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THE QUALITY OF FORMING RIDGES BY AGGREGATE WITH PASSIVE AND ACTIVE WORKING ELEMENTS

Summary

The paper presents a prototype of a combined aggregate for forming ridges, developed under the target oriented project, in collaboration Industrial Institute of Agricultural Engineering in Poznan with the BOMET Węgrów company. The results of prototype tests are shown, with regard to the quality of forming ridges in various versions of aggregate.
***Key words**: aggregate, passive and active working elements, ridge, potato, carrot*

JAKOŚĆ FORMOWANIA REDLIN AGREGATEM Z BIERNYMI I AKTYWNYMI ELEMENTAMI ROBOCZYMI

Streszczenie

Przedstawiono prototyp kombinowanego agregatu do formowania redlin, opracowany w ramach projektu celowego, we współpracy Przemysłowego Instytutu Maszyn Rolniczych w Poznaniu z firmą BOMET Węgrów. Omówiono wyniki badań prototypu w zakresie jakości formowania redlin agregatem w różnych wersjach roboczych.
***Słowa kluczowe**: agregat, bierne i aktywne elementy robocze, redlina, ziemniak, marchew*

1. Introduction

Today on the ridges are grown not only potatoes but also root vegetables, such as carrots [1], because they create good conditions for plant growth and harvest. However, if the potatoes are covered after planting, carrot seeds are sown on previously prepared ridges. This technological difference causes usage of various machines for forming ridges for potatoes and carrots. While the potatoes are covered, the working elements loosening the soil before covering corps can be set only in the inter-row, and the elements profiling crest of the ridge can't compact soil too strongly for not to cause damage to budding potatoes. During ridges formation for sowing the seeds of root vegetables the soil can be loosened across the entire width, and the last forming ridge element is a spool shaft, which heavily concentrates the top of the ridges and immunizes their deformation during sowing. Manufacturers offer both types of machines: passive and active [1, 2], which have more power, but provide better soil crushing. Technological changes include not only the way of forming ridges, but also their increased spacing. Currently, the standard ridge spacing is 75 cm [1, 2], and a wide and erosion resistant ridges provide a higher yield and commercial quality of potatoes or carrots.

Industrial Institute of Agricultural Engineering in Poznan in collaboration with BOMET Węgrów company developed, in the target oriented project ROW-III-265/2012, the construction of a combined aggregate, equipped with passive and active working elements. Aggregate, thanks to the possibility of different arrangement of the passive teeth, module distribution of knives in active milling drum and removable elements for ridges forming can be used both in the potato and carrots cropping [3].

2. Aggregate construction

Main components of aggregate for forming ridges, used in both versions are: the support frame with suspension system and covers, passive teeth, active milling drum driven from the tractor PTO and adapter with covering corps. In the version for potato cover the aggregate is additionally equipped with ridge forming shaped plates (fig. 1), and 3 passive teeth which are set in the inter row. However, in the version for the ridge formation for sowing carrots the aggregate is additionally equipped with spool shaft, guide wheels (fig. 2) and 2 passive teeth which are set in longitudinal axes of the ridge.

At first the soil is loosened by passive teeth and knives of active milling drum, which are arranged segmentally and loosen the soil before the covering corps. Milling drum has a concurrent rotation to the direction of work and had protection shields against ejection of soil and stones.

Fig. 1. Aggregate suitable for ridging potatoes during work [3]
Rys. 1. Agregat przystosowany do obsypywania ziemniaków podczas pracy [3]

Fig. 2. Aggregate with a spool shaft during work [3]
Rys. 2. Agregat z wałem szpulowym podczas pracy [3]

Rear hinged shields allows access to the milling drum during maintenance. The swinging cover are repealed under the pressure of the soil and closes the gap between the aggregate support frame and adapter with cover corps. The ridges are pre-formed by covering corps which are screwed under the adapter cover whose are connected to the aggregate frame with adjustment screws and fasteners. Side screws and fasteners allow adapter leveling and two top screw, equipped with shock-absorbing springs, allow to adjust the height of the adapter.

Ridges pre-formed by covering corps are final molded by cover plates or spool shaft. Cover plates have a tunnel tapered shape at the rear part and are connected to the adapter cover with screws and springs biasing them into ridge crests. The spool shaft is connected to the adapter frame by side connecting arms and the upper adjusting screw with the overload spring. Section of the spool shaft, consisting of a tubular axis and with adjustable spacing plates, are driven by a hydraulic motor through the side chain transmission. This solution of spool shaft drive makes it easy to assemble during the change of the aggregate version.

3. Quality of forming ridges

During the tests aggregate worked with the Ursus 912 tractor (80 HP), which at its maximum working loads allowed for a working speed up to 5 kmph. Quality of forming ridges checked on medium soils, on fields after seasoned plowing and shallow stubble cultivation.

Aggregate version for covering potatoes are checked off agrotechnical season, so in order to evaluate the quality of covering, before passing through the aggregate, the potato row was placed in the soil at a depth of about 5 cm, which corresponds to the depth of potato planting. After aggregate drive the ridge was opened and it could be stated that the potatoes are in the axis of the ridge at a depth of about 15 cm from the top of the ridge. This means that the potatoes are properly covered, and the cover corps and cover plates will not cause damage to germinating potatoes.

Passive teeth loosen the soil directly in front of the milling drum knives (fig. 3).

Table 1. Technical characteristics of the aggregate to form the ridges [3]
Tab. 1. Charakterystyka techniczna agregatu do formowania redlin [3]

Parameter	Unit	Data	
Purpose	-	potato covering	ridges formation for sowing the seeds of root vegetables
Aggregate type	-	suspended, combined	
Loosening soil elements	-	passive teeth active milling drum	
Ridge forming elements		covering corps covering plates	covering corps spool shaft
No. of forming ridges	items	2	
Ridge spacing	cm	75	
Working width	m	1,5	
Power demand	KM	70	80
PTO rotation	rpm	540	
No. of passive teeth	items	3	2
Number of knives on milling drum	items	30 (14 in the middle segment, 8 in side segments)	
Working width of the middle segment of knives on the milling drum	mm	340	
Working width of the side segment of knives on the milling drum	mm	190	
Free space between knive segments on the milling drum	mm	410	
Diameter of the milling drum	mm	720	
Rotation of milling drum	rpm	245	
Disc diameter in spool shaft	mm	-	495
Rotation of spool shaft	rpm	-	up to 250
Dimensions			
- width	mm	1980	
- height	mm	1200	
- length	mm	2320	2800
Mass	kg	715	900

Fig. 3. Working tracks of 3 passive teeth, knives of active milling drum and ridging corps [3]
Rys. 3. Ślady pracy 3 biernych zębów, noży aktywnego bębna frezującego i korpusów obsypujących [3]

The advantage of setting three teeth between the rows is loosening the wheel tracks of the tractor (fig. 4) and leave plump furrows between ridges. The maximum working depth of the milling drum is 20 cm, but field trials have shown that good loosening of the soil to form ridges can be obtained even at the trough of 15 cm. The maximum working depth of passive teeth is 25 cm, and may be set at the level of the milling drum or up to 10 cm below. The studies found no difficulty in maintaining a constant working depth while keeping the front of the aggregate by tractor's hydraulic lift and the rear supported by adapter with covering corps.

Knives of milling drum throw out crushed and mixed soil with plant residues to the back, under cover of the adapter with covering corps. The studies did not show the soil thrown outside the restricted area of protective cover of milling drum. Quality of formed ridges depends primarily on the height between the adapter and the milling drum.

Fig. 4. Passive tooth behind the wheel of the tractor [3]
Rys. 4. Bierny ząb za kołem ciągnika [3]

The study found that the adapter should be set to 5 cm above the milling drum to undercut by the blades only the loosened soil. Adapter set too low, limits penetration of milling drum and causes excessive soil movement on front wall of the upper lid, which causes a negative increase in operating resistance. On the other hand, setting adapter too high worsens preforming ridges, caused by insufficient amount of soil turned by covering corps. It is very important for the correct leveling of the adapter, and their upper lid was bent back and tightened top of the ridges only their rear part. The study tested the quality of forming ridges with same adapter (with covering corps) and adapter equipped additionally with covering plates. It was found that the shaped overlays improves the quality of forming ridges, providing good ridges forming even at higher setting of plates. Extension springs forcing pressure and tightened plates to ridge crests providing fixation of their shape (fig. 5) without excessive soil compaction. Parameters of ridges formed by plates, measured during the study were as follows: the height of the ridge - 26-30 cm, width of the crest of the ridge - 22-24 cm, width of the base of the ridge - 63-65 cm, width of the bottom of the furrow between the ridges - 10-12 cm. Open pit made during the tests showed good soil structure in the wide ridges, no large lumps of soil and empty spaces and plump bottom of furrows between ridges.

Fig. 5. Cover plates forming ridges [3]
Rys. 5. Nakładki formujące grzbiety redlin [3]

Aggregate version for forming ridges at carrots sowing loosens the soil across the entire work width, as segment-spaced knives of milling drum loosen the soil between the footsteps of the passive teeth (fig. 6).

Fig. 6. Working tracks of 2 passive teeth, knives of active milling drum and ridging corps [3]
Rys. 6. Ślady pracy 2 biernych zębów, noży aktywnego bębna frezującego i korpusów obsypujących [3]

The advantage of setting two teeth in formed ridge axis is the opportunity to further loosened the soil under ridges. Adapter with covering corps may be set, in this case, slightly higher than in potatoes covering version, because good pressing and preserve the shape of the ridges take a spool shaft. The study tested the quality of the ridges formation at different working speeds and different spacing of the plates in spool shaft forming the ridges escarpment. It was shown that the spool shaft in moist soil conditions well forming ridges, thickening and smoothing when its speed

exceeds 120 rpm, and the spacing of the plates is in the range 250-300 mm. With such a set of operating parameters of the spool shaft crests and escarpments of ridges are well smoothed (fig. 7).

Fig. 7. Ridges formed by spool shaft [3]
Rys. 7. Redliny uformowane wałem szpulowym [3]

Fig. 8. Ridges concentrated by spool shaft does not break down under the pressure of the foot [3]
Rys. 8. Redliny zagęszczone wałem szpulowym nie rozpadają się pod naciskiem stóp [3]

Fig. 9. Cross section of the ridge formed by spool shaft [3]
Rys. 9. Przekrój redliny uformowanej wałem szpulowym [3]

At lower speeds of the shaft the pushed soil break and it is impossible to obtain smoothed surfaces of the ridge crests. Also when the plates have too high spacing the ridges are irregular in shape, because the spaces between the plates are too large relative to the ridge pre formed by covering corps. The quality of forming ridges, especially soil compaction, depends primarily on the altitude of the spool shaft with relative to him the preceding adapter with covering corps. Properly set spool shaft presses the ridges formed by covering corps reducing their height by 3-5 cm. The height of plates for smoothing ridge escarpment is less than the height of ridges and is 16 cm, which provides a good basis for pressing the base of the ridges. Parameters of ridges formed by spool shaft, measured during the study were as follows: the height of the ridge - 24-28 cm, width of the crest of the ridge - 25-30 cm, width of the base of the ridge - 63-65 cm, width of the bottom of the furrow between the ridges - 10-12 cm. Open pit made during the tests showed good structure and density of the soil in the ridges. Ridges retain its shape under the pressure of the foot (fig. 8), which indicates their good durability and sowing on flat crests. Soil under the ridge have also correct structure as a result of loosening of the passive teeth (fig. 9), which should provide a good soaking of water to the ridge. The swell depth of the soil under ridges depends on relative recess of passive teeth to the knives of the milling drum which can be up to 10 cm higher. The studies found no difficulty in maintaining a constant working depth while keeping the front of the aggregate on copying wheels and rear on adapter with covering corps and spool shaft.

4. Conclusions

1. Aggregate equipped with passive teeth and active milling drum allows good loosening of the soil before the covering corps, with the minimum working depth of the milling drum, ensuring good forming ridges from loosened soil is 15 cm.

2 Passive teeth with adjustable trough to the knives of active milling drum, allow deeper (by a maximum of 10 cm) loosening the soil between the rows of covered potatoes or under ridges formed into carrots sowing.

3 The quality of the initial ridges formation depends on placing the adapter with the covering corps and milling drum, corps should be recessed to 5 cm shallower than knives of milling drum and the top plates should be tilted back.

4 The shaped plates, mounted with tension springs on the adapter with covering corps, improve the quality of forming ridges perpetuating the shape of the ridges without excessive soil compaction.

5 Spool shaft presses the ridges, smooth out the top of the ridges and escarpments, but the quality of his work determines the relative height to the covering corps, rotation speed (minimum 120 rpm) and the distance between the plates (250-300 mm).

5. References

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