Effect of Weed Treatment on Cereal Yield in Direct Seeding: A Challenge Between Soil Pollution and Seeds Quality

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ABSTRACT
The study was conducted at Technical Institute of Cereals (ITGC- Setif) during the years 2014-2018 for understanding the effect of weed treatment in direct seeding on cereal yield, soil and seeds quality. Two horizons were considered: horizon one (0-20 cm) and horizon two (20-40 cm) and four herbicide doses were applied: D₁ = 1080 g ha⁻¹, D₂ = 900 g ha⁻¹, D₃ = 720 g ha⁻¹ and D₄ = 540 g ha⁻¹. The yield results depended on the herbicide doses applied before seeding. The highest yield responded to the highest dose of herbicide applied (1080 g ha⁻¹). Study indicated that glyphosate reached soil during weed treatment and transferred in deep soil layer and to harvested seeds. Half-live values (DT₅₀) of glyphosate found under field conditions were high.

Key words: Direct seeding, Glyphosate, Seeds, Soil, Transfer, Yield.

INTRODUCTION
Food security was synonymous with the supply of high-calorie staples such as cereals and tubers to resolve problems of protein-energy malnutrition (Sage 2019). During the first decade of the twenty-first century, cereal prices rose to their highest levels in real terms since the early 1970s, reaching a peak in 2008. In Algeria, wheat durum represents 46% of grain crops (Benbelkacem and Kellou 2000). Moreover, the peak of cereal imports reached 7.4 million tons in 2011 and 6.9 million tons in 2012 (Touchan et al. 2016). The adoption of conservation agriculture worldwide as a sustainable cultivation system is a challenge to increase productivity (Hobbs et al. 2008). Sustainable agriculture involves optimizing agricultural resources and at the same time maintaining the quality of environment and sustaining natural resources (Kumari Aruna et al. 2018). In India, direct seeding played a greater role to improve rice yield (Kumari et al. 2017). It is considered as common practice before green revolution due to its potential to save water and labour (Gupta et al. 2006). In the other hand, 85% of the Brazilian soybean crop area was cultivated with no-tillage system to the expansion of soybean cultivation and for food security (Bohm et al. 2014). However, a rhythm of direct seeding adoption in Algeria is still very slow.

According to Rouabhi et al. (2018), no adoption of direct seeding is linked to technical and agronomic constraint as weeds control and proliferation of bromus. sp. Indeed, in the less developed areas of the world, the need for substantial increase in agricultural production is an urgent problem. On the other hand, direct seeding needs the use of agrochemical, so the increase in agrochemical use can be foreseen (Kumari Aruna et al. 2018). In direct seeding, the use of herbicides as “glyphosate” is the active matter; it will be imperative operation during first years of system adoption (Labad and Hartani 2016).

In the other ways, it was found that the use of glyphosate promoted high residual levels in soil and seeds...
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RESULTS AND DISCUSSION

Barley yield variation

According to our results, the yield recorded in S3 is more important than S2 (Fig 2). Hence, the yield values depend on the herbicide doses applied before seeding for weed treatment. Raunet et al. (1998) found that the use of herbicides in direct seeding involves weed control, especially before crops seeding and at the beginning of its cycle. Under control soil sample and the lowest dose applied (D4 = 540 g ha⁻¹), a significant decrease in yield was recorded (p<0.05). Soil was affected by weed development. Singh et al. (2014) were reported that weeds are a serious constraint to the productivity causing 100 per cent yield loss under uncontrolled conditions. On the other hand, the highest yield responses to the highest dose of herbicide applied (1080 g ha⁻¹) during S2 and S3. The average yield obtained during two crops seasons (S2 and S3) is 2.1 t ha⁻¹. Similar results were reported by Obour et al. (2016), where they recorded an increase in soybean yield applying a highest dose of glyphosate (840 g. ha⁻¹). Moreover, the yield variation was significant using D1 and D4 (P<0.05). These confirm that all yield parameters were affected by weed control treatment (Singh et al. 2015).

Herbicide kinetics in the soil

Soil analyses done during S1 showed that fractions of glyphosate reached soil during weed treatment by D1 applied on December, 2014. After 319 days, herbicide was not totally degraded and concentration recorded in H1 was 0.380 µg.kg⁻¹. The follow up of this concentration have continued in S2 as control soil. Thus, four soil sampling were done on

| Parameters                | First horizon 0-20 cm (H1) | Second Horizon > 20 cm (H2) |
|---------------------------|-----------------------------|-----------------------------|
| Particle size distribution|                             |                             |
| <0.002 mm (clay) (%)      | 35.72                       | 37.82                       |
| 0.002-0.05 mm (silt) (%)  |                             |                             |
| > 0.05 mm (sand) (%)      | 26.45                       | 26.45                       |
| Porosity (%)              | 51                          | 47                          |
| Organic matter (OM) (%)   | 3.95                        | 3.80                        |
| Organic carbon (OC) (%)   | 2.296                       | 2.209                       |
| Nitrogen (N) (%)          | 0.22                        | 0.198                       |
| C/N ratio                 | 10.436                      | 11.156                      |
| pH water                  | 7.44                        | 7.45                        |
| CEC (meq. 100 g⁻¹)        | 24.583                      | 24.418                      |
| CaCO₃ (%)                 | 21.56                       | 26.99                       |
373 days, 436 days, 476 days and 506 days. In control soil, herbicide concentrations decline to 0.267 µg.kg\(^{-1}\) over a period of 506 days in H\(_1\) (Fig 3). Otherwise, in H\(_2\), the amount of glyphosate was under LQ (LQ= 0.264 µg.kg\(^{-1}\)).

The variability of glyphosate concentrations in H\(_1\) during S\(_2\) and S\(_3\) from December to May (140 days) were given in Fig 4 (a/b). Glyphosate dynamic in soils depends on soil physical chemical and biological characteristics (Giesy et al. 2000; Duke et al. 2012).

The results showed that herbicide residues were more important in S\(_3\) than S\(_2\) and depend on the doses applied. Kinetics dissipation showed significant decline of herbicide concentration linked to high values of DT\(_{50}\) (Table 3). DT\(_{50}\) values calculated through SFO kinetics explain the persistence of molecule in the soil even using lowest doses, well half-live values of glyphosate found under field conditions were high compared to the results of literature (Grunewald et al. 2001).

On the other hand, a significant effect of rainfall on glyphosate in soil deep layer was observed analysing results of H\(_2\) presented in Fig 5 (a/b). Herbicide concentrations transferred in soil deep layer via soil structure were more important in S\(_3\) than S\(_2\), when 442 mm of rainfall were recorded. Borggaard and Gimsing (2008), mentioned that...
soil with high macro porosity may increase the leaching risk, but only when a large precipitation occurs close to the application. Similar results were reported by Peruzzo et al. (2008) about significant effect of rainfall on glyphosate dissipation in the soil.

**Seeds quality**

The analyses of grains after harvesting showed significant negative relationship between doses applied and herbicide accumulation in grains in two crops seasons (Fig 6 a/b). It was found that the accumulation of glyphosate in barley grains is more important applying highest doses (D₁ and D₂). On other hand, glyphosate concentration was under LQ in grains harvested in soil sample without treatment in S₃. It is important to highlight that analyses of soil sample without weed treatment showed the values under LQ in S₃. On the other hand, the concentration of glyphosate in the soil has a significant effect on herbicide accumulation in grains (P<0.05). High quantity accumulated varied between: 15.6 µg.kg⁻¹, 13.8 µg.kg⁻¹ for S₂ and 18.22 µg.kg⁻¹, 17.08 µg.kg⁻¹ for S₃. These results partially agree with Bohm et al. (2008), when the high residual levels of glyphosate were detected in soybean seeds after applying the recommended rate. Many authors explain high residual levels of glyphosate in grains by multiple factors as: soil and crop conditions, doses applied and season when glyphosate applications were performed (Busse et al. 2001; Araújo et al. 2003a; Duke et al. 2003; Reddy et al. 2004; Zablotowicz and Reddy 2007). On the other hand, Duke and Powles (2008) have explained accumulation of glyphosate on wheat seeds in relation with its systemic characteristics. When glyphosate is applied on the leaf surface, it will be relocated to the roots.

**Table 3:** Half-life values of glyphosate and remaining residues under field conditions during 140 days.

|        | S₂     |          | S₃     |          |
|--------|--------|----------|--------|----------|
| DT₅₀  (days) | RR (%) | DT₅₀  (days) | RR (%) |
| T₁     | 59     | 18       | 39     | 29       |
| T₂     | 55     | 18       | 46     | 38       |
| T₃     | 61     | 23       | 46     | 17       |
| T₄     | 75     | 23       | 58     | 23       |

DT₅₀: half life values, RR: remaining residues, T₁: treatment with D₁ = 1080 g.ha⁻¹, T₂: treatment with D₁ = 900 g.ha⁻¹, T₃: treatment with D₁ = 720 g.ha⁻¹, T₄: treatment with D₁ = 540 g.ha⁻¹.
stems and seeds. Seeds physiological quality is an essential factor for crop performance in the field.

**CONCLUSION**

During the study crop cycles and under field conditions, the following findings were tired:

- The use of herbicides in pre-direct seeding for weeds management is indispensable to save cereal yields.
- Glyphosate as total herbicide used can reduce weed development even with low dose applied ($D_4$). Nevertheless, to enhance productivity highest doses are required.
- Highest doses applied involve important level of residues in soil surface, which they transferred in soil deep layer and accumulate in cereal seeds.

In addition, it is clear via our findings that low $DT_{50}$ value corresponds to the highest doses, because glyphosate can be degraded biologically, but transfer and accumulation phenomena persisted. For these reasons, further investigations are needed to manage weed treatment in direct seeding for safety environment.

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