



*The Society for engineering
in agricultural, food, and
biological systems*

This is not a peer-reviewed article

Paper Number: 021174
An ASAE Meeting Presentation

A punch planter with adjustable seed spacing

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Written for presentation at the
2002 ASAE Annual International Meeting / CIGR XVth World Congress
Sponsored by ASAE and CIGR
Hyatt Regency Chicago
Chicago, Illinois, USA
July 28-July 31, 2002

Research supported by FAPESP, São Paulo, Brazil

Abstract. *Some attempts have been made trying to implement different approaches for seed placement into the soil for no-till systems, avoiding coulters and their accessories that still present problems working on crop residue. Punch planting is one of the possibilities, but is limited on seed spacing adjustment. A prototype was developed based on previous works and consists on a punch wheel that has the ability to adjust its diameter so the tips will change the distance, producing seed spacing that may vary from 0.16 to 0.21m. The idea is based on a set of two plates with opposite spiral slots and a third plate with radial slots in between those two. With an external effort the punches attached to the sliding plates will expand or contract. The prototype was built and required also a personalized vacuum seed meter. Test shown it feasible as the accessories and seed meter are implemented.*

Keywords. Planters, Punch planter, Seed spacing, No-till, Corn

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Introduction

The idea of using a device to insert seeds into the soil without opening a continuous row resulted in the concept of punch planters. It has shown promising results when used on no-till systems because it has a very good precision in spacing and it does not offer limitations with residue. The first attempts in this area used mechanically activated tips that opened up into the soil, forming the holes (Hunt, 1961). Another alternative was based on a metal wheel with inverted conical tips around it. Those inverted cones were responsible for opening the holes where the seeds were placed (Jafari & Fornstrom, 1972; Shaw et al., 1986). Shaw & Kromer (1987), proposed the use of fixed tips together with a combination of angles. The machine was constituted by 12 fixed tips or punches distributed around a metal wheel, with a vertical inclination of 30° and a longitudinal angle of 10° . That arrangement resulted in a lateral displacement of the punches, forming an ellipse into the soil, allowing the seed liberation through a hole on the opposite side to the moved soil.

The prototype was equipped with a spoon seed metering and Debicki & Shaw (1996), gave continuity to the works of Shaw & Kromer (1987) and accomplished changes in the seed meter, adopting a vacuum system. They also made some changes in the design, increasing the diameter of the wheel, reducing the vertical angle to 15° and increasing the number of punches to 15.

Molin et al. (1998a) projected a punch planter with pneumatic seed meter for no-till consisting on a wheel with 15 punches distributed around a metallic ring. The punches, without relative movement, with the rotation of the wheel, penetrate in the soil and house a seed in each hole. The holes are molded by the action of a vertical angle of 22° and an angle of 7° with the longitudinal axis. After that, Molin et al. (1998b) built a second prototype with the objective of testing the possibility of changing population of corn seeds by changing the spacing among plants. The project was based on the previous prototype, for which three wheels were built, with different diameters, varying the length of the punches. It was possible to obtain spacing among punches of 136, 165 and 210 mm and the prototype was able to plant with a minimum of soil displacement compared to no-till planters available in the market.

Later on, a sequence of test was run to evaluate this prototype and other two with different configurations and seed meters. Tests were conducted under Brazilian no-till and soil conditions. The other prototypes came from different sources and were obtained from previous works. They were tested in laboratory and in the field in three different areas at speeds of 1.5, 2.0 and 2.5 m.s^{-1} . Results showed that in the laboratory and in the field, the prototype from Molin et al. (1998b) obtained the best performance. For the other two machines, in spite of presenting similar configurations, the difference in seed metering was decisive, mainly in one of them that only reached the best performance at a speed of 1.5 m.s^{-1} (Molin & Acosta, 1999).

As the seed spacing is an important requirement on this kind of machine, solutions have to be found so the concept may be more explored by manufacturers and users. This paper aims to discuss the idea of a mechanical solution for diameter changes on a punch wheel

The Desing

An initial task was to establish the limits based on commitments of the project in terms of desirable and possible minimum and maximum populations for corn. The prototype planter built by Molin et al. (1998b) proposed the variation of the population with the use of interchangeable

wheels of different diameters obtained through different lengths of punches fastened to a hoop attached to the wheel. It allowed a variation of plant population, but with assigned rates and the change of wheel diameter was just to make possible the study. Now the proposal is to make possible the seed spacing variation on continuous, easy and quickly adjustable variable rate.

It was established a minimum hole spacing (seeds) of 0.16 m and maximum of 0.21 m. Some specific solutions were analyzed with different degrees of complexity and challenges on the project and on the final product. The mechanical solution found consists of a mechanism that combines three disks with parabolic-radial slots that allow the radial displacement of the punches. Each slot is associated with a punch support (Figure 1) and its radial displacement alters the wheel diameter and the distance between holes.

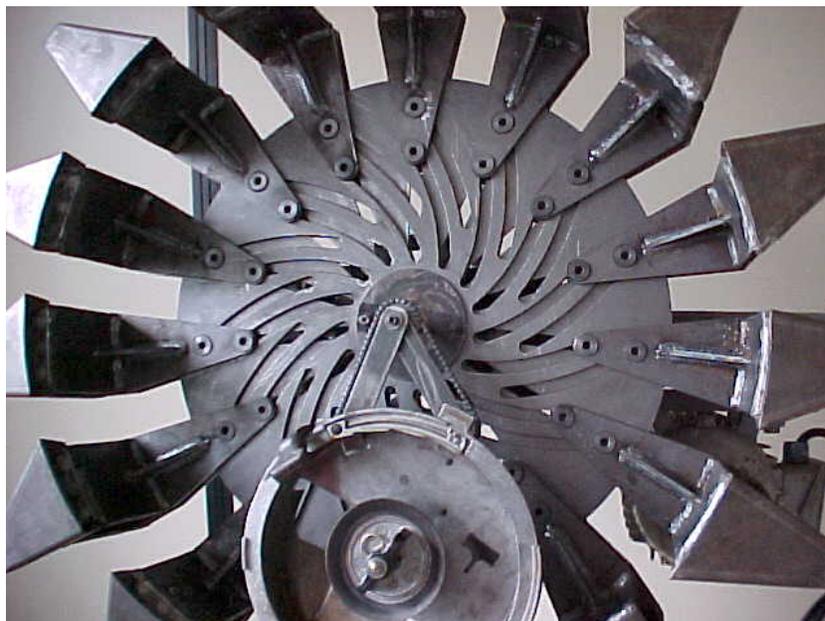


Figure 1. View of the unit with its front disk with curved slots and the fastened sliding plates with the punches at the end.

The unit is formed by three disks. Each one has a 12.7 mm wide slot, whose curvature is given by an equation of a spiral for the lateral disks and by a radial straight line for the center disk, allowing it to slide one against the other. The central disk is made of steel, with a diameter of 600 mm and thickness of 6.35 mm. The two external disks are also of diameter of 600 mm and 3 mm thick. The set has 15 punches and thirty sliding plates fastened under the supports of the punches. With an external effort the punches attached to the sliding plates will expand or contract.

Distance between the point where seeds are dropped from the seed meter and the top of each punch must be as much constant as possible. A bar mechanism (pantograph) was proposed and allows the chain transmission between wheel and seed meter to adjust it. The transmission has a rate of 1:3, in function of the characteristic of the seed meter that has a disk of 45 cells.

On preliminary works, several vacuum seed meters were tested to find one that would attend the planter demands. The major problem is that all of them have a disc with lateral cells and it

implicates in lateral release of seeds. As the unit uses a vertical angle of approximately 22° , there is a dragging effect on the seeds. A good synchronization between seed meter and punches is one of the most critical conditions of this kind of machine and that vertical angle causes some disruption on seeds when dropped. Also limitations of practical order were observed, mainly related to the external dimensions of the seed meters that do not fit into the wheel of the prototype. It is only possible to assemble the unit tilted to one side. Considering more than one row, it is necessary to compensate the lateral forces caused by the combination of angles that form the holes.

Based on those requirements, a dedicated seed meter had to be built. However it resulted in some challenges that were not in the scope of the project. Although it is a technology already dominated, difficulties have been related to the quality on construction and detail of adjustment, especially on the vacuum chamber. It consists on a vertical nylon ring with radial exit of the seeds (Figure 2) and is formed by 45 radial cells, disposed on the periphery of the ring. The vacuum is generated into the chamber and is transmitted to the cells at the temporary seed reservoir, through a individual tube for each cell. As the cells are in the top of the ring, the seed meter does not have larger limitations on being turned clockwise or counterclockwise. That is another great limitation of commercial units for allowing rows with left and right yawing for compensating the lateral force effect of the wheel (Molin et al., 1996).



Figure 2. View of the seed metering nylon ring with 45 radial cells.

A toolbar was set up for attaching the prototype to the three points hitch of the tractor (Figure 3). It contemplates a depth control and lateral leveling with two pneumatic wheels and a back wheel with independent adjustment.



Figure 3. View of the unit attached to the toolbar and support structure.

The Tests

Laboratory tests were run in the final of the development phase varying the wheel diameter and forward speed. Wheel diameters were 0.75, 0.88 and 1.00 m, resulting in spacing between tips of 0.16, 0.18 and 0.21 m, respectively. The speeds tested were 1.5, 2.0 and 2.5 $\text{m}\cdot\text{s}^{-1}$. The methodology was the same applied by Molin et al. (1999), using a greased belt with adjustable speeds.

As it was expected that the results would be strongly committed by the seed meter and its combination with the wheel, it was tested separately at simulated forward speeds of 1.5 and 2.5 $\text{m}\cdot\text{s}^{-1}$.

Figure 4 presents the results of the planter tests and Figure 5 presents the results of the seed meter performance. As there was a large incidence of failures attributed to the deficiencies of the seed meter, as already described, it was of no use a more detailed analysis of the data. An analysis for frequency classes (multiple, normal and defective) would have no sense here.

It is observed that the picks of frequencies are associated to each spacing that is a function of the external diameter of the wheel. It demonstrates that the seeds that were correctly individualized by the seed meter were properly deposited on the belt after passing through the punch, producing a regular spacing. That had already been observed in the previous prototype, with wheels of different diameters (Molin et al., 1998b).

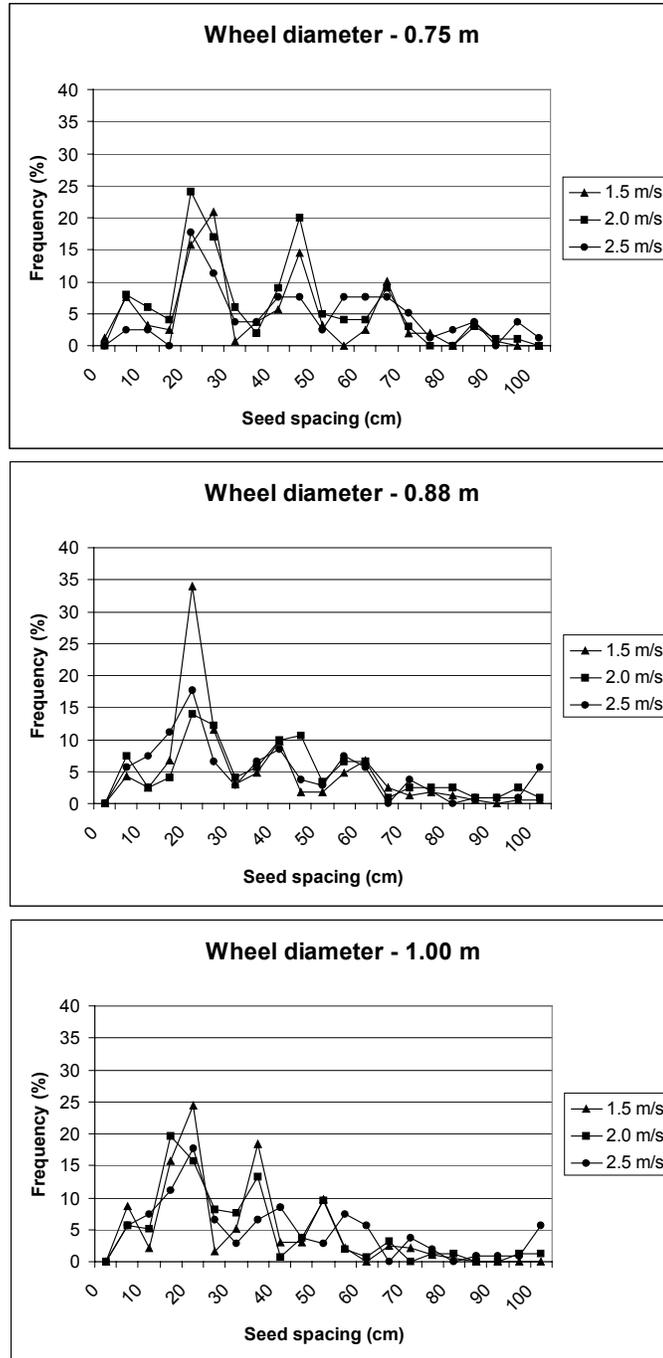


Figure 4 - Result of the prototype tests showing seed spacing frequency produced under belt conditions simulating forward speeds of 1.5, 2.0 and 2.5 m.s⁻¹ for three diameters of the wheel (1.00, 0.88 and 0.75 m) resulting in tip spacing of 0.21, 0.18 and 0.16 m.

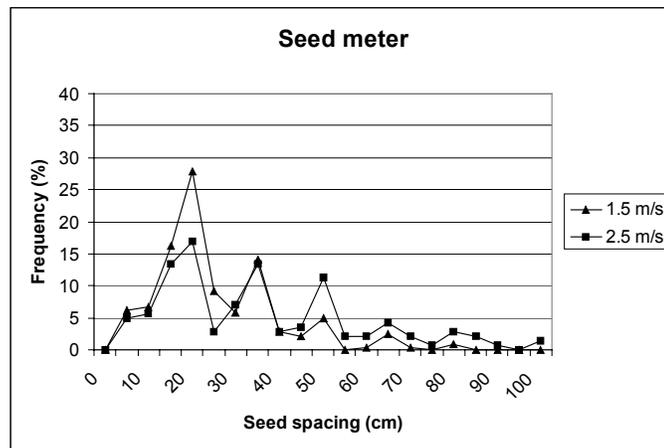


Figure 5 - Result of the frequency distribution of seed spacing produced by the seed meter under conditions of simulate speeds of 1.5 and 2.5 m.s² without the presence of the punches.

Results of the frequency distribution of seed spacing produced by the seed meter without the presence of the punches show the same tendency of frequencies associated to the nominal spacing. The levels of failure occurrences are equivalent to those of the frequency distribution of the prototype and are quite high and the deficiency is really in the seed meter and it should be treated separately.

Even with the deficiencies of the seed meter, the prototype was taken to the field, in areas of corn straw where conditions for no-till are the most severe (Figure 7). The objective of the tests in field was to verify the mechanical performance of the prototype, even without the direct concern on seed distribution. Assuming that the geometry of the parts involved with seed after the seed meter (punch and its relationship with the soil) practically did not alter from the previous prototype and that the action of the machine in terms of seed deposition into the holes was already known, only the wheel performance was observed. The prototype behaved as expected and some accessories are still on hold like an automatic depth control and seed meter automatic position associated with the external diameter of the wheel.

Conclusion

A prototype was developed and consists on a punch wheel that has the ability to adjust its diameter so the tips will change the distance, producing seed spacing that may vary from 0.16 to 0.21m. The device used for changing the distance between punches is based on a set of two plates with opposite spiral slots and a third plate with radial slots in between those two and the punches will expand or contract with an external effort. The prototype required a personalized vacuum seed meter that still needs some improvement.

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