DEVELOPMENT OF A NEW MACHINE FOR PLANTING PRE-CHITTED POTATOES

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1 INTRODUCTION

The use of pre-chitted potatoes is still very common in the seed potato growing areas in the Netherlands. In addition, though on a smaller scale, pre-chitted potatoes are planted in the starch potato growing area. Even and fast germination can be obtained only by planting undamaged pre-chitted seed. The short growing season for both these crops is the main reason for sticking to this labour consuming method.
For seed potatoes a healthy crop of sufficient size must be the ultimate aim, whereas with a crop for starch production, a high yield in the second half of August must be obtained.
The seed potatoes are pre-chitted in small trays, each containing about 10-12 kg. It depends on the size of the potatoes how many trays per hectare will be necessary. For example, 150 to 600 are needed for a planting rate of 60000 per hectare when planting respectively the sizes 28-35 and 45-55 mm.
In the past, pre-chitted seed was planted by hand and semi-automatic machines. In the latter case, one man was needed for every row. In addition, a tractor driver and an extra men for the transportation of the potatoes to the field were required. As the number of farm workers decreased considerably in the last 10 years, ways had to be found to automate the planting of pre-chitted seed without damaging the sprouts.
A first step in this direction was the modification of the Cramer automatic planter by a study group "farm mechanization" in the North of Friesland.
An agitated screen bottom was fitted in the hopper, enlarged for this purpose. The sprout damage was less than that of the standard machine but the capacity was too low. It took about 10 years before this study group conceived an idea for an entirely new planting system.
The Institute of Agricultural Engineering at Wageningen started research on this idea in 1971 and developed a first prototype that worked in practice in the spring of 1972. In the next year a second prototype was operated by a contractor.
Both contractor and customers were very satisfied which meant a demand for the machine for the following year. Therefore, a manufacturer had to be found for the production of a first batch. In close co-operation with this firm Machinefabriek H. de Vries, at St. Anna Parochie (Fr.), a first batch of five machines was

built for the 1974 season.

Principle

Except a laboratory model, all the prototypes were two-row machines. The idea was to convey the potatoes on a horizontal bed of belts on which a single line of potatoes must be formed.
The beds of belts are formed by mounting sheaves with different diameters on two shafts in such a way that a slope is obtained, thus preventing potatoes from falling off the sides, (see Figure 1).
Another important advantage of the various diameters of the sheaves were the differences in speed of the feed belts.
Each bed can be divided into two groups; in the centre there are four planting belts forming a trough, with the feed belts to either side. Planting belts and feed belts run in opposite directions. On the planting belts, a single line of potatoes is formed which are planted singly.

Belt material

A first laboratory model was equiped with V-belts. As these are non-elastic it was hard to find V-belts of the right length to form a tight bed of belts when placed together. Tightening of the belts by moving one of the shafts was impossible and an individual tensioning of each belt seemed to be the only solution. The decision was therefore taken to look for other materials.
P.V.C. and rubber were tested and the latter was chosen because of its low price in comparison with V-belts and P.V.C. belts and because it is very easy to glue in any length desired, even in the field.
The number of belts changed a number of times following practical experience (see Table 1).

Table 1. Number of belts used in the different stages of development

	Laboratory model	First prototype	Second prototype	First production series
Planting belts	4	4	6	6
Feed belts	18	17	26	22

The first models did not have sufficient space to meet all the practical requirements, such as planting large and irregularly shaped potatoes. Also the use of six instead of four planting belts meant an improvement, especially for the large tubers. Moreover, 4 belts form a definite trough, while the extra belts on either side of the trough stay at the level of the feed belts as the 4 planting belts are rising a little out of the bed.

Automatic control of the feed rate

The potatoes are dumped on to a conveying belt which conveys them to the bed of belts. As the number of potatoes leaving the bed of belts depends on the number of tubers to be planted, an automatic control of the feed rate was essential. The rear wall of the machine was therefore made movable. A microswitch installed behind this wall connects or disconnects an electro-magnetic clutch in the drive of the conveying belt. The rear wall is pushed back by an excess of potatoes. Depending on the setting more or less pressure is needed to connect the microswitch, thus stopping the conveying belt (Fig. 2).
In the first prototypes the rear wall moved in a horizontal plane and was spring-loaded to return automatically to its original position. The later models had a rear wall with a tilting motion supported by an adjustable counter weight to return to the starting position.

One conveying belt for two beds of belts

In a first two-row prototype one conveying belt supplied two beds of belts. As already stated, in the laboratory model the planting belts could be arranged asymmetrically in such a way that on the inside of the machine both beds had more belts than on the outside. The potatoes coming down from the conveying belt could not disturb the row of potatoes on the planting belts in this situation as the chosen width of the belt was within the row width (Fig. 3).
In the later models of the machine, in which the bed of belts was much bigger to ensure better filling of the planting belts, these belts were again at the centre of the bed.

Seed spacing

On the planting belts a single continuous row of potatoes is formed. To space these potatoes properly, the speed of the planting belts has to be adjusted. This depends on the desired number of tubers per metre on the planting belts in relation to the forward speed. The number of tubers per metre on the planting belts varies according to variety and grade. Therefore, an almost infinite transmission was needed to cover all possible combinations. For example, large potatoes (8-9 per metre) sometimes have to be placed at a close spacing, which means a high speed of the planting belts while, on the other hand, small potatoes may have to be planted at a wide spacing, which means a very low speed, all intermediate forms are possible.

Tuber distribution

At first the tuber distribution in the soil was very poor. At the end of the planting belts each tuber had its own moment, when it dropped into the furrow. Any fraction of a second difference between these moments led to an irregular spacing.
A foam plastic roller placed at the end where the potatoes leave the planting belts was an improvement (see Fig. 4). Each tuber is detained for a moment and the intervals between two tubers become more equal. Nevertheless, this system is affected by tuber size, so that the spacings cannot compete with those of conventional machines. To eliminate doubles a constriction can be introduced over a short lenght of the planting belts. This can be adjusted for each tuber size, which makes changing from one grade to another very simple (see Fig. 5).

Drive

The first prototype was hydraulically driven to have all desired belt speeds available. The second prototype and the later machines were ground wheel driven. A gearbox with sixteen well-chosen steps could cover all likely combinations of potato size and tuber spacing (Fig. 6).
The conveying belt was driven from the gearbox with a fixed tension. An electro-magnetic clutch was installed in this drive to control the number of potatoes conveyed to the bed of belts.

Field research

As the whole development was set up to construct a machine that could handle pre-chitted seed, the effect of the machine on the sprouts was investigated. The sprouts were counted and the number of sprouts was written on each tuber. After having passed through the machine, the sprouts were counted again and the sprouts left were examined. This was done with different grades and settings of the machine. The results are given in the Tables 2 and 3. The dates of the test are given because of the influence on the strenght of the sprouts. One should be very careful in comparing figures obtained on different days.

Table 2 Sprout damage from the laboratory model.

Date	Grade, mm	Forward speed, km/h	Spacing cm	Sprout damage, % broken off	Sprout damage, % top damage
2.2	35-45	3.6	28	3.5	13
2.2	35-45	5.4	28	3.3	12
2.2	35-45	7.2	28	3.3	14
29.3	28-35	3.6	28	4.0	8

Table 3 Sprout damage from the first prototype, planting in an open furrow.

Date	Grade, mm	Forward speed, km/h	Spacing cm	Sprout damage, % Not damaged	Sprout damage, % broken off	Sprout damage, % top damage
26.6	35-45	3.6	25	85.2	12.7	2.1
27.6	35-45	4.8	25	85.5	11.4	3.1
27.6	35-45*	3.5	25	54.7	31.1	14.2
2.6	45-55	3.6	25	81.5	8.5	10
2.6	45-55	4.8	25	77.5	6.6	15.8
2.6	45-55	6.0	25	72.1	8.8	19.1
2.6	45-55*	3.6	25	62.1	17.8	20.1

*
An automatic cup fed planter was used as a reference machine.

The field study was not confined to assessing the sprout damage The effect on yield and grade were of great interest for the further development of the machine, therefore an extended trial was carried out, with five replications. A hand-fed, a cup-fed and the newly developed belt fed machine were compared with two grades of the variety Bintje. The number of tubers emerged were counted. The results are given in Fig. 7.
As the conditions for all machines were the same, the differences can be attributed to the level of sprout damage caused by the different planting systems.
The differences were very clearly visible throughout the season. The haulm of the crop was killed by flaming on the 17th July. The growth of the crop is stopped immediately with this method. The number of stems per square metre were counted and yield samples were taken by digging almost 50 m^2 per plot. The data are given in Table 4.

Table 4 Yields in t/ha and number of stems per m^2

Machines	Prototype		Hand fed machine		Cup fed machine	
Grade of seed in mm	35-45	45-55	35-45	45-55	35-45	45-55
Total yield	36.1	39.1	34.9	37.8	34.6	36.3
No. of stems	39	38	34	36	34	37
Grade in mm						
28	2.4	1.9	2.4	1.8	2.1	2.1
28-35	8.0	6.5	7.9	6.2	7.2	6.8
35-45	20.0	21.9	20.0	21.6	20.3	21.3
45-55	5.6	8.6	4.3	8.2	5.5	6.1

The results demonstrate that the yield can be affected by the planter. The degree of sprout damage caused differences in yield of about 1.5 to over 2 t/ha.
The hand fed machine caused even more sprout damage than the belt fed one. Probably this was due to the operators picking the potatoes too hastily out of the trays.
As the amount of pre-chitted potatoes was limited, the automatic (cup fed) machine was only filled once. This never led to the maximum sprout damage. In practice one hears of greater differences.

Trials in the starch production area

Two varieties of potatoes were planted with the cup fed planter having an agitated screen bottom, and the belt fed machine. One variety, Promiment, is specially suitable for late delivery and has weak sprouts while the other variety, Element, has strong sprouts and is specially bred for early delivery.
On three dates samples were taken to estimate the yield, stems were counted on the first two dates. The data are given in Table 5.

Table 5 Yield in t/ha and number of stems per m^2

Variety	Machine	Aug. 6th	Aug. 31st	Sept. 10th
Prominent	Belt fed	31.2(32.8)	48.9(31.2)	67.8
Prominent	Cup fed	28.3(28.8)	46.5(26.4)	60.8
Element	Belt fed	44.5(30.4)	58.3(32.4)	68.3
Element	Cup fed	42.7(30.8)	56.6(30.8)	65.2

* Research workers of the Machinery Research Division

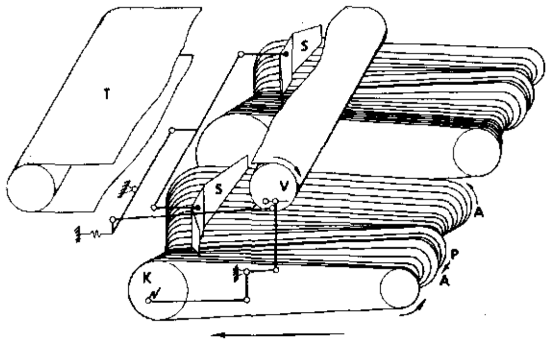

Fig. 1 Schematic drawing of the principle
T conveying belt
A feed belts
P planting belts
K crank
V freewheel clutch

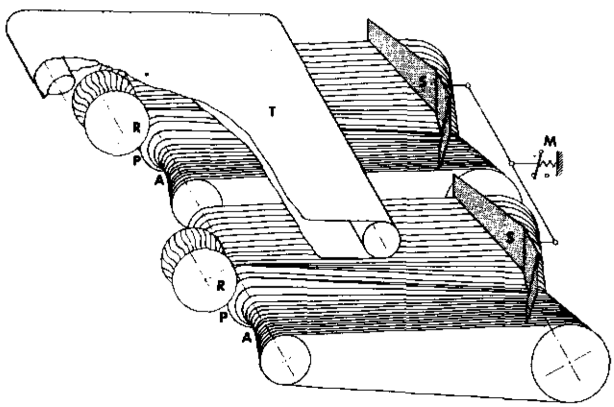

Fig. 2 Schematic drawing of the first factory machine equiped with micro switch to control the flow of potatoes
T conveying belt
A feed belts
P planting belts
S rear wall
M micro switch
R foam plastic roller

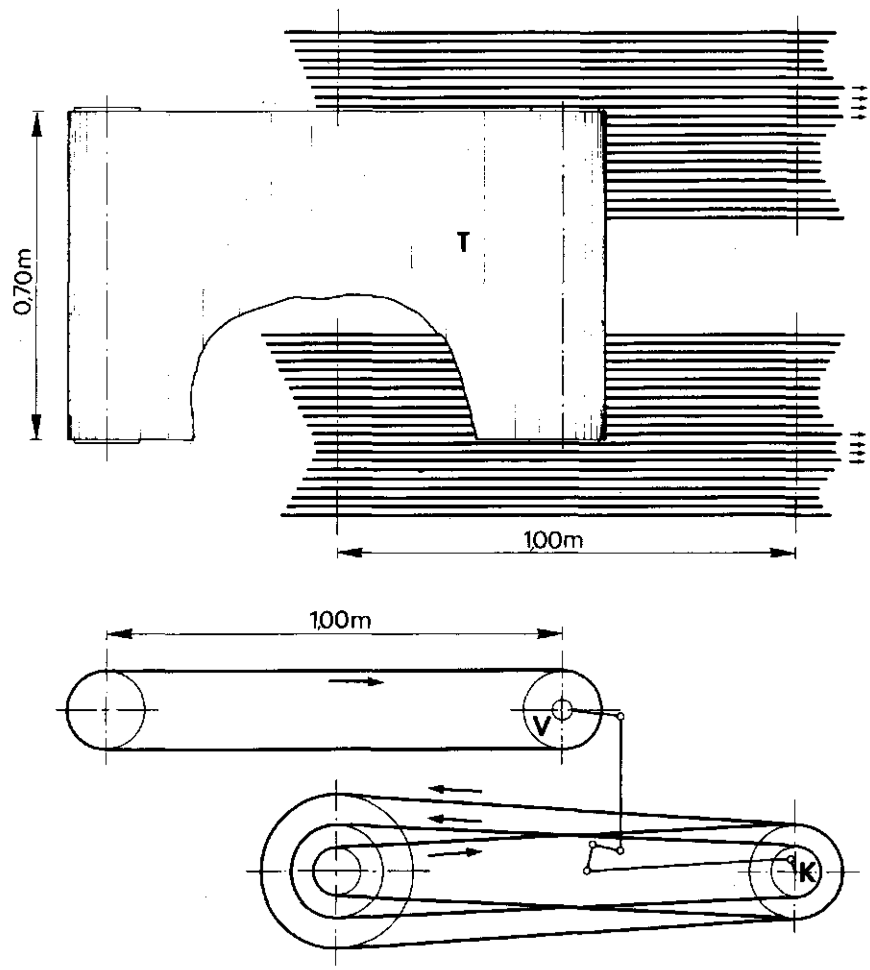

Fig. 3 Schematic drawing of the first prototype
T conveying belt
A feed belts
P planting belts
K crank
V freewheel clutch

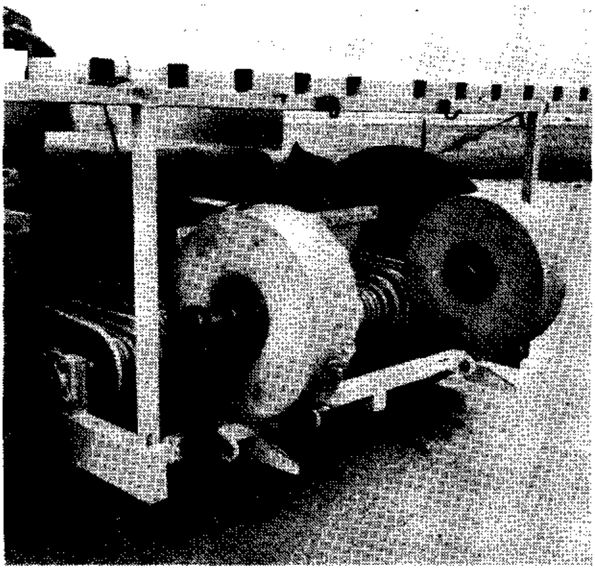

Fig. 4 Foam plastic roller installed to control moment of dropping of the seed into the furrow.

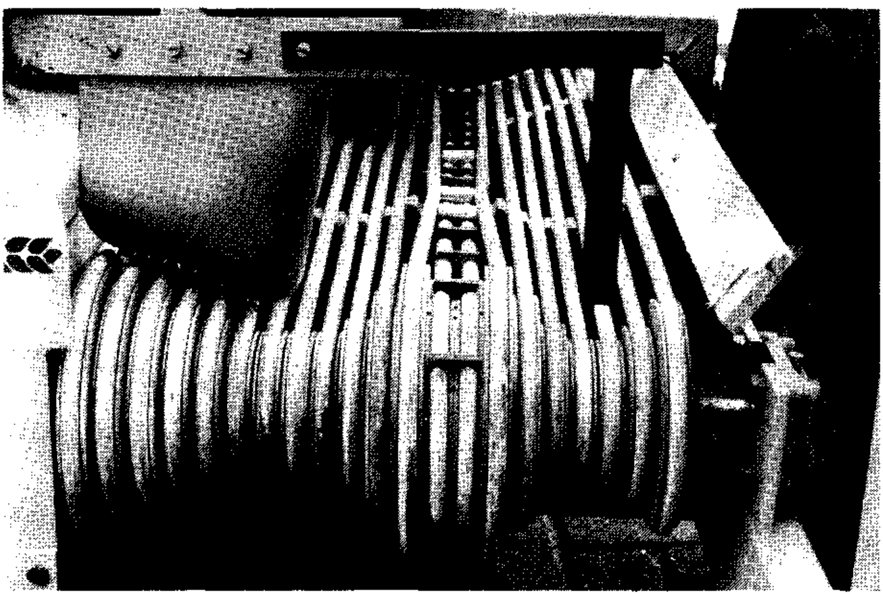

Fig. 5 Constriction of the planting belts to eliminate doubles.

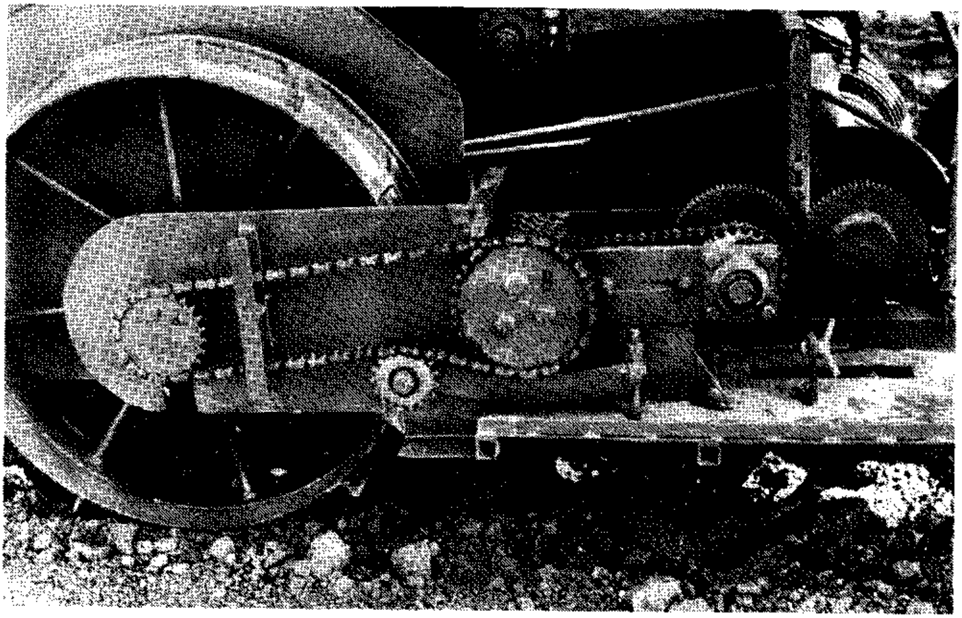

Fig. 6 Gearbox with 16 steps to cover all possible combinations of tuber size and planting rate of the wheel driven version.

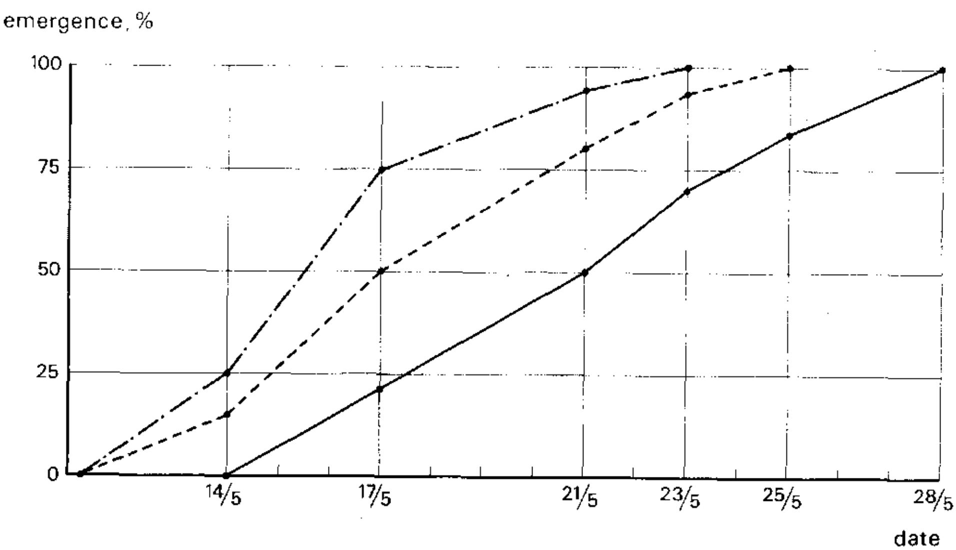

Fig. 7 Comparison of the effects of three planting systems on the rate of emergence (var. Bintje).

——— cup fed machine
- - - - - - hand fed machine
—·—·— belt fed