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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< H_1< 20 cm) and horizon two (H_2< 20 cm) and four herbicide doses were applied: D_1 =1080g ha^{-1}, D_2= 900g ha^{-1}, D_3= 720 g ha^{-1} and D_4= 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 (1080g ha^{-1}). Study indicated that glyphosate reached soil during weed treatment and transferred in deep soil layer and to harvested seeds. Half-live values (DT_{50}) of glyphosate found under field conditions were high.

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

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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 (Bohm *et al.* 2014; Aruna Kumari 2018). Also, the residues of glyphosate were found in surface waters, suspended sediments and bottom sediments in Argentina (Aparicio *et al.* 2013; Lupi *et al.* 2015; Giaccio *et al.* 2016; Primost *et al.* 2017), rivers, rainwater and groundwater in the United States (Battaglin *and al.*, 2014), soil and groundwater in Europe (Poiger *et al.* 2017; Silva *et al.* 2018) and even fish in Brazil (Moura *et al.* 2017). Hence, the present study was an attempt to direct seeding productivity along with herbicide accumulation in soil and seeds. The herbicide residues were present during three crop years (2014/2015- 2015/2016- 2017/2018).

MATERIALS AND METHODS

A field experiment was conducted at the Technical Institute of Cereals (ITGC- Setif) during three crops seasons (S_1= 2014/2015, S_2= 2015/2016, S_3= 2017/2018). S_1 was considered as "*reference season*" to test protocol and study its feasibility.

The climate of studied region is semi- arid with a cold rainy winter and a hot dry summer. A climate variability recorded during experiment period is mentioned in Fig 1.

The experimental site which is characterised by moderately deep soil was cultivated under direct seeding for ten years before (Table1). Thus, it was active biologically (Labad *et al. 2018*). The experiment comprising of five weed treatments based on "glyphosate" as active matter. T_1: weed treatment by D_1 = 1080g ha^{-1}, T_2: weed treatment by D_2= 900g ha^{-1}, T_3: weed treatment by D_3= 720 g ha^{-1}, T_4: weed treatment by D_4= 540 g ha^{-1} and T_5 is the control plot where no weed treatment was applied. The barley was sown one week after weed treatment for all experiment seasons, using seeds rate of 120 kg ha^{-1}. A series of soil sampling were done to determinate variation of herbicide concentrations in H_1 and H_2. In addition, the amount of glyphosate in barley seeds was determined after harvesting and grinding as flour (Table 2). Yield was calculated by the weight of the seeds obtained in the plot and extrapolated to hectare. The glyphosate as phosphonomethyl glycine herbicide is unstable in the environment, so derivation step with FMOC-Cl is peremptory, before using HPLC- UV method (Peruzzo *et al. 2008*). The protocol was adapted in our laboratory conditions (Software, temperature, pressure...).

RESULTS AND DISCUSSION

Barley yield variation

According to our results, the yield recorded in S_3 is more important than S_2 (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 (D_4= 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 (1080g ha^{-1}) during S_2 and S_3. The average yield obtained during two crops seasons (S_2 and S_3) is 2.1t.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 D_1 and D_4 ($P<0.05$). 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 S_1 showed that fractions of glyphosate reached soil during weed treatment by D_1 applied on December, 2014. After 319 days, herbicide was not totally degraded and concentration recorded in H_1 was 0.380 µg.kg^{-1}. The follow up of this concentration have continued in S_2 as control soil. Thus, four soil sampling were done on

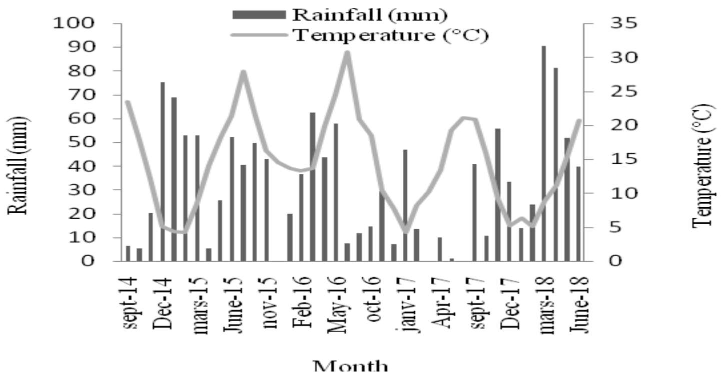

Fig 1: Cumulative precipitations and average temperatures of studied region (Sétif), recorded during four seasons (2014 to 2018).

Table1: General soil characteristics.

Parameters	First horizon 0-20 cm (H_1)		Second Horizon › 20 cm (H_2)
Particle size distribution			
‹0.002 mm (clay) (%)		35.72	
0.002-0.05 mm (silt) (%)		37.82	
› 0.05 mm (sand) (%)		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. $100g^{-1}$)	24.583		24.418
$CaCO_3$ (%)	21.56		26.99

Table 2: Progression steps of experiment.

S_1 (2014/2015)		S_2 (2015/2016)		S_3 (2017/2018)	
Treatment (D_1)	December 1st,2014	Treatment (D_1, D_2, D_3, D_4)	December 2th, 2015	Treatment (D_1, D_2, D_3, D_4)	December 19th, 2017
Seeding	December 8th, 2014	Seeding	December 7th, 2015	Seeding	December 24th, 2017
First sampling	October 15th, 2015	First Sampling	December 8th, 2015	First Sampling	December 25th, 2017
Second Sampling	February 9th, 2016	Second Sampling	February 9th, 2016	Second Sampling	February 26th, 2018
Third Sampling	March 20th, 2016	Third Sampling	March 20th, 2016	Third Sampling	April 7th, 2018
Fourth Sampling	April 24th, 2016	Fourth Sampling	April 24th, 2016	Fourth Sampling	May 7th, 2018
		Harvesting	June, 2016	Harvesting	June, 2018

S_1 First season, S_2: second season, S_3: third season, D_1: 1080 g ha^{-1}, D_2: 900g ha^{-1}, D_3 : 720 g ha^{-1}, D_4 : 540 g ha^{-1}.

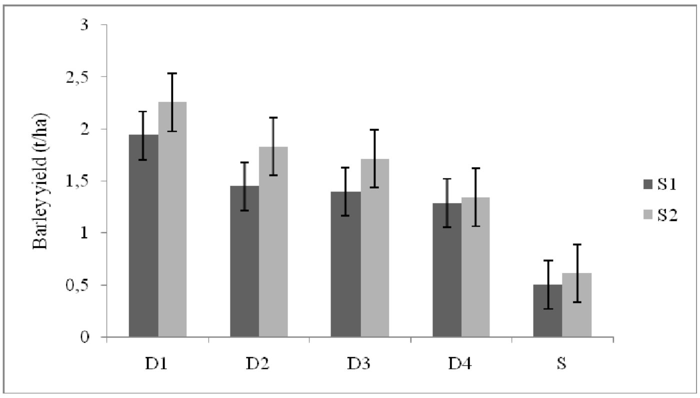

Fig 2: Barley yield variation recorded under field conditions during two experiment seasons. (S: uncontrolled condition, S1: 2015-2016, S2: 2017/2018)

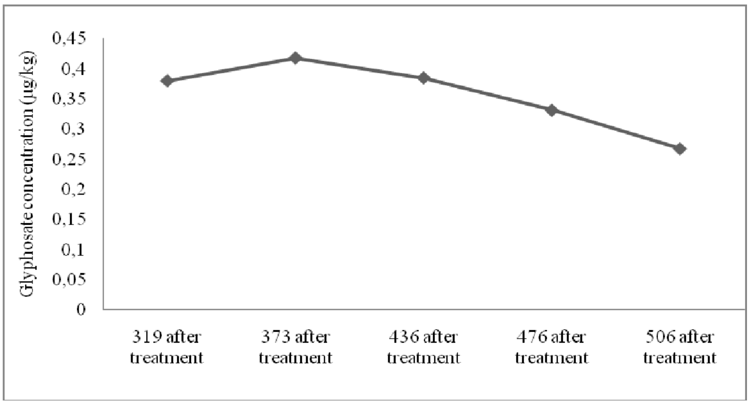

Fig 3: Herbicide kinetic distribution in soil sample.

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 (D_1 and D_2). On other hand, glyphosate concentration was under LQ in grains harvested in soil sample without treatment in S_3. It is important to highlight that analyses of soil sample without weed treatment showed the values under LQ in S_3. 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 S_2 and 18.22 µg.kg^{-1}, 17.08 µg.kg^{-1} for S_3. 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.

	S_2		S_3	
	DT_{50} (days)	RR (%)	DT_{50}(days)	RR (%)
T_1	59	18	39	29
T_2	55	18	46	38
T_3	61	23	46	17
T_4	75	23	58	23

DT50: half life values, RR: remaining residues, T_1: treatment with D_1= 1080 g.ha^{-1}, T_2= treatment with D_2= 900 g.ha^{-1}, T_3 treatment with D_3= 720 g.ha^{-1}, T_4 treatment with D_4= 540 g.ha^{-1}.

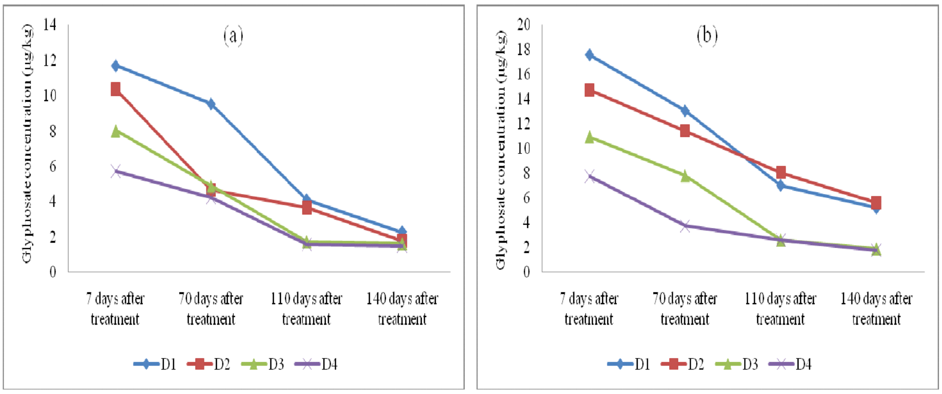

Fig 4: Herbicide kinetics distribution in the first soil horizon (H_1).
(a): 2015/2016
(b): 2017/2018

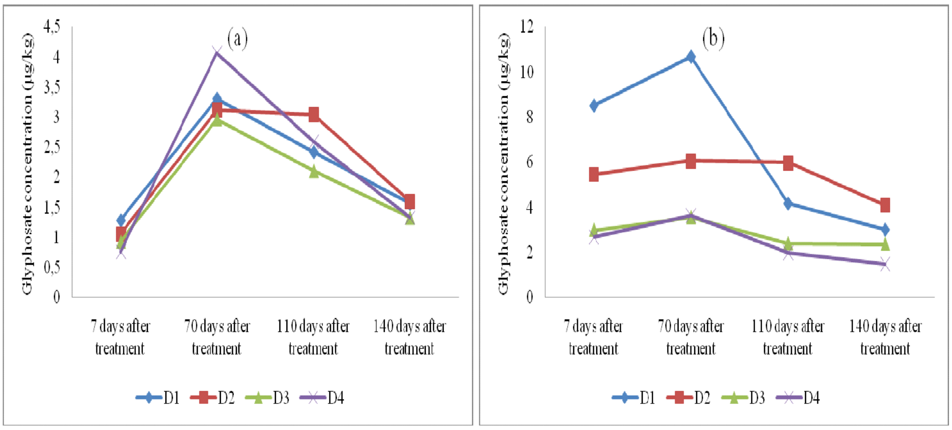

Fig 5: Herbicide kinetics distribution in the second soil horizon (H_2).
(a): 2015/2016
(b): 2017/2018

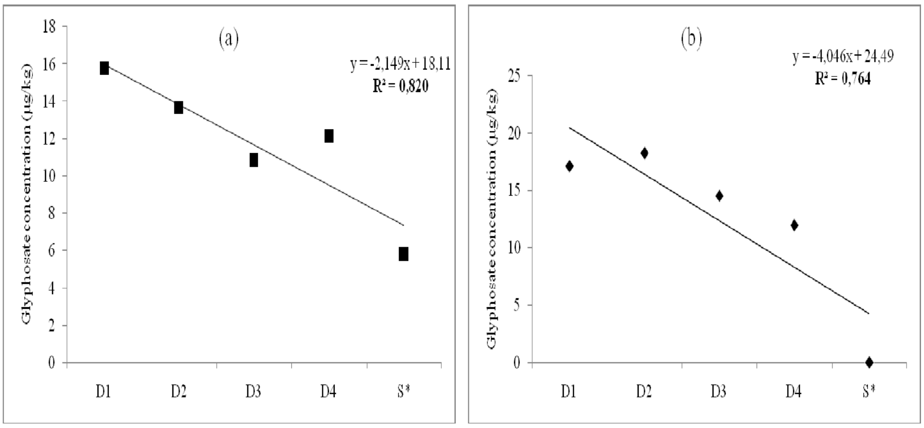

Fig 6 : Herbicide concentration in harvested seeds.
(a) : 2015/2016
(b) : 2017/2018

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.

REFERENCES

Aparicio, V.C., De Geronimo, E., Marino, D., Primost, J., Carriquiriborde, P., Costa, J.L. (2013). Environmental fate of glyphosate and aminomethylphosphonic acid in surface waters and soil of agricultural basins. Chemosphere. 93: 1866-1873.

Araújo, A.S.F., Monteiro, R.T.R., Abarkeli, R.B. (2003a). Effect of glyphosate on the microbial activity of two Brazilian soils. Chemosphere. 52: 799–804.

Battaglin, W.A., Meyer, M.T., Kuivila, K.M., Dietze, J.E. (2014). Glyphosate and its degradation product AMPA occur frequently and widely in U.S. soils, surface water, groundwater and precipitation. J. Am. Water Resour. Assoc. 50: 275-290.

Benbelkacem, A., Kellou, K. (2000). Evaluation du progrès génétique chez quelques variétés de blé dur (*Triticum turgidum* L. Var durum) cultivées en Algérie. In: Royo, C., Nachit, M., Di Fonzo, N., Araus, J.L. (Eds.), Durum Wheat Improvement in the Mediterranean Region: New Challenges. CEHEAM, Zaragoza, pp. 105e110 (Options méditerranéennes: Série A. Séminaires méditerranéens; n. 40).

Bohm, G.M.B., Genovese, M.I., Pigosso, G., Trichez, D., Rombaldi, C.V. (2008). Resíduos de glifosato e ácido aminometil- -fosfônicoe teores de isoflavonas em soja BRS 244 RR e BRS 154 cultivadas em Planossolo. Revista Brasileira de Ciência e Tecnologia de Alimentos. 28:192–197.

Bohm, G.M.B., Rombaldi, C.V., Genovese, M.I., Castilhos, D., Alves, B.J.R., Rumjanek, N.G. (2014). Glyphosate effects on yield, nitrogen fixation and seed quality in glyphosate-resistant soybean. Crop Sci. 54: 1737-1743.

Borggaard, O.K., Gimsing, A.L. (2008). Fate of glyphosate in soil and the possibility of leaching to ground and surface waters: a review. Pest Manag. Sci. 64(4) : 441-456.

Busse, M.D., Ratcliff, G.A., Shestak, C.J., Powers, R.F. (2001). Glyphosate toxicity and the effects of long-term vegetation control and soil on soil microbial communities. Soil Biol. Biochem. 33: 1777-1789.

Duke, S.O., Rimando, A.M., Pace P.F., Reddy, K.N., Smeda, R.J. (2003). Isoflavone, glyphosate and aminomethylphosphonic acid levels in seeds of glyphosate-treated, glyphosate-resistant soybean. J. Agric. Food Chem. 51: 340-344.

Duke, S.O., Powles, S. B. (2008). Glyphosate: a once in a century herbicide. *Pest Managment Science* : Special Issue : Glyphosate Resistant Weeds and Crops. 64 (4): 3019-325.

Duke, S.O., Reddy, K.N., Bu, K., Cizdziel, J.V. (2012). Effects of glyphosate on the mineral content of glyphosate-resistant soybeans (glycine max). J. Agric. Food Chem. 60: 6764-6771.

Giaccio, G.C.M., Laterra, P., Aparicio, V.C., Costa, J.L. (2016). Glyphosate retention in grassland riparian areas is reduced by the invasion of exotic trees. J. Exp. Bot. 85: 108-116.

Giesy, J. P., Dobson, S., Solomon, K. R. (2000). Ecotoxicological risk assessment for Roundup herbicide. Reviews of Environmental Contamination and Toxicology. Springer. 35:120.

Grunewald, K., Schmidt, W., Unger, C., Hanschmann, G. (2001). Behaviour of glyphosate and aminomethylphosphonic acid (AMPA) in soils and water of reservoir Radeburg II catchment (Saxomy/ Germany). Journal of Plant Nutrition and Soil Science. 164: 65-70.

Gupta, R. K., Ladha, J. K., Singh, S., Singh, R., Jat, M. L., Saharawat, Y., Singh, V. P., *et al* (2006). Production Technology for Direct Seeded Rice. Technical Bulletin Series 8. In "Rice–Wheat Consortium for the Indo-Gangetic Plains, New Delhi, India," 14pp.

Hobbs, P.R., Sayre, K., Gupta, R. (2008). The role of conservation agriculture in sustainable agriculture. Phil. Trans. R. Soc. B. 363: 543–555.

Kumari Aruna, J., A., Rao, P. C., Madhavi, M., Padmaja, G. (2018). Effect of herbicides on the activity of soil enzymes urease in maize crop. Indian J. Agric. Res. 52(3): 300-304.

Kumari, P., Kumar, P.V., Kumar, R., Wadood, A., Tirkey, D.A. (2017). Effect of weather on grain yield of direct seeded upland rice varieties in Jharkhand, India. Indian J. Agric. Res. 51(6): 562-567.

Labad, R., Hartani, T. (2016). Analyse des performances de quelques exploitations agricoles céréalières en semis direct dans la wilaya de Sétif. Revue Agriculture. Numéro spécial. 1: 78- 81.

Labad, R., Hartani, T., Belguet, H., Bendada, H., Louahdi, N., Taibi, M. (2018). Evaluation de la biologie du sol sous l'effet du traitement chimique en semis direct dans une zone semi-aride de l'Algérie. Agriculture Journal. 46-55.

Lupi, L., Miglioranza, K.S.B., Aparicio, V.C., Marino, D., Bedmar, F., Wunderlin, D.A. (2015). Occurrence of glyphosate and AMPA in an agricultural watershed from the southeastern region of Argentina. Sci. Total Environ. 536: 687-694.

Moura, F.R., Lima, R.R.S., Marisco, P.C., Aguiar, D.H., Sugui, M.M., Sinhorin, A.P., Sinhorin, V.D. G. (2017). Effects of glyphosate-based herbicide on pintado da Amazônia: hematology, histological aspects, metabolic parameters and genotoxic potential. Environ. Toxicol. Pharmacol. 56: 241-248.

Obour Augustine, K., Stahlman Phillip, W., Holman Johnathon, D. (2016). Soil chemical properties as influenced by long-term glyphosate-resistant corn and soybean production in the central Great Plains, USA. Geoderma. 277: 1-9.

Peruzzo, P. J., Porta, A. A., Ronco, A. E. (2008). Levels of glyphosate in surface waters, sediments and soils associated with direct sowing soybean cultivation in north pampasic region of Argentina. Environmental Pollution. 156(1): 61-66.

Poiger, T., Buerge, I.J., Bachli, A., Muller, M.D., Balmer, M.E. (2017). Occurrence of the herbicide glyphosate and its metabolite AMPA in surface waters in Switzerland determined with online solid phase extraction LC-MS/MS. Environ. Sci. Pollut. Res. 24: 1588-1596.

Primost, J.E., Marino, D.J.G., Aparicio, V.C., Costa, J.L., Carriquiriborde, P. (2017). Glyphosate and AMPA, "pseudo-persistent" pollutants under real world agricultural management practices in the Mesopotamic Pampas agroecosystem, Argentina. Environ. Pollut. 229: 771-779.

Raunet, M., Seguy, L., Rabots Fovet, C. (1998). Semis direct sur couverture vegétale permanente du sol : de la technique au concept. http ://agroecologie.cirad.fr.

Reddy, K.N., Rimando, A.M., Duke, S.O. (2004). Aminomethylphosphonic acid, a metabolite of glyphosate, causes injury in glyphosate-treated, glyphosate-resistant soybean. J. Agric. Food Chem. 52: 5139-5143.

Rouabhi, A., Laouar, A., Mekhlouf, A., Dhehibi, B. (2018).What are the factors affecting no-till adoption in the farming system of Sétif Province in Algeria? Turkish Journal of Agriculture - Food Science and Technology. 6(6): 636-641.

Sage, C. (2019). Food security. University College Cork, Irland. pp 1-11 (researchgate).

Silva, A.F.M., Albrecht, A. J. P., Pellicci, V.A., Giovanelli, B.F., Girardello, G.A., Viana, H.R.M., Filho, R.V. (2018). Glyphosate in agronomic performance and seed quality of soybean with *cp4-EPSPs* and *cry1Ac* genes. Journal of Plant Protection Research. 1-10.

Singh, M., Bhullar, M.S., Chauhan, B.S. (2015). Influence of tillage, cover cropping and herbicides on weeds and productivity of dry direct-seeded rice. Soil & Tillage Research. 147: 39-49.

Singh, M., Bhullar, M.S., Chauhan, B.S. (2014). The critical period for weed control in dry-seeded rice. Crop Prot. 66: 80-85.

Touchan, R., Kherchouche, D., Oudjehih, B., Touchan, H. (2016). Dendroclimatology and wheat production in Algeria. Journal of Arid Environments. 124: 102-110.

Zablotowicz, R.M., Reddy K.N. (2007). Nitrogenase activity, nitrogen content and yield responses to glyphosate in glyphosate-resistant soybean. Crop Prot. 26: 370-376.