

## Direct corn seeding. Effects of residue clearance on implant efficiency

M. Tourn\*, E. Soza, G. Botta and A. Mete

*Departamento de Ingeniería Agrícola y Uso de la Tierra. Facultad de Agronomía.  
Universidad de Buenos Aires. Avda. San Martín, 4453. 1417 Buenos Aires. Argentina*

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### Abstract

This article describes the effects of three seeding unit designs on plant residue clearance along the central line of direct corn (*Zea Mays* L.) seeding and the subsequent influence on crop emergence. The equipment assemblies tested were three different combinations of the implements turbo coulter blade (TCB), double disc opener with a seed press wheel and covering/packing wheels (DDO), notched disc row cleaner with a track wheel or floating star cleaner (RC) as follows: (1) TCB+DDO, (2) RC+TCB+DDO and (3) TCB+RC+DDO. Under the field conditions tested, residue clearance before the cutting action of the turbo coulter blade (combination 2) gave rise to the best crop stand and crop uniformity. The seeding assembly that moves soil and clears away plant debris along the seeding furrow shows a direct effect on seed emergence.

**Key words:** farm machinery, planter, soil cover, seeding assembly.

### Resumen

#### Siembra directa de maíz. Efectos del barrido de residuos vegetales en la eficiencia de implantación

El presente trabajo expone la incidencia de tres diferentes configuraciones de trenes de siembra sobre los residuos vegetales, en la línea de siembra, previo a la siembra directa de maíz (*Zea mays* L.) y su efecto sobre la emergencia de dicho cultivo. Los trenes de siembra probados fueron tres: 1) cuchilla labrasurco turbo, doble disco surcador con rueda apretadora de semilla y ruedas cubridoras compactadoras, 2) barredor de residuos vegetales de disco escotado flotante con rueda limitadora, cuchilla labrasurco turbo, doble disco surcador con rueda apretadora de semilla y ruedas cubridoras compactadoras, 3) cuchilla labrasurco turbo; barredores de residuos vegetales tipo estrella flotante, doble disco surcador con rueda apretadora de semilla y ruedas cubridoras compactadoras. Para las condiciones de trabajo dadas y establecidas en el presente ensayo, el barrido de los residuos vegetales previo a la acción de la cuchilla labrasurco produjo mayor población y uniformidad de plantas que los restantes conjuntos analizados. El alistamiento de trenes de siembra que provoquen la remoción de la línea de siembra y el barrido de los residuos vegetales inciden directamente en la emergencia.

**Palabras clave:** maquinaria agrícola, sembradoras, cobertura de suelo, trenes de siembra.

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### Introduction

In Argentina, the land area given over to direct seeding has recently increased substantially such that the area occupied in the crop cycle 1998/1999 exceeded  $7.2 \times 10^6$  ha. In this same crop year, the area of direct seeding was over  $2 \times 10^6$  ha in the Santa Fe province. Most of this land occurs in the south of this province and is mainly used for cultivating corn.

The direct seeding system gives rise to satisfactory yields, which are more stable than those obtained by

conventional tillage. Further advantages include better soil structure, improved organic matter content and a greater rain water filtration and storage capacity (Méndez Duhau and Satorre, 1998; Gil, 1999). However, this practice is also related to several drawbacks such as an increased incidence of some diseases, increased soil insect populations and impaired seeding when there is an abundance of crop remains on the soil surface. Martínez Peck (1998) stated that the greatest worry for users of direct seeding machines was to be able to penetrate areas with vast amounts of residue, to improve implant conditions and to achieve more vigorous seedling emergence and growth. Addressing these concerns would improve the performance of these implements.

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\* Corresponding author: mtourn@agro.uba.ar  
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Corn (*Zea mays* L.) shows poor leaf plasticity, scarce tillering capacity and a low prolificacy which leads to a reduced ability to compensate low plant densities. Further, if the plants do not reach the growth threshold for fixing the ear during the period from the fortnight before to the fortnight after flowering, they will be sterile (Andrade *et al.*, 1996). This reflects the importance of achieving a uniform stand.

The presence of plant residues on the soil surface has the consequence of diminishing soil temperature which in turn impairs crop emergence (Wicks *et al.*, 1994), requiring an increased density of seeding to achieve the same sized plant population compared to the use of conventional systems (Oplinger and Philbrook, 1992). On the other hand, the spatial distribution of residues is not uniform over the soil surface such that areas of different temperature occur. Thus, in this type of system, the seeding assembly of the planter plays an essential role since it works the soil that has not been previously tilled. Most planters have a circular blade, whose axis is horizontal and normal to the direction of travel, to cut the debris and till the line of seeding. The blade is followed by double disc furrow openers and rubber-coated packer and covering wheels (Maroni, 1994; Gargicevich, 1995). This combination has the advantage that it does not become obstructed and is of low maintenance. The drawbacks related with its use are superficial seed distribution (Kushwaha and Foster, 1993; Soza *et al.*, 2000), sidewall compaction and residue burying (Baker, 1994) and displacement (Balbuena *et al.*, 2000), effects that reduce seed cover, seed/soil contact and seedling emergence.

To resolve these problems, Baumer (1999) described several seeding unit designs proposing among other things that by placing a scourer between the blade and the double disc, the penetrating capacity of the seeding drill can be enhanced, overturning of the blade cutting band increased and the residue buried by the blade displaced. However, the same author states that this arrangement can also extract stones and lead to greater machine obstruction when the residue is damp.

The need to directly sow corn with large volumes of plant debris at an early seeding date and to improve the plant population achieved has prompted the use of row cleaners in seeding assemblies. This addition also responds to the need to reduce the amount of plant debris along the line of seeding, which enhances emergence. The aim of the present study was to quantify

the effect of residue clearance on corn emergence after direct seeding using a seeder equipped with a fluted circular blade commercially known as a turbo coulter blade.

## Material and methods

### Study site

The study was performed at the experimental farm Santa Ana (latitude 33°59' south, longitude 64°34' west) in the district Villa Cañas, Departamento General López, of the Santa Fe province. The soil belongs to the Santa Isabel series, a typical Hapludol of capacity of use 1-2. The soil profile shows 36 cm of dark top soil with substantial organic matter (horizon A1). This horizon gradually passes to a B2 horizon of weakly prismatic structure of a more reddish colour. Its permeability is moderately fast and it contains less clay than A1. From a depth of 95 to 100 cm, its consistency and structure diminishes to become massive and loose.

### Machinery

The machine used was a 2-wheel drive (2WD) Deutz A4120 tractor with an 84.96 kW (115.6 CV) motor (norm IRAM 8005) and an 18.4-38 rear drive and front drive 11.00-16. The features of the planter used in the tests are provided in Table 1.

**Table 1.** Characteristics of the Agrometal TX3 planter

Number of units	7
Weight	35 kN
Row spacing	0.70 m
Work width	4.90 m
Metering system	Horizontal seed plate planter
Seeding unit	Turbo coulter blade (TCB), double disc furrow opener (DDO) with a press wheel, rubber double packer wheel with notched discs.
Seeding unit accessories	Row cleaner that may be placed in front the TCB or between the TCB and the DDO
Seed depth controller	Two wheels on either side of the DDO

## Experimental design

Six 60 m by 4.90 m plots (for 7 rows 0.70 m apart) were established. These plots were randomly assigned to two replicates of each of the three treatments TCB+DDO, RC+TCB+DDO and TCB+RC+DDO, corresponding to the seeding assemblies described in Figure 1.

Seeds of the corn (*Zea mays* L.) hybrid DK4F37 were sown on September 23, 2001. The previous grain crop was also *Zea mays* L. Before seeding, residue cover was determined by the transect method (Gargicevich, 1995)

To control rows end and side rows effects, data for the initial and final 10 m of the plots and for the side rows of each plot were discarded. The observations

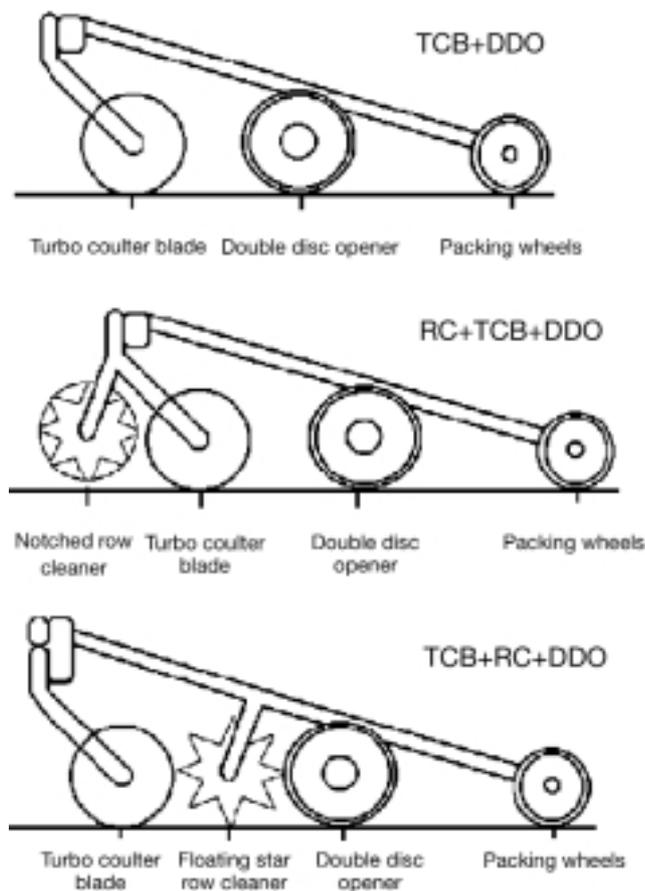
made were emerged plantlets per linear metre for all the rows, corresponding to 240 observations per treatment (40 observations/row × 3 rows/replicate 2 replicates/treatment). Counts were performed 11, 14 and 18 days after seeding.

The trial designed to establish the density of seeding was dynamically performed at a tractor speed of 5 km h<sup>-1</sup>. This was followed by counting the seeds distributed along each linear metre in uncovered furrows which resulted in 5.8 seeds per metre (82,940 seeds ha<sup>-1</sup>). The seeding depth was kept at 5 cm. After seeding, soil temperature throughout the crop cycle was monitored as an explanatory variable. This was achieved using a soil temperature probe capable of data storage. The implanting efficiency for each treatment was calculated as percentage seed loss (PSS) (Bragachini *et al.*, 2000) according to the expression:

$$PSS = 100 [1 - (A / B \times C)]$$

where: *A* = plants emerging per linear metre, *B* = seeds seeded per linear metre, and *C* = the seed germinating potential (GP/100). This last factor was provided by the firm supplying the hybrid used.

The results were subjected to analysis of variance ( $p \leq 0.05$ ) and means (plants emerged per linear metre of furrow) were compared using Tukey's test.



**Figure 1.** Seeding assemblies tested. Treatment TCB+DDO: turbo coultter blade, double disc opener with seed press wheel and packer wheels. Treatment RC+TCB+DDO: notched disc row cleaner with track wheel, turbo coultter blade, double disc opener with seed press wheel and packer wheels. Treatment TCB+RC+DDO: turbo coultter blade, floating star row cleaner, double disc opener with seed press wheel and packer wheels.

## Results and Discussion

In corn cultivation, surface crop residue clearance helps to reduce allelopathy problems arising when seeding over rows corresponding to the previous year and also speeds up soil warming. Early cleaner systems were fixed but these were soon replaced by moving implements that not only clear the debris but also move the soil (Baumer, 1999).

The plant residue cover achieved by the different seeding systems was found to depend upon the inclusion of the cleaner system (Table 2). The turbo coultter bla-

**Table 2.** Plant residue cover remaining according to the assembly used for seeding

Cover	Preseeding	TCB+ DDO	RC+ TCB+ DDO	TCB+ RC+ DDO
%	99.28 a	88.50 a	40.05 c	73.20 b

Different letters indicate a significant difference (Tukey,  $p \leq 0.05$ ). Treatments were defined in Fig. 1.

**Table 3.** Effect of seeding treatments on changes in maximum soil temperature (°C) of the zones inter-row (IR) and seeding line (SL)

Days from seeding	TBC+DDO		RC+TCB+DDO		TCB+RC+DDO	
	IR	SL	IR	SL	IR	SL
+1	10.44	10.46	10.09	11.60	10.93	11.51
+2	12.59	13.14	12.61	14.20	12.46	13.14
+4	16.55	16.91	16.53	17.44	16.39	16.97
+18	18.06	18.61	17.86	19.84	18.10	18.93

Treatments were defined in Fig. 1.

de/furrow opener (TCB+DDO) assembly cannot be considered a substitute for seeding units equipped with a row cleaner.

The effect on surface residue of including a row cleaner in front of the turbo coultter blade gave rise to best behaviour in terms of soil warming (Table 3). From a starting soil temperature of 11.7°C recorded the day before seeding at the seeding depth, daily temperature increases until the final plantlet count were: 0.36°C (TCB+DDO), 0.42°C (RC+TCB+DDO) and 0.38°C (TCB+RC+DDO). For the same date, the temperature differences between the inter-row (IR) soil and the seeding line (SL) soil (L) were 0.55°C, 1.98°C and 0.83°C (for treatments TCB+DDO, RC+TCB+DDO and TCB+RC+DDO, respectively). This finding is in agreement with observations made by Wicks *et al.* (1994). In our study, the difference between pre- and post-seeding soil temperature can be explained by frost recorded the night before seeding. This rise in temperature leads to changes in crop phenology, growth and index (Andrade *et al.*, 1996). Temperature affects the length of the crop cycle from seeding until physical maturity is reached, while the photoperiod can affect the time between sprouting and flowering. Thus, the total biomass produced depends on the rate of growth from emergence to maturity.

Residue clearance prior to the action of the turbo blade (RC+TCB+DDO) led to significantly improved counts on the three dates (Table 4). Despite the final plant populations for the 3 treatments showing similar absolute counts, plant emergences for each of these dates reflect a more uniform crop stand using the RC+TCB+DDO system. This effect is of particular relevance if we consider the different treatments, since in non-uniform stands, subordinate plants yield considerable less grain, and this effect is not compensated by greater production by the dominant plants (Andrade *et al.*, 1996)

The data in Table 5 indicate that the planter with the row cleaner positioned in front of the turbo blade (RC+TCB+DDO) showed best performance in terms of crop emergence. In contrast, in a similar study involving the direct seeding of soybean, Bragachini *et al.* (2000) reported best behaviour using a floating star cleaner placed behind the turbo blade.

Our results and observations indicate that the turbo blade is highly efficient at cutting and is good at penetrating and moving the soil with scarce burying of plant debris. The implement opens a furrow of approximately 8 to 10 cm depth and 3.5 cm width. This is followed by closing of the furrow which is then shaped by the double disc for seed deposition guided by the side wheel. Moreover, since the soil is slightly dis-

**Table 4.** Plant emergence (plants m<sup>-1</sup>) according to each treatment

Treatment	Plantlet count date								
	4/10			7/10			11/10		
	Mean	SD	CV (%)	Mean	SD	CV (%)	Mean	SD	CV (%)
TCB+DDO	0.25 a	0.63	252	2.80 a	1.93	68.92	5.15 a	0.80	15.53
RC+TCB+DDO	1.43 b	1.47	102	4.42 b	1.16	26.24	5.46 b	0.84	15.38
TCB+RC+DDO	1.10 c	1.48	134	4.02 c	1.75	43.53	5.31 c	0.85	16.00

Different letters in the same column indicate significant differences (Tukey,  $p \leq 0.05$ ). CV: coefficient of variation. SD: standard deviation from the mean (plants m<sup>-1</sup>). Treatments were defined in Fig. 1.

**Table 5.** Implant efficiency according to treatment

Treatment	TCB+ DDO	RC+ TCB+ DDO	TCB+ RC+ DDO
Mean (plants m <sup>-1</sup> )	5.15	5.46	5.31
Standard deviation (plants m <sup>-1</sup> )	0.80	0.84	0.85
Coefficient of variation (%)	15.53	15.38	16.00
Seed loss (%)	9.39	3.94	6.57

Treatments were defined in Fig. 1.

placed, this helps the action of the covering/packing wheel with notched discs.

The soil overturned on the surface of the seeding line, which is generally most visible, depends on the surface residue cover. If the soil is totally covered, no overturning of plant debris is observed along this line and there is consequently no movement of loose soil. Accordingly, as the plant cover diminishes, more loose soil appears along the line of seeding.

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