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Biological efficacy trial of several active substances against broadleaf weed herbicides Wheat: case of *Veronica* species in soft wheat fields (*Triticum aestivum* L.)

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Abstract

In Algeria, cereal crops are seriously rivaled by weeds, thus limiting production and yield. The continuous use of some herbicides has often resulted in the elimination of some species, in contrast to other species, *Veronica spp*., were strongly adapted to these chemical molecules. Becoming a real pest problem to solve, this has been the objective of this work. Recognizing this, the present study examined the determination of optimal doses and dates of two herbicides namely Tribenuron-Methyl (Granstar) and Triasulfuron + Dicamba (Zoom) effective for the control of speedwell in fields soft wheat variety El-Wifak, trial conducted at the Experimental Station of Sétif ITGC. The results showed a clear dominance *Veronica spp.* (*Veronica herbifolia, Veronica persica*) compared to other weeds encountered in the plot namely: *Fumaria officinalis*, *Fumaria densiflora*, *Gallium aparine*, *Papaver rhoeas*, *Diplotapsis muralis, Saponaria vaccaria*, *Polygonum aviculaire*. Using the Zoom at a dose of 150g/ha at 2-4 leaf of *Veronica spp*. showed significant efficacy in their control compared to other doses of the same herbicide (120g/ha and 180g/ha) and also regarding to the most herbicide (Granstar) used in the region at the doses of 12.5g/ha and 18 g/ha. This resulted in a gain of 12.94q/ ha grain yield compared to non-weeded plots and 5.51q/ha compared to the average of the control.

Mots clés :

Zoom, Granstar, doses, dates, mauvaises herbes, blé, efficacité.

Résumé

En Algérie, les cultures céréalières sont sérieusement concurrencées par les mauvaises herbes, limitant ainsi la production et le rendement. L'utilisation en continu de certains herbicides a conduit à l'élimination de certaines espèces de mauvaises herbes, mais d'autres espèces, le cas des *Veronica spp*., ont pu échappées avec le temps à été ces molécules chimiques. Elles sont devenues un véritable fléau agricole à résoudre dans la région de Sétif. La recherche de moyens efficaces de s'en débarrasser constitue justement l'objectif de ce travail. La présente étude vise à déterminer les doses et les dates de deux herbicides savoir Tribénuron-méthyle (Granstar) et Triasulfuron + dicamba (Zoom) optimales et efficaces pour le contrôle des véroniques dans une culture de blé tendre variété El-Wifak, conduite au niveau de la Station expérimentale de l'ITGC-Sétif. L'inventaire des mauvaises herbes montre la nette domination des véroniques (*Veronica herbifolia* et *Veronica persica*) comparativement aux autres espèces rencontrées à savoir: *Fumaria officinalis*, *Fumaria densiflora*, *Gallium aparine*, *Papaver rhoeas*, *Diplotapsis muralis, Saponaria vaccaria*, *Polygonum aviculaire*. L'utilisation du Zoom à la dose de 150g/ha au stade 2-4 feuilles des Veronica spp. a montré une efficacité significative dans l'élimination des véroniques par rapport aux autres doses du même herbicide (120g/ha et 180g/ha), et par apport à l'herbicide le plus

utilisé dans la région à savoir le (Granstar) appliqué aux doses de 12,5g/ha et 18g/Ha. Il en est résulté un gain de rendement en grain 12,94q/ha par rapport aux parcelles non désherbées et 5,51q/ha par rapport à la moyenne de l'essai.

Introduction

Cereals are the staple food in many countries of the world; they are a major global economic importance. In Algeria, the cereals sector is one of the main sectors of agricultural production (Djermoun, 2009). Despite the commitment of the country, cereal production is still very low compared to the needs on the basis of the last decade (1995-2005) represents an average of 24 million quintals a rate that hovers around 30% of needs.

Cereals in semiarid areas suffer from several agro-climatic and technical constraints: uncontrolled technical itinerary, use of non performance plant material, few realized fertilization, and to this are added phytosanitary problems more precisely: the invasion of the fields by weeds. They are often recognised as a major constraint for crop production (Milberg and Hallgren 2004) because they use part of the resources that are essential for crop growth. The weeds exert direct harmfulness which results in yield loss attributed to several factors: competition for water resources, competition for mineral resources and decrease in photosynthetic activity (Koocheki et al., 2009). They lead to higher economical losses when compared to other pests, such as insects or fungi (Oerke and Dehne 2004). The crop rotation, which alters the composition of weed communities and influences their density, helps stabilize agricultural crop and weed communities (Barbery, 2002). Therefore, weed control is considered as one of the crucial requisites for a successful production (Gerowitt 2003). A late elimination of weeds in the case of their occurrence earlier in autumn or spring can reduce yield by more than 20% (Markovitc et al., 2005). However, the generalised and continuous application of herbicides is being seriously questioned because it has prompted the appearance of herbicide resistance (Heap 2010) and the extension of the potential negative side effects on the environment (Boutin et al. 2004). Moreover, the use of herbicides has been identified as one of the main drivers of the current weed diversity decline in agroecosystems (Marshall et al. 2003).

In Algeria, cereal chemical weeding is not developed. Chemically weeded area each year is less 100000 ha or less than 3% of the cultivated area (Fenni, 2003). As such for the Setif region has about 4065 ha weeded 2001-2005, representing 2.75% of the cultivated area. In Algeria, Veronica began to grow following the almost unique use of the herbicide Granstar appointed at a dose of 12.5 g/ha. Several farmers in the Setif region complained of the multiplication of veronica species in plots planted by the durum and soft wheat. The lack of information and data on the real impact of the presence of Veronica species and the competition that they may exercise to cultivated plants led us to examine closely what pest problem. The aim of the research conducted in the Technical Institute for field crops-Sétif, Algeria, was to determine the optimal dates and rates of two herbicides Zoom and Granstar for weed control particularly Veronica species in wheat crop. And also, we will try to see the real competition from Veronica on wheat crop.

2. Materials and methods

2.1. Presentation of the experimental site

The experiment was conducted during the 2013/2014 crop year at the Agricultural Experiment Station of ITGC - Setif. The site is located at an altitude of 1080 m, at latitude 36° 9' N and longitude 5° 21' E. The soil of the experimental plot is silty clay texture, total calcium content exceeds 35%, The pH is basic and organic matter content of the worked horizon is low (Chennafi et al. 2008).

2.2. Climatic characteristics of the study site

According to meteorological data, the accumulated rainfall during the period surrounding the cycle of wheat from September to June amounted to 322 mm. The site has received less rain 4.84% compared to the average for the period 2000- 2013. Regarding the temperature, the distribution of the thermal regime during the 2013-2014 year compared to 2000-2013 period average, it shows no significant difference (ONM Setif, 2014).

2.3. Implementation of the test

Experiment was performed on the cultivation of soft wheat (*Triticum aestivum* L.) variety El-Wifak (G2), having chemical fallow as precedent crop. This variety is selected outcome of plant material from the CIMMYT centre.

Tillage was operated on 28/02/2013 and 10/30/2013 by using a cover-crop 16/32. The mono-ammonium phosphate (MAP) was applied for 80kg/ha on 11.10.2013 as background fertilizer. And Urea (46% nitrogen) was introduced after sowing dated 02.18.2014 dose 80kg/ha. Sowing was completed on 11/24/2013 with a grain seeder (Tarup) on elementary plots with a spacing of 18cm between the crop rows and a density of 130kg/ha. Emergence was noted 12.09.2014 and 09.06.2014 trial was harvested manually.

2.3.1. Herbicides and doses tested

Two herbicides were applied: Granstar (Tribenuron methyl) and Zoom (Triasulfron + Dicamba).

a. Granstar (Tribenuron methyl)

It is a selective herbicide for the control of catching up against broadleaf weeds in cereals. The active ingredient is Tribenuron-methyl is an herbicide that is rapidly absorbed by the leaves mainly, but also by the roots of plants. It inhibits acetate acetol the synthesizing enzyme indirectly causing arrest of cell division. On sensitive weeds, discoloration and necrosis appear then (Syngenta, 2014).

b. Zoom (Triasulfron + Dicamba)

It is a selective herbicide, with high efficiency and with a broad spectrum of activity against even the toughest broadleaf weeds (Veronicas, returned to idle and bindweed). Zoom is the combination of two systemic active substances, compounds of 4.1% Triasulfron and 65.9% of Dicamba (Syngenta, 2014).

2.3.2. Experimental design

The adopted experimental design is a randomized complete block with four replications. The elementary plots with an area of 7.5 m^2 (5m x 1.5m) are treated at different doses of herbicides: Zoom (120,150 and 180 g/ha); Granstar (12.5 and 18 g/ha). Herbicides were applied at 2 to 3 leaves Veronica spp. stage, on the date of 16/02/2014. The elementary plots are as follows:

- TNT: untreated plot and not weeded.
- TW: plot manually weeded: all weeds are removed from sowing to harvest.
- TV: Plot only infested with Veronica. Other weeds are removed manually and continuously
- T1: plot treated with Zoom at the dose of 120 g/ha
- T2: plot treated with Zoom at the dose of 150 g/ha
- T3: plot treated Zoom at the dose of 180 g/ha
- T4: plot treated with Granstar at a dose of 12.5 g/ha
- T5: plot treated with Granstar at a dose of 18 g/ha.

2.4. Conduct of the experiment

Numbers of broadleaf weeds and Veronica species were counted on 1m^2 at each plot before the application of herbicides followed by hand weeding of TW and TV plots done on 09/02/2014. At the date of 16/02/2014 we performed chemical weed control according the experimental protocol. Weed counts were performed on plots treated chemically to the 3rd, 6th and 9th week after treatment corresponding to the dates of 03.10.2014, 30.03.2014 and on 20.04.2014 respectively. At the latter date it has weighed the weight speedwell (g/m2).

The effectiveness of each treatment was estimated by comparison with the untreated control and applying the following rating scale: 1 = 0-15% killing; 2 = 16-35% killing; 3 = 36-65% killing; 4 = 66-85% killing; 5 = 86 to 100% destruction.

2.5. Statistical analysis of the data

The results were treated statistically using SPSS 18 software to compare means. Tukey's test was also calculated to determine the statistical significance of differences at 5%.

3. Results and Discussion

3.1. Study of the weed flora

The identification of the weed flora present at the experimental site was performed based on several botanical guides and thesis (Fenni, 2003). This identification was made on four lines (5m each) chosen randomly. We identified eight weed species at the experimental site (Figure 1). Species encountered are: *Veronica herbifolia* L., *Veronica persica* P. *Fumaria officinalis* L. *Fumaria densiflora* L., *Gallium aparine* L., *Papaver rhoeas* L., *Diplotapsis muralis* L. *Saponaria vaccaria* L. *Polygonum avicularium*, L.

Among the species found we see a clear dominance of Veronica spp. They represent 68% of all species encountered. They are followed by knotweed *Polygonum avicularium* with 23% of the overall density of the weed flora. All weed species encountered are winter annuals germinate. They wear their growth cycle parallel to the life cycle of wheat (Figure 1).

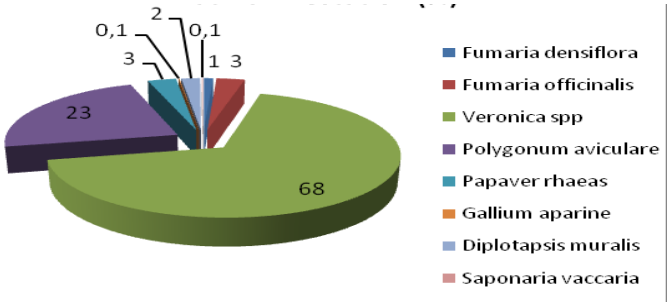

Figure 1: infestation rate in% by weeds encountered before applying herbicides.

3.2. Veronica Species met

We identified two species of Veronica, belonging to the family *Scrophulariaceae,* distinguished by different botanical characteristics. Persian speedwell (*Veronica persica*), which has an annual germination, while the ivy-leaved speedwell (*Veronica herbifolia*) has preferentially autumn-winter germination (Fenni, 2003).

3.3. Density of veronica and weeds before weeding

As noted earlier, Veronicas have a significant dominance, confirmed by an average of 107 plt/m^2 compared to the density of other weeds which have 80 plt/m^2 as average (Figure 2). This far exceeds the damage threshold of Veronica, which is between 50-60 plts/m² and can thus lead to a reduction of 5% yield (Arvalis 2010).

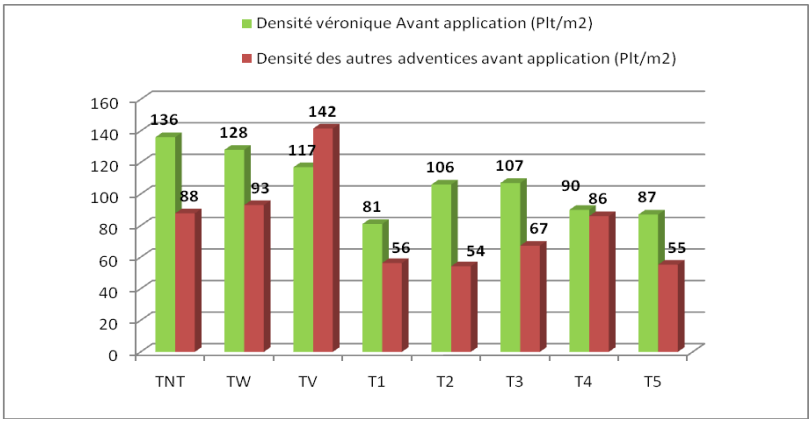

Figure 2: Veronica species and weeds (Plt/m^2) encountered before the herbicides application.

3.4. Weed biomass

The control of wet weight and dry weight of weeds is a key operation for mastering and conservation of the water reserve, especially in our semi-arid bioclimatic regions, where water is usually a determining factor in the evolutionary cycle crop. From the results, we find that Veronica is significant competition for water consumption; and represent approximately 60% of the amount of water absorbed by comparison to other weeds (Figure 3). Ahmad *et al*. (1982) estimated that synthesizing a gram of dry matter, a weed needs on average 2 times more water than a crop (6.57g against 3.20g).

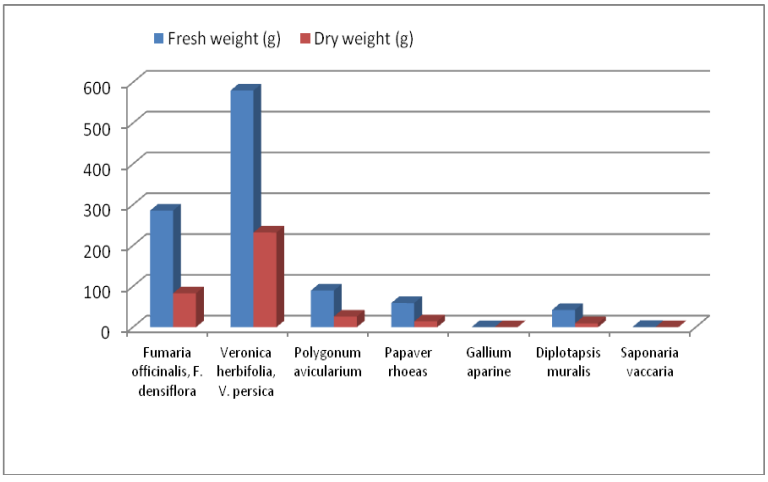

Figure 3: The fresh and dry weight expressed as weight (g) of weeds encountered.

3.5. Efficiency of Zoom on Veronica species

We note without any herbicide treatment at designated elementary plots (TNT and TV), the density of Veronica spp. has diminished with time. In non-weeded plots (TNT), there were 116plt/m^2 at the third week after treatment, the number increased to 99 and arrived at 38plt/m^2 for the sixth and ninth week respectively. While at the TV plots, we found 89plts/m^2 at the third week, and reached 61plts/m^2 and 29plts/m^2, at the sixth and ninth week after treatment, respectively. This can be explained by the normal senescence of Veronica species.

At plots weeded chemically by Zoom was ineffective in T1 level at the dose of 120g/ha 6 weeks after application because the number of Veronica was almost unchanged after the third and sixth week with a density 61 and 63plt /m^2, respectively. Against at T2, the application of Zoom (150 g/ha) showed a highly significant efficiency display decreased from 92 to 44.5plt/m^2 at the 3rd and 6th week respectively after application. This meaning was confirmed by Tukey's test (ANOVA). With a lesser degree for T3 or Zoom was used at a dose of 180g/ha, we only see a decrease of 10plt/m^2 from 97 to 87plt/m^2 for the sixth and the ninth week, respectively. Considering the dose of 120g/ha recommended by the pest company seller, proved ineffective, our results partially explain the high levels of infestation by Veronica observed everywhere in plots planted in Setif region.

3.6. Effectiveness of Granstar on Veronica species

Results also show that at TNT plots where no herbicides were used, speedwell density decrease slightly at 17plt/m^2, which can be explained by the ending of the cycle development. When we use Granstar at the rate of 12.5g/ha, T4 showed moderately significant results with a decrease of 25plt/m^2 after 6 weeks of herbicide application, by cons for the T5 when using Granstar at 18g/ha showed efficacy and satisfactory results with lower of 29plts/m^2. This meaning was confirmed by Tukey's test.

The dose of 12.5 g/ha of Granstar recommended by phytosanitary firm is low efficient compared to the dose of 18 g/ha tested, which is only able to control the high levels of veronicas infestation observed in the Setif region.

3.7. Comparison of the most effective herbicides tested doses

The comparison of the most effective doses against the veronicas for both herbicides Granstar (18g/ha) and Zoom (150g/ha), we can conclude that the application of Zoom is better than Granstar, when it eliminated 18 plants/m^2 more (Table 1). Zoom in dose of 150 g/ha can be an ideal solution against the toughest broadleaf weeds. To this end, the choice of herbicide by farmers would be based primarily on the economic cost of the operation of weeding.

Table 1: Density of speedwell (Pl/m^2) after applying the Zoom Granstar

Period	3rd week		6th week		9th week	
Treatement	**Zoom**	**Granstar**	**Zoom**	**Granstar**	**Zoom**	**Granstar**
TNT	116	/	99	/	38	/
TW	0	/	0	/	0	/
TV	89	/	61	/	29	/
T1	61	/	63,5	/	26	/
T2	92	/	44,5	/	30	/
T 3	97	/	87	/	28	
T4	/	82	/	57	/	37
T5	/	86	/	57	/	32

3.8 Zoom effect on stages speedwell:

The notations made after three weeks of herbicide treatment shows that the two-leaf stage speedwell proved to be the most sensitive stage against herbicide Zoom action. Indeed, we recorded a decrease in the density of the 2-leaf speedwell (T1) higher compared to the average to the other stages. We noted an average of 125 plants/m² speedwell the two-leaf stage before application of the herbicide, to reach an average equal to 96 plants/m² after treatment. When applying the Zoom to 4 leaf stage (T2), we observed an average equal to 98 plants/m² increased to 86 plants/m² after applying the herbicide. As for treatment at the stage of branching (T3), we identified the presence of 97 plants/m² before treatment and we got to 80 plants/m² after applying ² (Table 2). Statistically, the three stages of treatment have proven to be significant, however the application of the Zoom flowering proved insignificant then we noticed an average of 126 plants/m^2 before treatment and we got to 120 plants/m² after treatment, a difference of only 6 plants/m^2. In conclusion, we can advance only from the two-leaf stage until early branching, the veronicas proved sensitive Zoom used at a dose of 180g/ha.

Table 2: Zoom Effect on speedwell density according to the different stages of development.

Treatement	Densité véronique (plante /m²)			
	Before application	3rd week	6th week	9th week
TNT	126 b	134 b	102 c	49 b
TW	0 a	0 a	0 a	0 a
TV	117 b	89 b	61 b	29 b
T1	125 b	96 b	57 b	22 b
T2	98 b	86 b	68 b	30 b
T3	97 b	80,75 b	69 b c	27 b
T4	126 b	120 b	80 b c	33 b
Average	98,43	86,54	62,43	26,86

3.9. Behaviour of crops to weed's infestation

3.9.1. Impact of Veronicas on cereal culture

The results of plots weeded manually (TW) shows greater number of spike/m^2 (264) compared to other plots, this confirms that the veronicas have significant competition in the cultivation of wheat soft. At plots weeded chemically and despite competition from veronica, the use of Granstar at 18g/ha and Zoom at 150g/ha gave acceptable results where we obtained 225spikes/m^2 and 220 ears/m^2, respectively, with a loss of 275tillers/m^2 for the T5 and 291tillers/m^2 for T2. These results lead us to conclude that the gain is 26tillers/m^2 between TNT and T5 (Figure 4).

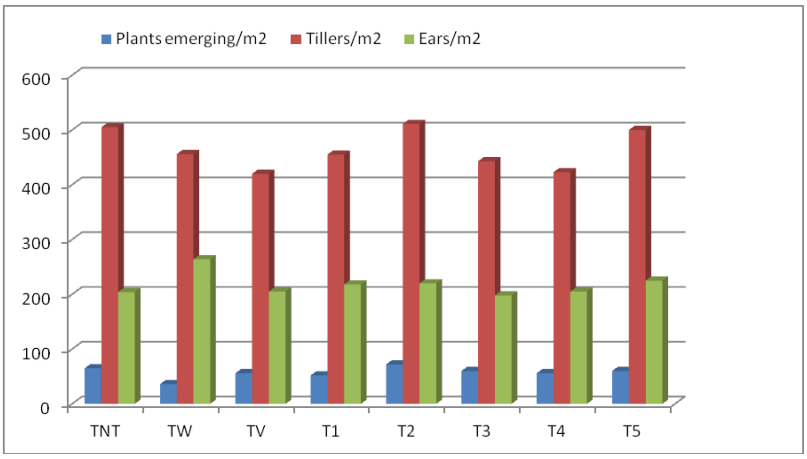

Figure 4: Impact of Veronica species on the number of plants, tillers and ears/m^2.

3.9.2. Study of the yield components

3.9.2.1. The number of ears/m^2

Untreated plots (TNT and TV) had 204 and 205ears/m^2, respectively. This is well below the average of the test which is 217ears/m^2. While plots chemically weeded reveals that the treated plots (T5) with Granstar at 18 g/ha, the number of ears/m^2 is equal to 225 ears/m^2 well above the average test. With a lesser extent T2 or Zoom was used at 150g/ha, the number of ears/m^2 is 220. We obtain a gain of 21ears/m^2 compared to the non weeded control and the treated plot with Granstar at 18g/ha.

3.9.2.2. The number of grains/ear

For this component, in non-weeded plots (TNT), we see a small number of grains/ear at 36grains/ear. While it is equal to 45grains/spike at T2 Zoom treated at 150 g/ha. This is higher than the test average (4grains/ear) and a gain of 9grains/ear relative to TNT.

3.9.2.3. Weight thousand grains (WTG)

Based on our findings, we see that for both treatments T2 Zoom at 150g/ha and T3 at 180g/ha we had a PMG 43.5 and 45.85g respectively upper than average test which is equal to 42.78g.

3.9.2.4. Grain yield

As we can see, plots treated with Zoom at 150g/ha (T2), the yield was equal to 43.66q/ha, that's mean 5q/ha more than the yield average experiment equal to 38.15q/ha. However non-weeded plots (TNT), gave a performance of 30,72q/ha. So, we can deduce that using Zoom at 150g/ha gives a gain of 12.94q/ha compared to the control (TNT) (figure 5).

3.10. Economic gain

The comparison of wheat yields when dealing with the zoom at the registered rate of 120g/ha and a dose of 150g/ha which proved best during the experiment are 37.23 and 43.66q/ha, respectively. A surplus of 30g/ha of Zoom resulting in an efficiency gain of 6,43q/ha. And considering the purchase price of the Zoom and wheat, a net gain of 28,485DA/ha goes to the treasury of the farmer.

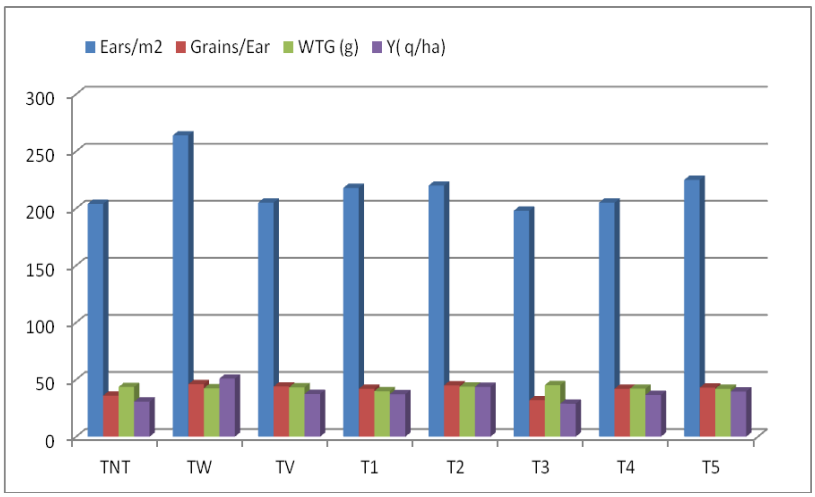

Figure 5: The yield and its components of the culture of wheat.

Conclusion

Weeds infestation shows a low diversified flora; only eight (08) species have been identified. Among the species found, we saw the clear dominance of Veronica species with 68% density of the weed flora. This dominance is significant competition in water consumption of material and about 60% of the total amount of water absorbed by the weeds. This delicate problem to be controlled, involves the introduction of chemical control that allows crops to optimize soil water reserves.

The results show that using the Zoom at 150g/ha gave satisfactory results in decreasing the density of Veronicas from 92 to 44.5plt/m^2 at the third and sixth week respectively after application. We also found that application of the Zoom at 150g/ha gave a gain of 12.94q/ha compared to non-weeded control and 5.51t/ha compared to the average of the experiment. The quantitative gain of 6,43q/ha when we use Zoom at 150 g/ha was estimated equal to 28485DA/ha as gain regarding the yield obtained by using recommended dose of 120g/ha by the commercial firm.

Particular attention should be go to the choice of herbicide, the continuous use of the same herbicides can cause in most cases more than it solves problems: the proliferation of speedwell in our fields is the most obvious example.

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