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Ashwin Patel
JNKVV-College of Agriculture, Rewa, Madhya Pradesh, India

Akhilesh Kumar
JNKVV-Krishi Vigyan Kendra, CoA, Rewa, Madhya Pradesh, India

RK Tiwari
JNKVV-College of Agriculture, Rewa, Madhya Pradesh, India

AK Pandey
JNKVV-Krishi Vigyan Kendra, CoA, Rewa, Madhya Pradesh, India

Correspondence
Ashwin Patel
JNKVV-College of Agriculture, Rewa, Madhya Pradesh, India

Efficacy of new molecules of insecticides against girdle beetle, *Obereopsis brevis* Swed. and white fly, *Bemisia tabaci* Genn. and their analysis of economics

Ashwin Patel, Akhilesh Kumar, RK Tiwari and AK Pandey

Abstract
A Field experiments were conducted during Kharif season of 2017-2018 to evaluate the efficacy of new molecule of insecticides i.e. Triazophos 40% EC, Indoxacarb 15.8% EC, Thiacloprid 21.7% SC, Profenophos 50% EC, Flubendiamide 39.35% SC, Chlorantraniliprole 18.5% SC, Betacyfluthrin 8.49%+ Imidacloprid 19.81% 300 OD, Thiamethoxam 12.6%+ Lambdacyhalothrin 9.5% ZC, will be compared with untreated control plot against the Girdle Beetle, *Obereopsis brevis* Swed. and White fly, *Bemisia tabaci* Genn. Among them, Triazophos @ 320 g a.i./ha were found as the best treatment against Girdle beetle followed by Chlorantraniliprole @ 30 g a.i./ha. The efficacy of insecticide against White fly had also shown the Thiacloprid @ 60 g a.i./ha as the best tested insecticides besides being safer to environment and Triazophos @ 320 g a.i./ha was found second best treatment. The highest yield of 13.13 q/ha, was recorded in the plot treated with Triazophos @ 320 g a.i. /ha. The lowest yield of 8.13 q/ha was recorded in untreated control. The C: B ratio of various insecticide treatments was calculated and the maximum C:B ratio (1:10.7) was recorded from Triazophos treatment followed by Thiamethoxam + Lambdacyhalothrin (1:10).

Keywords: Soybean, *Obereopsis brevis*, *Bemisia tabaci*, triazophos, thiacloprid, chlorantraniliprole

Introduction
Soybean [*Glycine max* (L.) Merrill] has established its recognition as both a pulse and an oilseed crop and ranks third among oilseed crops grown in India. Nationally it occupies an area of 110.65 lakh ha and its production is 69.29lakh MT. Madhya Pradesh ranks first in soybean production in India. Area and production of soybean in Madhya Pradesh are 56.12 lakh ha and 34.12 lakh MT, respectively (Sopa, 2015) [18]. Soybean is mostly grown for oil (20%) and protein (40%) around the world. (Chouhan *et al*, 2002) [2]. The crop is infested by more than 275 insect pests on different plant parts throughout its growth stage and about a dozen of them have been reported causing serious damage to soybean from sowing to harvesting (Ramesh Babu, 2010) [14]. The low productivity of soybean is attributed to abiotic and biotic stress like drought and insect pests attack. About 380 species of insects have been reported on soybean crop from many parts of the world. In India, soybean is reported to be attacked by 273 species of insects, 1 mite, 2 millipedes, 10 vertebrates and 1 snail (Singh, 1999) [16] and in India, 20 insect species have been recorded major pests infesting soybean crop (Singh and Singh, 1990) [17]. Girdle beetle, *Obereopsis brevis* (Swed.) (Coleoptera: Lamiidae) has been reported as a major stem borer pest in Madhya Pradesh, Rajasthan, Delhi, West Bengal, etc. The pest infestation ranged from 19.5% to 26.5% (Kumawat *et al*, 2010) [9]. The White fly, *Bemisia tabaci* adults are small, yellow bodied insects with white wings which are densely covered with a waxy powder. Pupae have marginal bristles. The white fly population ranged from 0.1 to 3.2 nymphs and adults per plant with seasonal mean of 2.15 flies (Ahirvar, 2013) [1]. Looking to the severity of damage and economic losses on soybean by major insect pests, development of resistance against pesticides in insects, and for giving satisfactory control of the pests, some new insecticides need to be tried for their efficacy against the insect pests, chemical insecticides are the best giving fast and effective results. Some insecticides are effective against sucking pest, some are against defoliators or stem borer. In order to control pest complex of both types, two kind of chemical required to be sprayed.

Materials and Methods

A field experiment was conducted at Entomology Instructional Farm, JNKVV-College of Agriculture, Rewa (M.P.) during *Kharif* 2017-18 on Soybean variety JS-20 29. Rewa district comes under the sub-tropical zone of the north-eastern part of Madhya Pradesh, which is situated at 24º 31' and 88 º 15' longitudes in the north and east respectively, with an altitude of 306.6 m above the mean sea level (MSL). The average rain fall in the region varies between 1050 to 1250 mm and the maximum and minimum temperature during *Kharif* season ranged between 34 to 38^{0}C and 23 to 24^{0}C respectively.

The experiment was laid out in Randomized Block Design with nine treatments including control having three replications. The treatments were Triazophos 40% EC @ 320 g ai/ha, Indoxacarb 15.8% EC @ 60 g ai/ha, Thiacloprid 21.7% SC @ 60 g ai/ha, Profenophos 50% EC @ 625 g ai/ha, Flubendiamide 39.35% SC @ 48 g ai/ha, Chlorantraniliprole 18.5% SC @ 30 g ai/ha , Betacyfluthrin 8.49%+ Imidacloprid 19.81% 300 OD @ 100 g ai/ha and Thiamethoxam 12.6%+ Lambda cyhalothrin 9.5% ZC @ 27 g ai/ha along with control. All agronomic practices were followed as per recommendations. The quantity of insecticide per plot was calculated on the basis of active ingredients and standard dose. Before the application of insecticides each plot was bunded separately, and then insecticides were applied at 15 day after interval. The spray of insecticides was applied as soon as the pest incidence is noted. Population of mentioned insect were counted before spray of insecticides and the population of insects larvae were counted one day, 3, 7 and 15 day after the treatment.

The data was analyzed as per the experimental design to test the significant of the treatment. Second spray of insecticide was done after 15 days of 1st treatment. Observations related to plant population and yields were also made. Population of white fly (*Bemisia tabaci* Gennadius) was recorded separately from five tagged plants randomly selected in each plot and observation for Girdle beetle (*Obereopsis brevis* Swed.) number of larvae/ring was counted in one meter row length (mrl) were counted one day before and 1,3,7 and 15 days after the treatments. The data obtained were subjected to analysis of variance (ANOVA) after suitable transformation to find out the critical difference between the treatments (Gomez and Gomez, 1984) [3]. Yield data was recorded and lastly economics and CBR were calculated for each treatment.

Results and Discussion

Efficacy of above mentioned eight insecticides were evaluated against White fly and Girdle beetle after one, three, seven & fifteen days of the insecticide spray (Table 1-6).

Girdle beetle (*Obereopsis brevis*)

The efficacy of eight insecticides namely i.e. Triazophos 40% EC, Indoxacarb 15.8% EC, Thiacloprid 21.7% SC, Profenophos 50% EC, Flubendiamide 39.35% SC, Chlorantraniliprole 18.5% SC, Betacyfluthrin 8.49%+ Imidacloprid 19.81% 300 OD and Thiamethoxam 12.6%+ Lambda cyhalothrin 9.5% ZC were evaluated after two spray done on 40 and 55 DAG against girdle beetle (Table 1 and 2). The observation was recorded after one day, 3, 7 & 15th day of the insecticide spray. All insecticides were found effective against the pest but variation in the degree of pest control was observed. The post treatment effect, after one day, indicated a significant reduction in the population of insect in the insecticide treated plot than untreated control. The average number of pest varied from 3.43 to 4.10 rings/mrl in insecticide treated plot as against (7.00 rings/mrl) of untreated control. A significance reduction in the pest population due to insecticide treatment was seen after 3rd and 7th day of the application with a record of 2.91 to 3.73 and 2.70 to 3.33 rings/mrl, respectively. However, the populations in untreated control consequently, were found at 7.14 and 7.21 rings/mrl. Among the insecticides, Triazophos @ 320 g a.i. /ha was found superior over the rest of the insecticides with a per cent reduction of 62% in pest population after 1st spray and 7th day after the insecticide application followed by Chlorantraniliprole @ 30 g a.i./ha (61%). However, after 15th day of insecticide application an increase in the pest population was again seen in all the treatment plots including check.

After second spray of insecticide, further reduction in girdle beetle population was seen in various treatments in comparison to untreated control. In the insecticide treated plots population of girdle beetle was observed between 2.56 to 3.80 rings/mrl as against 6.69 rings/plant in untreated control one day after the second spray. A significance influence of the insecticide was further seen after 3rd and 7th day of the treatment, with a record of 1.70 to 2.32 and 1.13 to 1.73 rings/mrl population, respectively. However, the respective population in untreated control was found at 6.33 and 6.73 rings/mrl. Among the insecticides, Triazophos @ 320 g a.i./ha was found superior over other insecticides with a record of 82% reduction in population followed by Chlorantraniliprole @ 30 g a,i./ha 81% after 7th day of spraying. Similar findings regarding Triazophos efficacy against Soybean were also reported by Jain and Sharma (2011) [4] and Reshma *et al.*, 2015 [15]. Trizophos 40% EC at 40-45 days after sowing to reducing the pest population of girdle beetle and most economic, Kumar and Pandey (2017) [7]. Kumar *et al*, (2010) [6] reported that Triazophos proved to be most effective against girdle beetle and stem fly and maximum grain yield was also obtained.

White fly (*Bemisia tabaci* Gennadius)

Evaluation of efficacy of above mentioned insecticides against white fly have indicated effectiveness of all insecticide over the untreated control (Table 2 and 4). The post treatment effect, after one day, indicated a significant reduction in the population of insect in the insecticide treated plot than untreated control. The average number of insects varied from 5.23 to 6.80 N&A /plant in insecticide treated plot as against 10.50 N&A /plant of untreated control. A significance influence of the insecticide was further seen after 3rd and 7th day of the treatment with an average population ranging from 1.94 to 3.60 and 01.55 to 3.28 N&A /plant, respectively as against respective population of 9.80 and 9.60 N&A /plant in untreated control. Thiacloprid @ 60 g a.i. /ha was found superior with a percent reduction of 83% in insect population after 7th day, followed by Triazophos @ 320 g a.i. /ha with a reduction of 82% percent. After 15th day of insecticide treatment a slight increase in the pest population was seen in all the insecticide treated plots and untreated control.

After second spray of insecticide, no doubt, further reduction in white fly population was observed in various treatments with a count of 3.77 to 4.60 N&A /plant in comparison to untreated control (8.13 N&A /plant). One day after the second spray, a significance reduction in the pest population was

further seen after 3rd and 7th day of the treatment. At this stage, the population varied between 1.83 to 3.60 and 1.28 to 2.21 N&A /plant respectively, as against of respective population of 6.03 and 4.57 N&A /plant in untreated control. Among the tested insecticides, Thiacloprid @ 60 g a.i. /ha was found superior over the rest of the insecticides with a percent reduction of 72% in insect's population after 7 days which was followed by Triazophos @ 320 g a.i. /ha with a reduction of 63%. Similar findings regarding Thiacloprid efficacy against white fly were also reported by Kujur (2011) [5], Patidar and Kumar (2018) [11] and Rajawat *et. al.,* (2017) [13]. Triazophos @ 320 g a.i. /ha as the most effective in reducing the population of white fly, Kushram *et al.,* (2017) [10]. Reshma *et al.,* (2015) [15]. Reported that Triazophos 40 EC were found to be significantly most effective in minimizing the cumulative average population of whitefly.

The results revealed that all insecticides were proved to be significantly effective in managing the major insect pests of soybean and obtained comparatively highest yield, net monetary return and CBR.

Effect on grain yield

The findings on the yield per plot (Table 5) shows a significant difference in yield among the treatments. The highest yield of 1313.0 kg/ha, was recorded in the plot treated with Triazophos @ 320 g a.i. /ha followed by Thiamethoxam 12.6%+ Lambda cyhalothrin @ 27 g a.i./ha (1286.0 kg/ha) as against the yield of 813 Kg/ha in untreated control.

The order of yield as influenced by insecticide was found in descending order Triazophos 320 g a.i./ha, > Thiamethoxam + Lambdacyhalothrin 27 g a.i./ha, > Chlorantraniliprole 30 g a.i./ha, > Thiacloprid 60 g a.i./ha, > Propenophos 625 g a.i./ha, > Indoxacarb 60 g a.i./ha, > Betacyfluthrin + Imidacloprid 125 g a.i./ha, > Flubendiamide 60 g a.i/ha.

An increase in yield due to insecticide treatment has reported by various scientist at national & global level. Patil and Phadv (2014) [12] found that significantly higher yield due to Triazophos 40 EC @ 800 ml/ha was found most superior in reducing the damage of girdle beetle and stem fly and gave the highest yield (2061 kg/ha). Kumar *et al.* (2019) [8] also recorded maximum yield (1960 kg/ha) with Triazophos 40 EC @ 750 ml/ha treated field.

Cost benefit ratio

The C:B ratio of various insecticide treatments was calculated and presented in Table 6, which divulge that maximum C:B ratio (1:10.7) was recorded from Triazophos treatment followed by Thiamethoxam + Lambda cyhalothrin (1:10). However, the minimum CB ratio was noted in the plot treated with Flubendiamide (1:2).

Table 1: Efficacy of new molecules of insecticides against Girdle beetle, *Obereopsis brevis* Swed. after first and second spray in Soybean, during *Kharif* 2017-18

Treatments	Treatment name	Population of Girdle beetle /mrl									
		First spray					Second spray				
		Before treatment	After Treatment				Before treatment	After Treatment			
			1DAT	3DAT	7DAT	15DAT		1 DAT		7 DAT	15DAT
T1	Triazophos 40% EC	6.46 (2.63)	3.43 (1.89)	2.91 (1.84)	2.70 (1.78)	4.03 (2.11)	4.71 (2.26)	2.56 (1.74)	1.70 (1.43)	1.13 (1.20)	1.11 (1.26)
T2	Indoxacarb 15.8% EC	6.41 (2.62)	3.93 (2.10)	3.40 (1.97)	2.93 (1.85)	4.63 (2.25)	5.01 (2.34)	3.33 (1.95)	2.10 (1.60)	1.51 (1.35)	1.33 (1.33)
T3	Chlorantraniliprole 18.5% SC	7.42 (2.81)	3.58 (2.01)	3.02 (1.87)	2.74 (1.79)	4.10 (2.11)	4.63 (2.25)	2.59 (1.73)	1.84 (1.49)	1.26 (1.28)	1.22 (1.31)
T4	Profenophos 50% EC	6.50 (2.64)	3.70 (2.04)	3.35 (1.96)	2.93 (1.85)	4.60 (2.24)	4.93 (2.30)	3.13 (1.90)	2.00 (1.53)	1.46 (1.32)	1.29 (1.32)
T5	Thiacloprid 21.7% SC	7.25 (2.87)	4.03 (2.11)	3.69 (2.04)	3.27 (1.94)	4.73 (2.25)	5.10 (2.38)	3.53 (1.99)	2.28 (1.61)	1.73 (1.46)	1.66 (1.44)
T6	Flubendiamide 39.35% SC	6.51 (2.64)	3.96 (2.11)	3.53 (2.00)	2.94 (1.85)	4.71 (2.26)	5.12 (2.36)	3.40 (1.97)	2.14 (1.60)	1.54 (1.41)	1.44 (1.38)
T7	Betacyfluthrin 8.49% + Imidacloprid 19.81% 300 OD	6.86 (2.70)	4.10 (2.11)	3.73 (2.05)	3.33 (1.95)	4.83 (2.30)	5.34 (2.40)	3.80 (2.07)	2.32 (1.64)	1.73 (1.43)	1.88 (1.52)
T8	Thiamethoxam 12.6% +Lambda cyhalothrin 9.5% ZC	6.64 (2.67)	3.60 (2.02)	3.18 (1.91)	2.80 (1.81)	4.11 (2.20)	4.83 (2.30)	2.86 (1.83)	1.94 (1.55)	1.33 (1.34)	1.25 (1.30)
T9	Untreated (Control)	7.30 (2.79)	7.00 (2.73)	7.14 (2.76)	7.21 (2.77)	7.25 (2.77)	7.17 (2.76)	6.69 (2.68)	6.33 (2.61)	6.73 (2.68)	6.92 (2.72)
	SEm±	0.141	0.165	0.080	0.075	0.234	0.188	0.160	0.223	0.191	0.192
	CD at 5%	NS	0.360	0.174	0.163	0.509	NS	0.350	0.486	0.417	0.418

* Figure in parenthesis are square root transformed values $\sqrt{X+0.5}$

DAT = Day after treatment, NS = Non Significant

Table 2: Efficacy of new molecules of insecticides against White fly, *Bemisia tabaci* Gennadius after first and second spray in Soybean, during *Kharif* 2016-17

Treatments	Treatment name	Population of white flies /five leaves/plant									
		First spray					Second spray				
		Before treatment	After Treatment				Before treatment	After Treatment			
			1 DAT	3 DAT	7 DAT	15 DAT		1 DAT	3 DAT	7 DAT	15 DAT
T1	Triazophos 40% EC	12.37 (3.58)	5.53 (2.45)	1.96 (1.86)	1.59 (1.75)	3.68 (2.03)	7.47 (2.82)	3.98 (2.11)	2.07 (1.60)	1.62 (1.45)	0.72 (1.08)
T2	Indoxacarb 15.8% EC	11.20 (3.41)	6.60 (2.66)	3.59 (2.02)	2.92 (1.84)	4.93 (2.32)	8.37 (2.97)	4.45 (2.22)	2.83 (1.82)	2.18 (1.63)	1.53 (1.42)

T3	Chlorantraniliprole 18.5% SC	11.36 (3.44)	6.23 (2.59)	3.28 (1.93)	2.73 (1.79)	4.00 (2.12)	7.75 (2.87)	4.37 (2.20)	2.32 (1.67)	1.94 (1.56)	1.25 (1.32)
T4	Profenophos 50% EC	11.67 (3.48)	6.56 (2.65)	3.48 (1.99)	2.78 (1.81)	4.63 (2.26)	7.97 (2.91)	4.42 (2.21)	2.58 (1.75)	2.00 (1.58)	1.41 (1.38)
T5	Thiacloprid 21.7% SC	12.51 (3.60)	5.23 (2.39)	1.94 (1.85)	1.55 (1.74)	3.62 (2.02)	7.32 (2.79)	3.77 (2.06)	1.83 (1.51)	1.28 (1.32)	0.64 (1.06)
T6	Flubendiamide 39.35% SC	11.26 (3.43)	6.80 (2.70)	3.60 (2.02)	3.28 (1.94)	5.76 (2.50)	8.45 (2.99)	4.60 (2.25)	3.60 (2.02)	2.21 (1.64)	1.66 (1.46)
T7	Betacyfluthrin 8.49% + Imidacloprid 19.81% 300 OD	11.98 (3.52)	5.90 (2.52)	3.14 (1.90)	2.62 (3.08)	3.86 (2.08)	7.71 (2.86)	4.18 (2.16)	2.16 (1.60)	1.86 (1.53)	0.97 (1.21)
T8	Thiamethoxam 12.6% +Lambda cyhalothrin 9.5% ZC	11.45 (3.44)	5.73 (2.49)	2.88 (1.83)	2.36 (1.69)	3.31 (1.95)	7.51 (2.83)	4.14 (2.15)	2.16 (1.62)	1.69 (1.42)	0.86 (1.15)
T9	Untreated (Control)	11.40 (3.44)	10.50 (3.31)	9.80 (3.21)	9.60 (3.17)	9.94 (3.23)	9.10 (3.08)	8.13 (2.93)	6.03 (2.55)	4.57 (2.25)	4.00 (2.12)
	SEm±	0.167	0.070	0.130	0.107	0.092	0.097	0.086	0.109	0.081	0.096
	CD at 5%	NS	0.152	0.283	0.232	0.201	NS	0.188	0.238	0.175	0.208

* Figure in parenthesis are square root transformed values $\sqrt{X + 0.5}$
DAT = Day after treatment, NS = Non Significant

Table 3: Percentage of population reduction of Girdle beetle, *Obereopsis brevis* Swed. after spray of insecticide

Treatments	Insecticides	Dosage g a.i./ha	First spray		Second spray	
			7 DAT	15 DAT	7 DAT	15 DAT
T_1	Triazophos 40% EC	320	62	44	82	84
T_2	Indoxacarb 15.8% EC	60	59	36	77	80
T_3	Chlorantraniliprole 18.5% SC	30	61	44	81	82
T_4	Profenophos 50% EC	625	59	36	78	81
T_5	Thiacloprid 21.7% SC	60	54	34	74	76
T_6	Flubendiamide 39.35% SC	60	59	35	77	79
T_7	Betacyfluthrin 8.49% + Imidacloprid 19.81% 300 OD	100	53	33	74	72
T_8	Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC	27	61	43	80	81
T_9	Untreated (Control)		-	-		

Table 4: Ppercentage of Population reduction of White fly, *Bemisia tabaci* Gennadius after spray of insecticide

Treatments	Insecticides	Dosage g a.i./ha	First spray		Second spray	
			7 DAT	15 DAT	7 DAT	15 DAT
T_1	Triazophos 40% EC	320	83	62	64	82
T_2	Indoxacarb 15.8% EC	60	69	50	56	64
T_3	Chlorantraniliprole 18.5% SC	30	71	59	57	68
T_4	Profenophos 50% EC	625	71	53	52	61
T_5	Thiacloprid 21.7% SC	60	83	63	72	84
T_6	Flubendiamide 39.35% SC	60	65	42	51	58
T_7	Betacyfluthrin 8.49% + Imidacloprid 19.81% 300 OD	100	72	61	59	75
T_8	Thiamethoxam 12.6% +Lambda cyhalothrin 9.5% ZC	27	75	66	63	78
T_9	Untreated (Control)		-	-		

Table 5: Effect of insecticides on Yield of Soybean, *Kharif* 2017-18

S. No.	Treatments	Dosage ml or g/ha	Dosage g a.i./ha	Yield (Kg/plot)	Average Yield (Kg/ha)	Additional yield over control (Kg/ha)	%Yield increased
1.	Triazophos 40% EC	800 ml/ha	320	1.96	1313.0	500.0	61.0
2.	Indoxacarb 15.8% EC	333 ml/ha	60	1.75	1173.0	360.0	44.0
3.	Chlorantraniliprole 18.5% SC	160 ml/ha	30	1.87	1253.0	440.0	54.0
4.	Profenophos 50% EC	1250 ml/ha	625	1.78	1190.0	377.0	46.0
5.	Thiacloprid 21.7% SC	650 ml/ha	60	1.81	1210.0	397.0	48.0
6.	Flubendiamide 39.35% SC	150 ml/ha	60	1.74	1162.0	349.0	42.0
7.	Betacyfluthrin 8.49% + Imidacloprid 19.81% 300 OD	350 ml/ha	125	1.72	1149.0	336.0	41.0
8.	Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC	125 ml/ha	27	1.92	1286.0	473.0	58.0
9.	Untreated (Control)		-	1.21	813.0	0.00	0.00
	SEm±			0.027			
	CD at 5%			0.060			

Table 6: Effect of different insecticide treatment on the economics of the crop

S. No.	Treatments	Dosage ml or g/ha	Average Yield (Kg/ha)	Additional yield over control (Kg/ha)	Gross monetary return due to treatment (Rs./ha)	Protection cost for 2 spray (Rs. /ha)	Net return due to treatments (Rs. /ha)	C: B ratio
1.	Triazophos 40% EC	320	1313.0	500.0	15250	1420	13830	1:10
2.	Indoxacarb 15.8% EC	60	1173.0	360.0	10980	2165	8815	1:5
3.	Chlorantraniliprole 18.5% SC	30	1253.0	440.0	13420	5020	8400	1:2.6
4.	Profenophos 50% EC	625	1190.0	377.0	11498	3350	8148	1:3.4
5.	Thiacloprid 21.7% SC	60	1210.0	397.0	12108	3820	8200	1:3
6.	Flubendiamide 39.35% SC	60	1162.0	349.0	10644	5740	4904	1:2
7.	Betacyfluthrin 8.49% + Imidacloprid 19.81% 300 OD	125	1149.0	336.0	10248	2590	7658	1:4
8.	Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC	27	1286.0	473.0	14226	1400	12826	1:10
9.	Untreated (Control)	-	813.0	0.00				
	SEm±		0.027					
	CD at 5%		0.060					

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