

## EVALUATION OF BIO-EFFICACY AND PHYTOTOXICITY OF GLUFOSINATE AMMONIUM 13.5% SL IN TEA (CAMELLIA SINENSIS L.)

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### Abstract

An experiment was conducted at Cooch Behar Tea estate, West Bengal during kharif season of 2015 to evaluate the bio-efficacy and phytotoxicity of glufosinate ammonium 13.5% SL in tea (*Camellia sinensis* L.). The experiment was laid out in a randomized block design (RBD) with seven treatments. *Eleusine indica*, *Panicum repens*, *Ageratum conyzoides* and *Axonopus compressus*, *Borreria hispida* were the major weeds found infesting the tea crop during the season. The result from the experimental trial revealed that the weeds flora in tea were controlled effectively by applying glufosinate ammonium 13.5% SL at dosages varied from 375 g a.i. ha<sup>-1</sup> to 625g a.i. ha<sup>-1</sup>, which were statistically superior to the standard checks paraquat dichloride 24% SL @ 1 kg ha<sup>-1</sup>. Significant increase in total leaf yield of tea was obtained by application of glufosinate ammonium 13.5% SL at the tested dose ranging from 375 g a.i. ha<sup>-1</sup> to 625g a.i. ha<sup>-1</sup>, in comparison to the weedy check & standard check. No phytotoxicity symptoms were observed in any of the doses of glufosinate ammonium 13.5% SL including double the recommended dose ie 1000 g a.i. ha<sup>-1</sup> and hence, it can be used safely at the recommended rate in tea for effective weed management.

**Key words:** Bio-efficacy, Glufosinate ammonium, paraquat dichloride, Tea and Weed

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## Introduction

Tea is one of the most popular and lowest cost beverages in the world and consumed by a large number of people. Owing to its increasing demand, tea is considered to be one of the major components of world beverage market. India has witnessed a many fold increase in production of tea, which is mainly attributed to efficient and integrated agricultural practices including efficient weed management practices.

The reduction in tea leaves yield due to weeds can be as high as 12 to 21% (Ilango *et al.* 2010) depending upon the management practices followed. Besides competing for nutrient, water, light and space, weeds harbour crop pests and pose many operational hazards in tea crop. Thus, weeding is an important practice for efficient management and sustenance of production in tea crop. Manual and mechanical methods do not present a better option because of time, season and expense involved.

Chemical control scores over other methods (Prematilake *et al.* 2004, Rajkhowa *et al.* 2005, Ilango *et al.* 2010, Mirghasemi *et al.* 2012) due to their efficiency, cost effectiveness and ease of operation. However, keeping in view the diverse weed species infesting tea crop, new chemical are required for effective weed management in tea. The present investigation was aimed at evaluating the bio-efficacy of glufosinate ammonium 13.5% SL against weed flora in tea & phytotoxicity on tea.

## Materials and methods

Field experiment was carried out at Section no. 13B of Cooch Behar Tea Estate, West Bengal during *Kharif* season of 2015. Cooch Behar Tea Estate is situated in the terai agro climatic zone of West Bengal at 26°32'42" N latitude and 89°45'10" E longitude and at an elevation of 43 meters above mean sea level. Soil pH of the experimental block was 5.50 showing slightly acidic, blackish gray in colour mostly due to high organic matter and poor bases with moderate availability in primary major nutrients.

The experiment was laid out in a randomized block design with three replications. There were seven treatments Viz., T<sub>1</sub>= Glufosinate ammonium 13.5% SL @250g a.i./ha , T<sub>2</sub>= Glufosinate ammonium 13.5% SL @375g a.i./ha, T<sub>3</sub>= Glufosinate ammonium 13.5% SL @500g a.i./ha, T<sub>4</sub>= Glufosinate ammonium 13.5% SL @625g a.i./ha, T<sub>5</sub>= Paraquat dichloride 24% SL @1000g a.i./ha, T<sub>6</sub>= Hand weeding as an when required and T<sub>7</sub>= Untreated control for bio-efficacy study and T<sub>8</sub>= Glufosinate ammonium 13.5% SL @1000g a.i./ha for

phytotoxicity study. 10 year old TV-25 variety was used in the trial which was planted with a spacing of 100 cm X 70 cm. A plot size of 10 m x10 m was maintained. Herbicides were sprayed by using knapsack sprayer with a flat fan nozzle used spray water volume of 500 L ha<sup>-1</sup>. The application of all the herbicide treatments was done by directed spraying using hood. Hand weeding was taken up twice once before the application of treatments and second at 35 Days after first weeding. Observations on species wise weed count (per sq. m area) was recorded at initial (before herbicide application) followed by 45 and 75 days after application (DAA) of tested herbicides from each plots. Weed dry weight were calculated based on total weed population at 45 & 75 DAA. Average values were calculated and the data were presented on m<sup>-2</sup> basis. Other crop management was followed as per recommendation.

Weed control efficiency (WCE) was calculated on the basis of data recorded at 45 & 75 DAA of the tested herbicide in tea by using formula outlined by Mishra and Tosh, 1979. Yield data of green leaf tea was also recorded month wise from each picking for 3 months and calculated 3 month total yield from each herbicidal treatments including plots of two hands weeded and untreated weedy check. The count and dry weight of weeds were analyzed after subjecting the original data to square root transformation ( $\sqrt{X+0.5}$ ).

The observations on crop phytotoxicity viz yellowing, epinasty, hyponasty, vein clearing, leaf tip and surface injury and wilting of plants, due to application of tested herbicides was recorded on 1, 3, 7, 10 and 15 DAA. Phytotoxicity rating was done at 0-10 scale, where scale : 0-No phytotoxicity, scale 1: 1-10% phytotoxicity, scale 2: 11-20% phytotoxicity, scale 3: 21-30% phytotoxicity scale 4: 31-40% phytotoxicity, scale 5: 41-50% phytotoxicity, scale 6: 51-60% phytotoxicity, scale 7: 61-70% phytotoxicity, scale 8: 71-80% phytotoxicity, scale 9: 81-90% phytotoxicity, scale 10: 91-100% phytotoxicity.

## Results and Discussion

### Effect on weeds

Weed flora in the experimental field were predominantly consisted of five species of grasses, four species of broad leaved weed. The dominant grassy weed species were *Digitaria sanguinalis*, *Panicum repens*, *Eleusine indica*, *Paspalum conjugatum*, *Imperata cylindrica*, and broad leaf weeds like *Borreria hispida*, *Commelina benghalensis*, *Ageratum conyzoides*,

*Axonopus compressus*. Beside this negligible numbers of *Cyperus rotundus*, *Cynodon dactylon*, *Euphorbia hirta* and *Lucus aspera* has been found in the experimental area.

Among the grassy weeds *Eleusine indica* was found most dominant weed followed by *Panicum repens*, while in case of broad leaf *Ageratum conyzoides* become predominant followed by *Axonopus compressus*.

### Weed density

Data presented in table 1 on weed density observed at initial stage (before application of herbicides) showed that weed density was uniform in all the plots as the difference was statistically non-significant. *Ageratum conyzoides* is the most dominant weed found in experimental field which contribute almost 25.13% of total weed population followed by *Axonopus compressus* (18.41%), *Borreria hispida* (12.84%) and *Eleusine indica* (12.11%) before application of herbicides. However, observations on weed density after 45 & 75 days of application of herbicides clearly indicate that herbicidal treatment was better than weedy check condition in reduction of the weed density of all categories of weeds (table 2 & 3).

Among all the treatments, twice hand weeded plot recorded lowest total weed population of grassy and broad leaf weeds. Among herbicidal treatments glufosinate ammonium 13.5% SL @ 625 g a.i. ha<sup>-1</sup> gave more impressive control of weeds due to its herbicidal effect on inhibition of glutamine synthetase leading to a complete breakdown of ammonia metabolism (Hack *et al.* 1994) though on par with its lower doses @ 500 g a.i. ha<sup>-1</sup> and 375 g a.i. ha<sup>-1</sup> at 45 DAA and 75 DAA. Paraquat dichloride 24% SL @ 1000 g a.i. ha<sup>-1</sup> recorded highest total weed population of grassy and broad leaf weeds as compared to the rest of the herbicides treatment at 45 DAA and 75 DAA though on par with glufosinate ammonium 13.5% SL @ 250 g a.i. ha<sup>-1</sup>.

### Weed dry weight

Weed dry matter is the most important parameter to assess the weed competitiveness for the crop growth and productivity. Sparse weeds with high biomass might be more competitive for crops than dense weeds with lesser dry matter (Ramalingam *et al.* 2013). Dry weight of total weeds population was recorded at 45DAA & 75 DAA and represented in Table 4. Among the weed management treatments, twice handed weeding was recorded the lowest dry weight of the grassy and brad leaf weeds. Among the herbicidal treatment considerable reduction in dry weight of weed was recorded with glufosinate ammonium 13.5% SL @ 625 g a.i. ha<sup>-1</sup> which was followed glufosinate ammonium 13.5% SL @ 500 g a.i. ha<sup>-1</sup> and glufosinate ammonium 13.5% SL @ 375 g a.i. ha<sup>-1</sup> though all are statistically at

par. Maximum dry weed biomass was noticed in weedy check, where weeds were not controlled. The lower doses of glufosinate ammonium 13.5% SL @ 250 g *a.i.* ha<sup>-1</sup> is found on par with market standard paraquat dichloride 24% SL @ 1000 g *a.i.* ha<sup>-1</sup> in terms of dry weight of the grassy and broad leaf weeds.

### **Weed control Efficiency**

Weed control efficiency which indicates the comparative magnitude of reduction in weed dry matter was highly influenced by different weed control treatments. The results of weed control efficiency (WCE) of grassy and broad leaf weeds are presented in table 4 and it was revealed that all the herbicidal treatments gives effective control of grassy weeds ranged from 77.8 % to 96.1% at 45 days after application of herbicides and 75.2% to 90.0% at 75 days after application of herbicides as well as broad leaf weeds ranged from 72.4% to 94.6% at 45 DAA and 74.1% to 91.3% at 75 DAA. Among herbicidal treatments glufosinate ammonium 13.5% SL @ 625 g *a.i.* ha<sup>-1</sup> which was on par with its lower doses and found most effective treatment for managing grassy and broad leaf weeds in tea. Twice hand weeded plot recorded highest values of weed control efficiency at both the dates of recording observation owing to the fact that it registered lesser weed count and dry matter. It was also observed that herbicidal treatments are quite superior in controlling grassy weed than broad leaf.

### **Leaf yield of tea**

Leaf yield of tea was recorded during the month of August, September and October. It is quite obvious that twice hand weeded plot recorded highest (39 quintal ha<sup>-1</sup>) leaf yield of tea and this might be due to weed free environment and effective utilization of all above and below ground available resources. Among the herbicidal treatment, significant increase in leaf yield of tea was obtained with the application of glufosinate ammonium 13.5% SL @ 625 g *a.i.* ha<sup>-1</sup> followed by glufosinate ammonium 13.5% SL @ 500 g *a.i.* ha<sup>-1</sup> and 375 g *a.i.* ha<sup>-1</sup> which were on par to each other and statistically superior in comparison to paraquat dichloride 24% SL @ 1000 g *a.i.* ha<sup>-1</sup> (table 5). The reason is due to better control of weeds at critical stages thus providing favorable environment for better growth and development leading to enhanced leaf yield of tea. Plot receiving glufosinate ammonium offer most practical, effective and economical method of weed control and recorded 2.3 to 22.25 % more tea yield than paraquat dichloride due to better control of weeds thus providing favorable environment for better growth and development leading to enhanced leaf yield.

### Phytotoxicity on tea plants

The observations on the level of phytotoxicity due to application of glufosinate ammonium 13.5% SL was recorded on 1, 3, 7, 10 & 15 DAA and presented in the table 6. The results revealed that glufosinate ammonium 13.5% SL did not show any kind of phytotoxicity symptoms (leaf injury on tips/surface, vein clearing, necrosis, wilting, epinasty and hyponasty) on the tea plants even up to the dose of 1000 g *a.i.* ha<sup>-1</sup> (double the recommended dose).

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### Conclusion

The result from the experimental trial revealed that the weeds flora in tea were controlled effectively by applying glufosinate ammonium 13.5% SL at dosages rate from @ 2500 ml ha<sup>-1</sup> to 4166 ml ha<sup>-1</sup>, which were statistically superior to the standard checks paraquat dichloride 24% SL @ 1000 g *a.i.* ha<sup>-1</sup>. Significant increase in total leaf yield of tea was obtained by application of glufosinate ammonium 13.5% SL at the tested dosages from @ 375 g *a.i.* ha<sup>-1</sup> to @ 625 g *a.i.* ha<sup>-1</sup>, in comparison to the weedy check & standard check.

No phytotoxicity symptoms were observed in any of the doses of glufosinate ammonium 13.5% SL including double the recommended dose and hence, it can be used safely at the recommended rate in tea for effective weed management.

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**Table 1. Weed density (per m<sup>2</sup> area) at initial stage (before herbicide application) in the experimental tea field**

Treatments	Grassy weeds					Broad leaf weeds			
	<i>Digitaria sanguinalis</i>	<i>Eleusine indica</i>	<i>Paspalum conjugatum</i>	<i>Imperata cylindrica</i>	<i>Panicum repens</i>	<i>Commelina benghalensis</i>	<i>Ageratum conyzoides</i>	<i>Borreria hispida</i>	<i>Axonopus compressus</i>
T <sub>1</sub> = Glufosinate Ammonium 13.5% SL@250g a.i./ha	(4.7) 2.28	(7.3) 2.79	(2.3) 1.67	(1.7) 1.48	(6.7) 2.68	(2.3) 1.67	(15.3) 3.97	(7.0) 2.74	(11.0) 3.39
T <sub>2</sub> = Glufosinate Ammonium 13.5% SL@375g a.i./ha	(5.0) 2.35	(6.7) 2.68	(2.7) 1.79	2.0 (1.58)	(6.3) 2.61	(3.0) 1.87	(14.7) 3.90	(7.3) 2.79	(11.7) 3.49
T <sub>3</sub> = Glufosinate Ammonium 13.5% SL@500g a.i./ha	(4.3) 2.19	(7.0) 2.74	(2.7) 1.79	(2.0) 1.58	(7.0) 2.74	(2.3) 1.67	(15.0) 3.94	(7.3) 2.79	(10.3) 3.29
T <sub>4</sub> = Glufosinate Ammonium 13.5% SL@625g a.i./ha	(4.7) 2.28	(7.7) 2.86	(3.0) 1.87	(1.7) 1.48	(7.0) 2.74	(2.7) 1.79	(14.3) 3.85	(8.0) 2.92	(11.0) 3.39
T <sub>5</sub> = Paraquat dichloride 24% SL@1000g a.i./ha	(4.7) 2.28	(7.3) 2.79	(3.0) 1.87	(2.3) 1.67	(6.3) 2.61	(3.0) 1.87	(15.0) 3.94	(8.0) 2.92	(10.7) 3.35
T <sub>6</sub> = Hand weeding (Two)	(4.3) 2.19	(7.0) 2.74	(2.7) 1.79	(1.7) 1.48	(7.3) 2.79	(2.3) 1.67	(14.7) 3.90	(7.7) 2.86	(11.0) 3.39
T <sub>7</sub> = Weedy check	(4.0) 2.12	(7.0) 2.74	(3.0) 1.87	(2.0) 1.58	(6.7) 2.68	(2.7) 1.79	(14.7) 3.90	(7.7) 2.86	(10.3) 3.29
CD at 5 %	NS	NS	NS	NS	NS	NS	NS	NS	NS

Data in parentheses are original means



Table 2. Weed density (per m<sup>2</sup> area) at 45 Days after application of herbicidal treatments in tea

Treatments	Grassy weeds					Broad leaf weeds			
	<i>Digitaria sanguinalis</i>	<i>Eleusine indica</i>	<i>Paspalum conjugatum</i>	<i>Imperata cylindrica</i>	<i>Panicum repens</i>	<i>Commelina benghalensis</i>	<i>Ageratum conyzoides</i>	<i>Borreria hispida</i>	<i>Axonopus compressus</i>
T <sub>1</sub> = Glufosinate Ammonium 13.5% SL@250g a.i./ha	(1.0) 1.22	(2.7) 1.79	(0.3) 0.89	(0.7) 1.10	(3.0) 1.87	(1.0) 1.22	(3.7) 2.05	2.3 1.67	(2.0) 1.58
T <sub>2</sub> = Glufosinate Ammonium 13.5% SL@375g a.i./ha	(0.0) 0.71	(1.0) 1.22	(0.0) 0.71	(0.3) 0.89	(1.7) 1.48	(0.3) 0.89	(0.0) 0.71	1.7 1.48	(0.7) 1.10
T <sub>3</sub> = Glufosinate Ammonium 13.5% SL@500g a.i./ha	(0.3) 0.89	(1.3) 1.34	(0.0) 0.71	(0.0) 0.71	(1.3) 1.34	(0.0) 0.71	(0.0) 0.71	1.3 1.34	(0.7) 1.10
T <sub>4</sub> = Glufosinate Ammonium 13.5% SL@625g a.i./ha	(0.0) 0.71	(0.7) 1.10	(0.0) 0.71	(0.3) 0.89	(1.3) 1.34	(0.3) 0.89	(0.0) 0.71	1.0 1.22	(0.3) 0.89
T <sub>5</sub> = Paraquat dichloride 24% SL@1000g a.i./ha	0.7 1.10	(3.3) 1.95	(1.3) 1.34	(1.0) 1.22	(3.7) 2.05	(1.3) 1.34	(3.3) 1.95	3.0 1.87	(3.7) 2.05
T <sub>6</sub> = Hand weeding (Two)	0.0 0.71	(0.0) 0.7	(0.30) 0.89	(0.7) 1.10	(1.0) 1.22	(0.0) 0.71	(1.0) 1.22	0.0 0.71	(0.7) 1.10
T <sub>7</sub> = Weedy check	4.3 2.19	(7.0) 2.74	(4.7) 2.28	(3.7) 2.05	(6.7) 2.68	(3.0) 1.87	(16.3) 4.10	7.7 2.86	(11.7) 3.49
CD at 5 %	0.32	0.29	0.18	0.16	0.12	0.23	0.11	0.13	0.37

Data in parentheses are original means

Table 3. Weed density (per m<sup>2</sup> area) at 75 Days after application of herbicidal treatments in tea

Treatments	Grassy weeds					Broad leaf weeds			
	<i>Digitaria</i>	<i>Eleusine</i>	<i>Paspalum</i>	<i>Imperata</i>	<i>Panicum</i>	<i>Commelina</i>	<i>Ageratum</i>	<i>Borreria</i>	<i>Axonopus</i>
	<i>sanguinalis</i>	<i>indica</i>	<i>conjugatum</i>	<i>cylindrica</i>	<i>repens</i>	<i>benghalensis</i>	<i>conyzoides</i>	<i>hispidia</i>	<i>compressus</i>
T <sub>1</sub> = Glufosinate Ammonium	(2.0)	(2.7)	(1.0)	(1.3)	(3.0)	(1.3)	(5.3)	(3.0)	(2.0)
13.5% SL@250g a.i./ha	1.58	1.79	1.22	1.34	1.87	1.34	2.41	1.87	1.58
T <sub>2</sub> = Glufosinate Ammonium	(0.7)	(1.3)	(0.3)	(0.7)	(1.7)	(0.3)	(2.3)	(1.7)	(1.0)
13.5% SL@375g a.i./ha	1.10	1.34	0.89	1.10	1.48	0.89	1.67	1.48	1.22
T <sub>3</sub> = Glufosinate Ammonium	(0.3)	(1.7)	(0.3)	(0.3)	(1.7)	(0.3)	(2.0)	(1.3)	(0.7)
13.5% SL@500g a.i./ha	0.89	1.48	0.89	0.89	1.48	0.89	1.58	1.34	1.10
T <sub>4</sub> = Glufosinate Ammonium	(0.3)	(1.0)	(0.0)	(0.3)	(1.3)	(0.7)	(1.3)	(1.3)	(0.7)
13.5% SL@625g a.i./ha	0.89	1.22	0.71	0.89	1.34	1.10	1.34	1.34	1.10
T <sub>5</sub> = Paraquat dichloride 24%	(1.3)	(4.0)	(1.7)	(2.0)	(3.7)	(2.0)	(5.0)	(3.7)	(4.0)
SL@1000g a.i./ha	1.34	2.12	1.48	1.58	2.05	1.58	2.35	2.05	2.12
T <sub>6</sub> = Hand weeding (Two)	(0.7)	(1.0)	(1.0)	(0.7)	(1.0)	(1.0)	(3.0)	(0.7)	(1.0)
	1.10	1.22	1.22	1.10	1.22	1.22	1.87	1.10	1.22
T <sub>7</sub> = Weedy check	(5.0)	(7.7)	(4.7)	(4.0)	(6.7)	(4.0)	(17.0)	(7.0)	(11.0)
	2.35	2.86	2.28	2.12	2.68	2.12	4.18	2.74	3.39
CD at 5 %	0.35	0.31	0.18	0.20	0.33	0.25	0.26	0.15	0.26

Data in parentheses are original means

**Table 4. Total weed dry weight and weed control efficiency at 45 DAA & 75 DAA of herbicide in tea**

Treatments	Dry weight of weeds (g m <sup>-2</sup> )							
	Grassy				Broad leaf			
	45 DAA	% WCE	75 DAA	% WCE	45 DAA	% WCE	75 DAA	% WCE
T <sub>1</sub> = Glufosinate Ammonium 13.5% SL@250g <i>a.i./ha</i>	3.3	77.40	5.3	75.12	6.1	72.40	9.3	74.09
T <sub>2</sub> = Glufosinate Ammonium 13.5% SL@375g <i>a.i./ha</i>	1.0	93.15	3.3	84.51	2.3	89.59	5.4	84.96
T <sub>3</sub> = Glufosinate Ammonium 13.5% SL@500g <i>a.i./ha</i>	0.7	95.21	2.4	88.73	1.7	92.31	4.1	88.58
T <sub>4</sub> = Glufosinate Ammonium 13.5% SL@625g <i>a.i./ha</i>	0.6	95.89	2.1	90.14	1.2	94.57	3.1	91.36
T <sub>5</sub> = Paraquat dichloride 24% SL@1000g <i>a.i./ha</i>	2.5	82.88	7.0	67.14	6.6	70.14	11.7	67.41
T <sub>6</sub> = Hand weeding (Two)	0.4	97.26	1.2	94.37	0.8	96.38	2.0	94.43
T <sub>7</sub> = Weedy check	14.6	-	21.3	-	22.1	-	35.9	-
CD at 5 %	0.82	-	1.90	-	2.31	-	3.14	-

**Table 5: Effect of herbicidal treatments on green leaf yield (q ha<sup>-1</sup>) of tea during the period of experimentation**

Treatments	August	September	October	Total
T <sub>1</sub> = Glufosinate Ammonium 13.5% SL@250g <i>a.i./ha</i>	11.8	10.4	8.2	30.4
T <sub>2</sub> = Glufosinate Ammonium 13.5% SL@375g <i>a.i./ha</i>	13.5	12.0	9.7	35.2
T <sub>3</sub> = Glufosinate Ammonium 13.5% SL@500g <i>a.i./ha</i>	14.1	12.7	10.2	37.0
T <sub>4</sub> = Glufosinate Ammonium 13.5% SL@625g <i>a.i./ha</i>	14.3	12.9	11.0	38.2
T <sub>5</sub> = Paraquat dichloride 24% SL@1000g <i>a.i./ha</i>	11.4	10.3	8.0	29.7
T <sub>6</sub> = Hand weeding (Two)	15.2	13.5	10.3	39.0
T <sub>7</sub> = Weedy check	9.6	8.6	6.6	24.8
CD at 5 %	2.2	1.9	1.8	3.9

**Table 6: Percent rating of phyto-toxic effect of glufosinate ammonium 13.5% SL on tea**

Treatments	Leaf injury	Wilting	Necrosis	Vein clearing	Epinasty	Hyponasty
	on tips/ surface					
T <sub>1</sub> = Glufosinate Ammonium 13.5% SL@250g <i>a.i./ha</i>	0	0	0	0	0	0
T <sub>2</sub> = Glufosinate Ammonium 13.5% SL@375g <i>a.i./ha</i>	0	0	0	0	0	0
T <sub>3</sub> = Glufosinate Ammonium 13.5% SL@500g <i>a.i./ha</i>	0	0	0	0	0	0
T <sub>4</sub> = Glufosinate Ammonium 13.5% SL@625g <i>a.i./ha</i>	0	0	0	0	0	0
T <sub>5</sub> = Paraquate dichloride 24% SL@1000g <i>a.i./ha</i>	0	0	0	0	0	0
T <sub>6</sub> = Hand weeding (Two)	0	0	0	0	0	0
T <sub>7</sub> = Weedy check	0	0	0	0	0	0