DEVELOPMENT OF A GARLIC CLOVE PLANTER

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ABSTRACT

Positioning garlic cloves in upright standing in garlic field has been regarded as a very important job because it affects clove rooting, growing and, eventually, quality and yield in garlic production. Because of the geometrical uniqueness and irregularity of garlic cloves in shape, the planting operation has been conducted by manual work that needs a tremendous human labors and increases garlic production cost. The overall objective of this research was to develop garlic planting machine through investigating physical properties of garlic and designing clove upright positioning device after figuring out the factors affecting metering device and upright clove positioning mechanism. With the outcomes of the metering and posture positioning experiment, a garlic clove planter having twelve planting rows was developed for 37kW type tractor and feasibility test was carried out in the field. And, According to the performance test and cost analysis, the planter could accomplish planting operation of one hectare plot in 6.3 hours giving 48 times better efficiency, 6.3hrs/ha, and 74.2% of production cost reduction effect, 1,092,546won/ha, than the manual works of 299hrs/ha and 282,258won/ha. And, break-even point of the planter was calculated as of 2.71 hectares.

Key words : Garlic clove planter, Metering device, Upright-positioning and planting device, Clove positioning hopper, Upright-position planting hopper, Break-even point

INTRODUCTION

Based on the survey results of garlic cultivation regions in Korea, considering growth, quality and harvest productivity of garlic, it is desirable to develop a garlic clove planter putting upright position on the ground. And it should be equipped with rotary device in order to eliminate the effect of the wheel rotation.

In this paper, based on the results of the metering and positioning experiments, a 12 row garlic clove planter mounted to a 37kW type tractor was developed and tested for the feasibility in the field. And analyzed for the economic of developed garlic clove planter.

MANUFACTURE OF A GARLIC CLOVE PLANTER

1. Garlic clove metering device

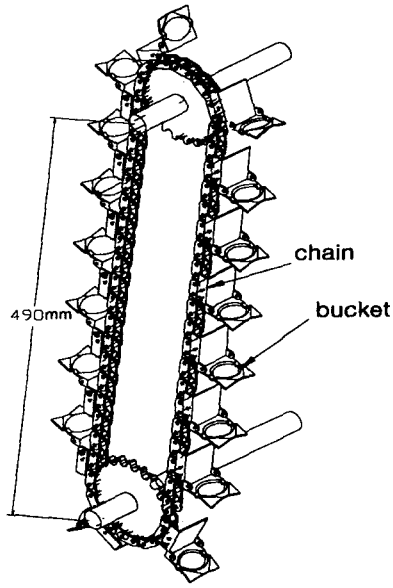


Fig. 1. Drawing of the prototype Garlic clove metering device.

Garlic clove metering device utilizing the mechanism of chain bucket vibration is made to pick up one clove by each bucket that can be covered with a cap. As shown in Figure 1, the device has two sprockets that are fixed onto two separate axles, and it works as the sprockets, connected to each other by a chain carrying buckets, revolves around the axles. While the buckets that contain cloves move vertically, the vibration produced by the vibration producing bar, enables the device to adjust and contain only one clove per each bucket. In the process of planting, it is possible for a metered clove to fall out of the bucket when the garlic clove planter is swayed by any obstacles on the field, and this is prevented by installing a cap to cover each bucket.

2. Garlic clove upright-positioning and planting device

In order to plant cloves in an upright position, it is necessary for the garlic clove planter to employ the clove upright-positioning system which induces a clove to correct its posture to an upright position. Therefore, clove upright positioning and planting device is made of clove positioning hopper(2.1.) and upright position planting hopper(2.2.).

2.1. Clove positioning hopper

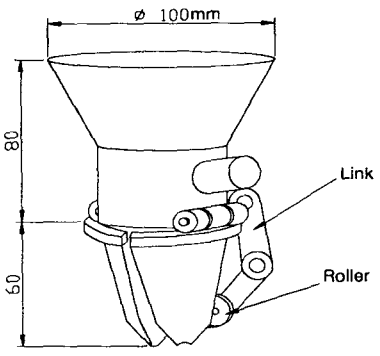


Fig.2. Drawing of the prototype clove positioning hopper.

As shown in Figure 2, the clove positioning hopper is composed of two openings: one is the mouth part where the metered clove is introduced to be repositioned, and to maintain the upright position: and the other part is an outlet where the upright-positioned clove is discharged into the planting hopper. The up-and-down movement of the link that is attached on the side of the hopper

makes it possible to open or close the outlet for the discharge of the clove.

2.2. Upright-position planting hopper

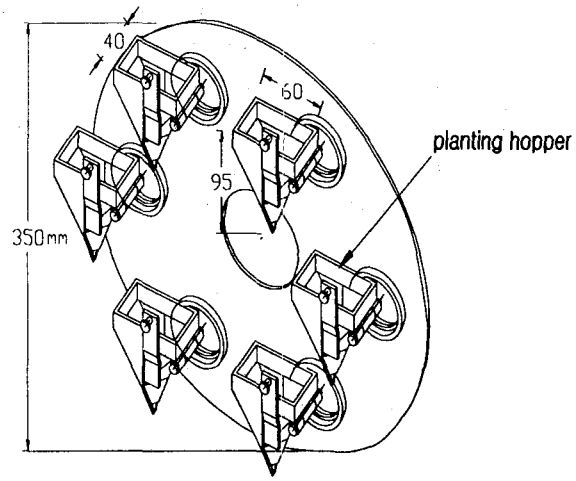


Fig. 3. Drawing of the prototype upright-position planting hopper.

As shown in Figure 3, the upright position planting hopper system consists of six small planting hoppers, and each hopper is attached by an axle onto a round plate that is also fixed to an axle. As the planting hopper system revolves around the axle, each planting hopper plants each garlic clove in an upright-position. The center axle of the round plate and the axles of the hoppers are geared in to maintain the upright position of the hoppers. The planting hopper system is designed in such a way that when the bottom part of the hopper reach the field, it opens its outlet for the discharge of a clove, plant the clove in an upright position, and closes itself as it revolves away from the field. This planting process is done successively by six hoppers as they reach the field one after another, and the lengths of the outlet part of the hopper that opens and closes, are different – one side is longer than the other – in order to prevent cloves from falling off.

MATERIALS AND METHODS

1. Field performance test

1.1. Tested material

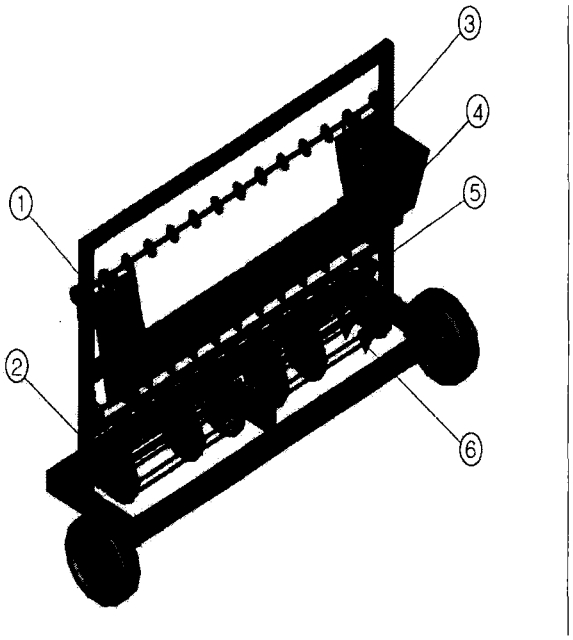
The tested material for the field performance test on the garlic clove planter is Seosan garlic, a Hanji type, and the dimensional properties of garlic cloves used in the test are described in the Table 1.

Table 1. Dimensional properties of garlic cloves used in the field tests(N=130).

Dimension	Minimum	Maximum	Average	S. D.
Length(mm)	31.0	57.0	47.1	5.1
Width(mm)	12.0	20.0	15.8	2.0
Thickness(mm)	14.0	23.0	17.5	2.2
Weight(g)	2.1	6.0	3.4	1.0

1.2. Tested garlic clove planter

The garlic clove planter developed through this research work can be linked to 37kW type tractor, and it can plant 12 rows with row spacing of 140mm and hill spacing of 120mm. Rotary is attached in front of the garlic clove planter so that it can eliminate the tire tracks and thus even out the field ready for planting. While being driven, the driving power of the garlic clove planter is generated from the rotating wheels, which are connected by a chain. When a metered clove in a bucket falls into the clove positioning hopper, it repositions itself to an upright position. And when the upright position planting hopper moves to right below the bottom part of the clove positioning hopper, the outlet for discharge opens and drops down a clove into the upright-position planting hopper. Maintaining its upright position, the planting hopper then rotates to plant the clove on the field completing a cycle of this planting system. Figure 4 shows the structure of the garlic clove planter and Table 2 presents the specifications for the garlic clove planter.



1. Metering device 2. Planting device 3. Cap type bucket 4. Garlic clove hopper
5. Clove positioning hopper 6. Upright-position planting hopper

Fig. 4. Drawing of the prototype garlic clove planter.

Table 2. Specifications for the prototype garlic clove planter.

Items		Type and specification
Type		Tractor attached 12-row
Size(L×W×H)(mm)		1,360×2,200×1,340
Weight(kg)		720
Metering device	Type	Bucket & cover attached chain
	Inclination angle(°)	80
	Bucket size(mm)	45×50×52
Planting device	Type	Rotating hopper
	Clove positioning hopper(mm)	ϕ 100×140
	Upright-position planting Hopper(mm)	60×40×95
Driving power		Rotating wheel driven

1.3. Testing method

The garlic clove planter that has been manufactured and used for the field test is the type with 12-row planting, with row spacing of 140mm and hill spacing of 120mm, and the distance between the clove positioning hopper and the upright-position planting hopper has been set to 4mm, which was found to be optimum from the primary test. As shown on Figure 5, the clove planter was attached to a 37kW tractor and was tested on the field for its efficiency in planting. The tractor was driven to plant the test field of 25m, making a round trip for the total distance of 50m, at the speed of 0.15m/s, set at low speed gear 2.

Fig. 5. Field tests of the tractor attached garlic clove planter.

Since the clove planter can plant 12 rows with hill spacing of 120mm, the expected number of the total garlic cloves planted is calculated to be about 5,000 cloves. From the planted field, 30 different sites with the same area(width of 1,400mm, length of 360mm) were chosen arbitrarily for sample study, 30 cloves were planted in each of the sample

sites, and all the cloves from 30 different sample sites were evaluated on how they were planted by the planter. And then they were analyzed statistically for the upright-landing rate, side landing rate, upset-landing rate, and missing rate.

2. Economic analysis

In order to analyze the cost-efficiency of the garlic clove planter, fixed cost and variable cost for the manual work and for the automated work done using the garlic clove planter, were calculated and compared for the cost cutting effect on the automated planter in terms of planting effort and expenses.

RESULTS AND DISCUSSION

1. The upright-landing rate from the performance test

From the field planted with the garlic clove planter developed from this research, 30 different sample sites were arbitrarily selected to observe the conditions of the 30 planted cloves from each of the sites. The cloves were differentiated by their conditions into four categories such as upright-landing, side landing, upset-landing, and missing, and the cases where two cloves were planted were also studied at the same time. From this study, the rate of the upright-landing from each of the sample sites fell in the range of 76.6 to 90%; for the side landing and upset-landing that result in poor germination and growth, affecting even the surrounding cloves, and cause poor quality and less harvest, the rates fell in the range of 3.3 to 10%, and in the range of 0 to 10%, respectively; the missing rate fell in the range of below 10%. With this result, the average of the overall rates were figured out; the upright-landing rate of 81.8%, the side-landing rate of 7.1%, upset-landing rate of 5.7%, and missing rate of 5.4%. And the rate of upright-landing from this performance test was statistically analyzed with the confidence interval of 95%. Consequently, with the confidence interval of 95%, the upright-landing rate is calculated to be $81.8 \pm 1.39\%$.

2. Cost-benefit analysis

The labor hours required for planting by the garlic clove planter is 6.3hrs/ha, while the labor hours by manual work is 299hrs/ha. This indicates that the former is 48 times more efficient than the latter which was done through manpower. The input cost for upright-position planting by the planter is 282,258₩/ha, whereas it cost 1,092,546₩/ha for manual work, which shows that the automated work has 74.2% more cost-cutting effect when compared to that of manual work. Therefore planting done by the garlic clove planter is found to be far more effective economically than planting done through the manpower. Figure 6 is the comparison between automated work and manual work in working performance and input cost.

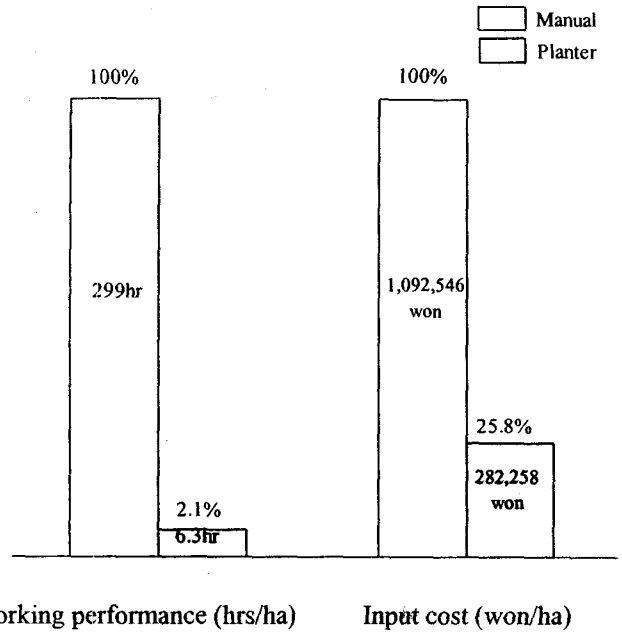


Fig. 6. Comparison of the garlic planter with manual work in working performance and input cost.

Furthermore, the break-even cost was calculated to analyze the size of the cultivation area where the clove planter can bring more cost effectiveness than the manual work can. The annual fixed cost being 2,794,086won, the manual cost was 1,092,546won per ha, whereas the operation cost for using the machines for automated work was 282,258₩/ha including the variable cost of 62,231won per ha. With this result, the break-even point is calculated. Figure 7 shows the break-even point of the garlic clove planter.

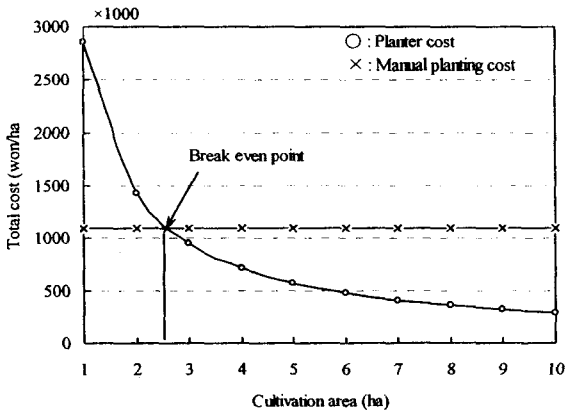


Fig. 7. Break-even point of the garlic clove planter.

The operation cost, which varies depending on the size of the cultivation area, decreases gradually as shown on Figure 7 until it reaches the break-even point with the manual cost of 1,092,546won, and at this point, the size of the cultivation area is found to be 2.71ha or greater. When planted on this size of area of 2.71ha or greater, the automated planting by the garlic clove planter is found to be far more effective than planting manually.

CONCLUSIONS

The following conclusions were reached in this work;

1. Based on the survey results, a garlic clove planter should have a planting capacity of at least 140 cloves in a pyung with the row spacing of 140mm and hill spacing of 120mm for a productive cultivation.

2. Based on the results of the metering and positioning experiments, a 12 row garlic clove planter mounted to a 36.8kW tractor was developed and tested for the feasibility in the field. The field test showed the upright, side and upset landing rates of 76.6 ~ 90%, 3.3 ~ 10% and 0 ~ 10% respectively, depending on the operating skill and bed preparation. Further studies are recommended for improving performance of the clove positioning hopper under tractor vibration.

3. According to the performance and cost analysis, the garlic clove planter could have a capacity of 6.3hrs/ha, 48 times better efficiency, and a reduced product cost of 282,258₩/ha, 74.2% less cost, compared with manual works of 299hrs/ha and 1,092,546 ₩/ha, respectively.

4. The break-even point of the designed garlic clove planter was expected as of 2.71 hectares.

REFERENCES

1. Choi. D. K. et al.. 1998. Development of Garlic Planter-Development of Metering Device. Proceedings of the KSAM '98 Summer Conference 3(2) : 27-34
2. Lee. Y. B. et al.. 1998. Development of Mechanization Model for Garlic Cultivation. Proceedings of the KSAM '98 Summer Conference 3(2) : 72-81
3. National Agricultural Mechanization Research Institute. 1998. Annual Research Report : 281-288
4. National Agricultural Mechanization Research Institute. 1999. Annual Research Report : 267-273
5. Rural Development Administration. 1999. Method of Economic Analysis : 39-60