide tolerant mutant. The number of productive tillers has been increased in the herbicide sprayed plot. In the Herbicide Tolerant Mutant (HTM) plot, when the dry weight of the weeds is high (627.35g) in the untreated plot, the grain yield/plant is 16.01g whereas when the dry

Table 1. Performance of the CO51, Nagina 22 and HTM Mutant- Robin genotypes

S. No	Parameters	CO51		Nagina 22		HTM		HTM Sprayed vs HTM Unsprayed	
		Sprayed	Unsprayed	Sprayed	Unsprayed	Sprayed	Unsprayed	t-value	P-value
1	Plant Height(cm)	0	95.9	0	102.1	115	117	2.755*	<0.05
2	Total number of tillers	0	13	0	8	12	10	1.593	>0.05
3	Number of productive tillers	0	13	0	8	11	9	3.221*	<0.05
4	Panicle length(cm)	0	20.26	0	21.89	19.21	18.52	1.174	>0.05
5	Total grains/panicle	0	136	0	105	120	104	7.015*	<0.05
6	Filled grains/panicle	0	125	0	97	113	97	6.322*	<0.05
7	Spikelet fertility %	0	91.9	0	92.3	94.2	93.2	0.467	>0.05
8	Grain yield/plant(g)	0	19.2	0	15.03	28.5	16.01	9.263*	<0.05
9	Straw yield/plant(g)	0	18.72	0	16.72	26.1	14.7	6.189*	<0.05
10	Dry weight of weeds(g)	112.3	522.95	189.1	731.3	48.7	627.35		

weight of weeds has decreased (48.7g) due to herbicide spray, the grain yield/plant is 28.5g. Thus dry weight of weeds is negatively correlated with grain yield of the crop. The mean height of the plants in the control (117 cm) plot is found to be higher than the height of the plants in herbicide treated plot (115 cm). This may be due to the competitive ability of the plant height against the weeds. These results may be supported by the studies conducted by Garrity *et al.,*(1992) where the weed suppression ability of the taller cultivars was explained. The traits such as the total number of tillers, spikelet fertility, panicle length had no significant difference between the control and sprayed plot of herbicide tolerant mutant.

Table 2. Weed flora observed in the experimental area

Botanical Name	Common Name	Family
Grasses		
Brachiaria reptans	Signal grass	Poaceae
Chloris barbata	Peacock plumegrass	Poaceae
Cynodon dactylon	Bermuda grass	Poaceae
Echinochloa crus-galli	Cockspur grass	Poaceae
Broad-leaved		
Basilicum polystachyon	Musk Basil	Lamiaceae
Bergia ammannioides	Ammannia Waterwort	Elatinaceae
Ammannia baccifera	Red stem	Lythraceae
Eclipta prostrata	False daisy	Asteraceae
Alternanthera paronychioides	Smooth joyweed	Amaranthaceae
Sedges		
Cyperus rotundus	Nut grass	Cyperaceae

Herbicide tolerant mutant “Robin” recorded an yield of 16.01 g/plant under unsprayed conditions and one round of Imazethapyr spray had significant influence on the grain yield (28.5 g/plant). Similarly, HTM “Robin” recorded significantly higher straw yield (26.1 g/plant) than the unsprayed control (14.7 g/plant). The grain yield has increased in accordance with the decrease in the dry weight of the weeds in the herbicide treated plot which is in accordance with the results obtained from the studies conducted by Sharma *et al.,*(1977) in direct seeded rice cultivation. This may be due to the increased availability of the nutrients and water resources for the crop in the weed-free plot. Dry weight of the weeds is the most important parameter to assess the weed competitiveness for the crop growth and productivity. Weed biomass (dry weight) was significantly higher in the unsprayed control plots (627.35 g) and one spray of Imazethapyr has reduced the weed biomass. The dry weight of the weeds is higher in the unweeded control plot. This may be due to the uncontrolled growth of the weeds. The lowest accumulation of the weed dry matter in the treated plot is due to the effective control of weeds by Imazethapyr application (**Fig. 2).** Teja *et al.,*(2017) in their studies have recommended Imazethapyr herbicide as a promising

Fig. 1A Performance of CO51 on Imazethapyr spray

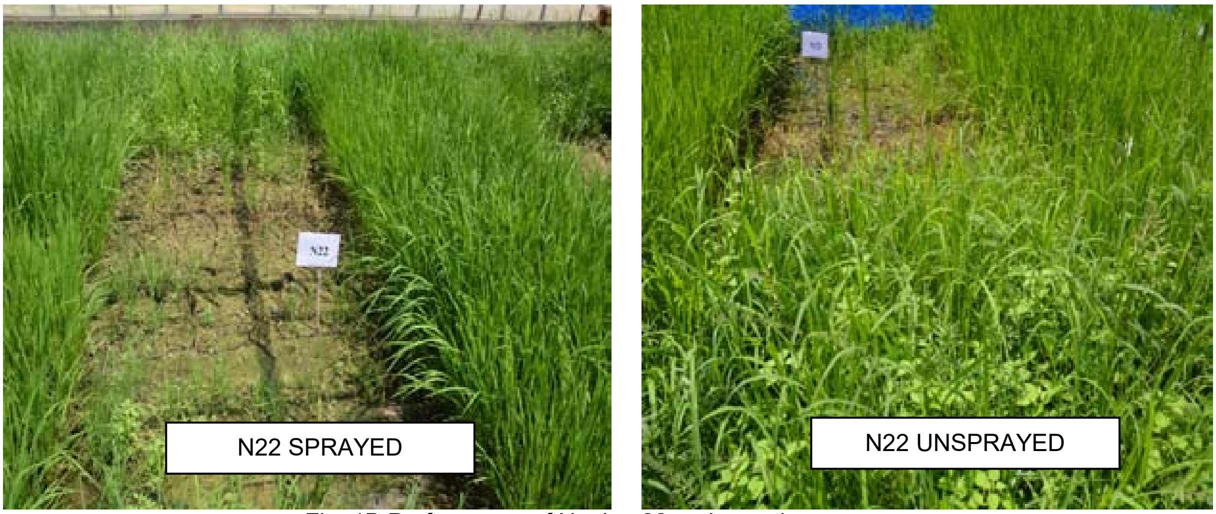

Fig. 1B Performance of Nagina 22 on Imazethapyr spray

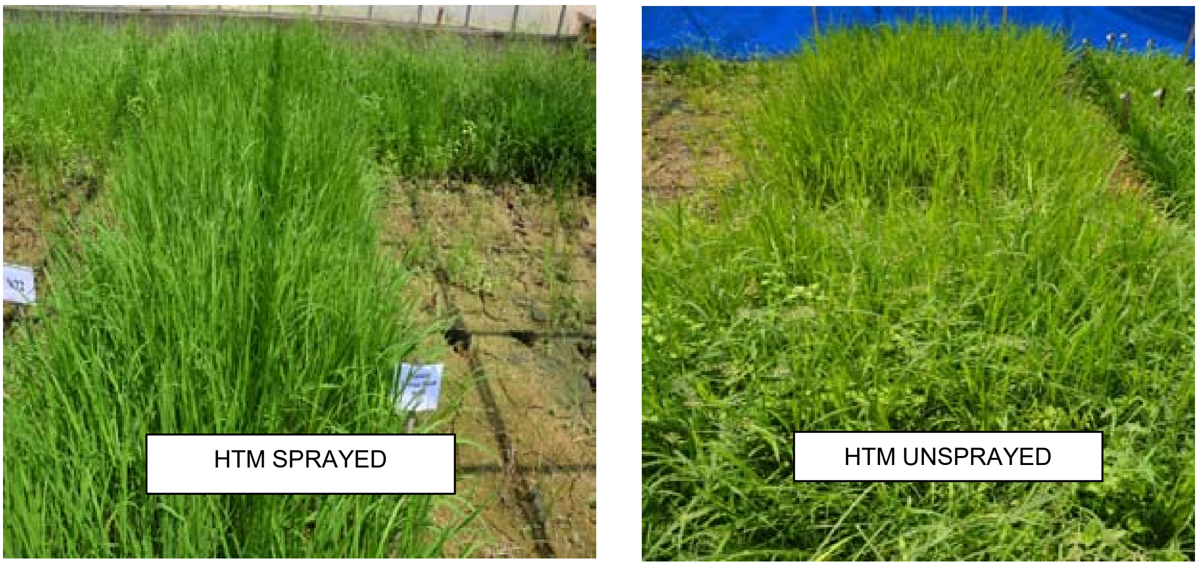

Fig. 1C Performance of HTM-Robin on Imazethapyr spray control of broad-spectrum of weed flora and for lower values of weed dry weight and high weed control efficiency of upto 85-90%. Weed control efficiency indicates the magnitude of reduction of weed density by weed control treatment over the unweeded control. Application of the Imazethapyr 21 DAS had an efficient control on broad spectrum of weeds. The WCE of Imazethapyr ranged from 74-92% (**Table 3)**

Results indicated that use of a novel chemical Imazethapyr did not exhibit any negative effect on growth and developmental characters of HTM "Robin" and thus paved way for using this mutant in breeding applications. Imazethapyr is a chemical approved for weed management in pulses and this study has thrown light on the potential of this mutant in deploying a new chemical weed management strategy in rice. Further experiments on the residue analysis is required for assessing its safety issues. As suggested by (Carpenter and Gianessi 1999) in their review on herbicide tolerant soybean, herbicide tolerant crops offer the simplicity and flexibility of the weed control which provides broad spectrum control of weeds by applying one product over the crop and at any stage of growth without causing crop injury.

The herbicide tolerant mutant when raised in control and weed-free plot showed significant differences for yield contributing traits. This was due to the crop-weed competition that the plants in the weed-free plot had higher mean for certain growth and yield traits. But there was no significant difference for total number of tillers, panicle length, 1000 grain weight and spikelet fertility. The weed control efficiency of the herbicide Imazethapyr was high in the mutant crop whereas it was low in N22 and CO51 varieties.

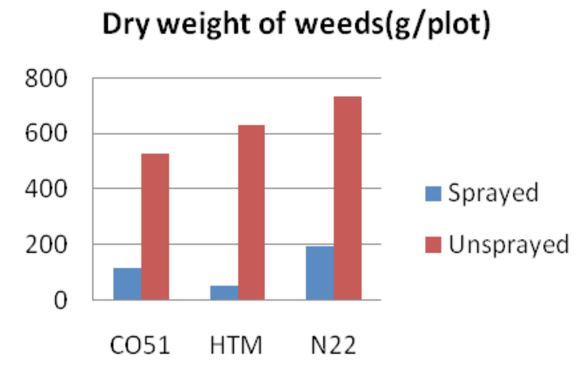

Fig. 2. Dry weight of the weeds in sprayed and unsprayed condition

Table 3. Weed Control Efficiency of Robin mutant with other genotypes (%)

Genotypes	Dry weight of weeds in control (g/plot)	Dry weight of weeds in herbicide sprayed (g/plot)	WCE(%)
CO51	522.95	112.3	78.5
HTM	627.35	48.7	92.2
N22	731.3	189.1	74.1

From this experiment it is concluded that the herbicide tolerant mutant (Robin mutant) showed the 92.2 % weed control efficiency. This mutant will be utilised as donor for breeding rice varieties with herbicide tolerance trait which will pave the way for controlling environment friendly weed control in direct seeded rice cultivation.

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