Włodzimierz TALARCZYK, Tomasz SZULC, Jan SZCZEPANIAK, Łukasz ŁOWIŃSKI
Przemysłowy Instytut Maszyn Rolniczych
ul. Starołęcka 31, 60-963 Poznań, Poland
e-mail: office@pimr.poznan.pl

FUNCTIONAL VERIFICATION OF UNIT FOR STRIP TILLAGE, FERTILIZATION AND CORN SOWING

Summary

Results of functional verification of unit for strip tillage, fertilization and corn sowing, developed by the Industrial Institute of Agricultural Engineering in Poznań under the project PBS1/B8/4/2012 are shown. Experimental model of the unit consists of two working modules, which allows simultaneous strip tillage with deep application of large fertilizer granules, and corn sowing with shallow application of small fertilizer granules. Purpose of the study was to verify unit in the field conditions.
***Key words**: Strip-Till, fertilization, corn sowing, azomais*

WERYFIKACJA FUNKCJONALNA AGREGATU DO UPRAWY PASOWEJ, NAWOŻENIA I SIEWU KUKURYDZY

Streszczenie

Przedstawiono wyniki weryfikacji funkcjonalnej modelu badawczego agregatu do uprawy pasowej, nawożenia i siewu kukurydzy opracowanego w projekcie PBS1/B8/4/2012 realizowanym w ramach Programu Badań Stosowanych. Model badawczy agregatu składa się z dwóch modułów roboczych umożliwiających wykonanie jednoczesnej uprawy pasowej z głęboką aplikacją nawozu w postaci dużych granul oraz siewu kukurydzy z płytką aplikacją nawozu w postaci małych granul. Celem badań była weryfikacja funkcjonalna modelu agregatu w warunkach polowych.
***Słowa kluczowe**: uprawa pasowa, nawożenie, siew kukurydzy, uprawa, azomais*

1. Introduction

Soil preparation for corn sowing is performed in different systems or completely omitted in the case of direct sowing in the uncultivated soil. Traditional plowing, with a number of supplementary cultivation, still predominates. Simplifications in cultivation are used more often. They consist in the replacement of plowing by strip tillage. Most treatments performed in the no-tillage system include cultivation of the soil over the entire surface of the field, but in the case of corn, it is also possible to use strip tillage. Strip-Till has the advantages of intensive tillage and direct sowing [2]. It consists in the deep soil loosening and seedbed cultivation in narrow strips. It can be used without prior cultivation, or with prior stubble cultivation, which can be combined with sowing a catch crop destined for mulch. During strip tillage the mineral fertilization and corn sowing can be done [1].

Industrial Institute of Agricultural Engineering in Poznań, under the project PBS1/B8/4/2012, has designed and built a research model of the unit for strip tillage, fertilization and corn sowing [3, 4]. Next functional test on the field was carried out.

2. Purpose of research

Aim of the research was to verify Strip-Till unit functionality. Verification consists of checking functional cooperation with tractor and quality assessment of strip tillage cultivation, fertilizer application on different depth and corn sowing.

3. Unit research model

Unit for strip tillage consists of two working modules. They are connected by a coupler, which can be moved hydraulically. It is a four row unit, with a working width of 3 m (4 x 75 cm).

The first module is a semi-mounted unit with sections for strip tillage and fertilizer drill placed on frame (fig. 1). Each section for strip-till consist of: wheels, coulter, cleaning stars, tooth, discs and tube disk roller. Fertilizer drill is built on main unit frame with four support beams. Rail and foldable ladder ensure safe access to it. Large granules of fertilizer (10 mm) are dosed from tank with electrically driven rotors. Then they spill gravitationally through elastic tubes, which applies them deeply (up to 30 cm behind teeth). Main frame is equipped with drawbar and hydraulically adjusted trolley with a 1500 mm spacing. The coupler for corn seeder is mounted on trolley.

Source: author's own study / Źródło: opracowanie własne

Fig. 1. Unit for Strip-Till and deep application of large fertilizer granules (first working module of research model)
Rys. 1. Agregat do uprawy pasowej i głębokiej aplikacji nawozu w postaci dużych granul (pierwszy moduł roboczy modelu badawczego)

Second working module is pneumatic corn seeder (fig. 2) equipped with corn seeding sections, fertilizer tank and disc coulters. Starter fertilizer as small granules (4 mm) is applied shallowly (up to 10 cm) next to the corn rows. Seed distributors are driven by wheels through gearboxes. Wheels have spacing of 1500 mm, the same as trolley wheels. Hydraulic motor powers seeder fan. Row markers and fan hydraulic connections are located on coupler.

Source: author's own study / Źródło: opracowanie własne

Fig. 2. Corn seeder mounted on unit coupler (second working module of research model)
Rys. 2. Siewnik kukurydzy zawieszony na sprzęgu (drugi moduł roboczy modelu badawczego)

4. Research results

Functional test of unit (fig. 3) was carried out on light and medium soils. Corn grain and forage were collected from fields before test. Between harvest and test any cultivation wasn't performed. Strip-Till unit was connected to a tractor with a minimum power of 130 HP. They allow to achieve working speed of 6-8 kmh. Large fertilizer granules (10 mm) were placed 25 cm deep, corn was sown at 5 cm deep and small fertilizer granules (4 mm) were put 10 cm into the ground.

Source: author's own study / Źródło: opracowanie własne

Fig. 3. Unit during strip tillage, fertilizing and corn seeding
Rys. 3. Model badawczy agregatu podczas uprawy pasowej, nawożenia i siewu kukurydzy

4.1. Overall assessment of the functionality of the model

During test it have been found that connection of drawbar with tractor works correctly and allows to achieve field and transport positions. Unit hydraulic system, powered by tractor, works properly. It ensures smooth trolley, coupler and markers adjust, and guaranties required fan speed. There was no problem with connecting corn seeder to the unit. Corn can be sown from start to the end of the field thanks to coupler mounted on trolley. Corn seeder works fine while connected directly to the tractor.

With wheels at front and tube disk rollers at back we can adjust soil loosening depth and fertilizer application depth (fig. 4). Research has shown that it's desired to support unit additionally with trolley, specially on light soil. It prevents tube disk rollers from sinking too deeply into the soil. Final machine should have hydraulic cylinder stroke limiter to provide ability to preset working depth.

Source: author's own study / Źródło: opracowanie własne

Fig. 4. Strip tillage section
Rys. 4. Sekcja robocza uprawiająca pasowo glebę

Mixer and distribution rotor are driven jointly by electric motor. Low fertilizer dose requires low electric motor speed. It results in drop of motor power and inability to maintain required speed. Because of that another electric motor was installed to drive mixer and distribution rotors separately. This solution improves stability of mixer and distribution rotors rotational speed. Application of large fertilizer doses (600 kg/ha) caused elastic tubes and steel tubes clogging. It was caused by too small diameter of the tubes and low resistance of the fertilizer granules to dust up and crumble. Increased diameters (40 mm) and better granules properties eliminated dusting and crumbling.

4.2. Strip tillage and corn sowing quality

Strip tillage quality depends mainly on soil conditions. Good soil loosening with teeth and crumbling with soil reconsolidation using tube disk rollers have been found regardless of soil cohesion. Each tools enables proper corn seedbed preparation. In case of large amount of crop residues it is advantageous to use cleaning stars (fig. 4). It prevents crop residues from hanging on teeth and improves crop emergence and sowing quality. Discs holds loose soil and cover groove behind tooth. On light soils there were no lumps on tilled soil after tube disk roller pass. On medium soils cloddiness of field, measured by number of lump bigger then 3 cm, was small with maximum value of 12%. Additional scrapers in front of seeding sections of corn seeder weren't needed to remove large soil lumps. Soil cloddiness decreases after seeder section pass. It is due to cutting soil with coulter and crumbling with wheels, which determine seeding depth and compress soil with seeds. Cultivation depth was set to 25 cm. Depth measured along cultivated strip of soil ranged from 23 to 27 cm. Coefficient of working depth irregularity was 2,5%. Soil loosening depth, and thus the application of large fertilizer granules, reference is not to the surface of the field before cultivation, but to the soil surface compressed with the roller, which determines the seeding depth. Soil loosened with teeth is uniformly compressed with rollers and seeding sections. Soil cohesion before tillage was 2200 kPa. Soil cohesion after tillage, measured at 10 cm depth at row center, ranged from 390 to 580 kPa. Soil surface in rows is lowered relative to row-spacing surface. On light soil this difference was 9 cm, and on medium soil it was 6 cm. Variance from the mean was small and was ±1,5 cm. Little deviation in soil cohesion and compressed soil surface depth show uniform soil compression of seedbeds.

Soil tilled strips was 25 cm wide. Seeder sowing section width fits strips width (fig. 5). Depression of soil surface after seeding has width of 15 cm at bottom and 30 cm at top (fig. 6). Seeder wheels follows trolley wheels tracks (fig. 5).

Source: author's own study / Źródło: opracowanie własne

Fig. 5. Seeder sections on tilled soil strip, seeder wheels following trolley wheels
Rys. 5. Sekcje siewnika kukurydzy ustawione w śladach uprawy pasowej, a koła siewnika w śladach kół wózka jezdnego

Source: author's own study / Źródło: opracowanie własne

Fig. 6. Depression of soil after strip tillage and sowing
Rys. 6. Głębokość śladów po uprawie pasowej i siewie kukurydzy

It ensures uniform rolling and driving of fertilizer distributors. Seeding section position correlates with tilled soil strips. Also seeder wheels correlate with unit wheels. Both ensure good sowing conditions. Deviation between tilled soil strips center line and corn rows was ±1,8 cm. It means a good correlation of corn rows and large fertilizer granules located 25 cm deep. Small starter fertilizer granules were sown 10 cm deep and 5 cm aside corn row. Fertilizer coulter fit tilled soil strips. Based on soil exposures (fig. 7) it have been found that corn seeds and fertilizer were correctly placed in soil. Actual seeding depth of 5 cm was assessed by the position of seedlings and is within the range of 4,5 to 5,5 cm. Coefficient of seeding depth irregularity was 2,7%. Set crop spacing was 14,8 cm and actual value was 15,4 cm. It was within the range of 12,5 to 17,5 cm. Seeding rate was 8-9 seeds per square meter. Emergence of corn was very good, despite small amount of crop residues (fig. 8).

Source: author's own study / Źródło: opracowanie własne

Fig. 7. Soil exposure below corn row
Rys. 7. Odkrywka gleby pod rzędem kukurydzy

Source: author's own study / Źródło: opracowanie własne

Fig. 8. Corn row on tilled soil strips cleaned of crop residues
Rys. 8. Rzędy kukurydzy w śladach uprawy pasowej oczyszczonych z nadmiaru resztek pożniwnych

5. Conclusions

1. Functional verification of the unit for strip tillage, fertilization and corn sowing allows to evaluate recommended changes in machine design. Changes are needed to improve dosing and fertilizer application quality.
2. Research has shown usefulness of simultaneous tillage, fertilizer application and corn sowing on field with large amount of crop residue.

3. Corn seeder works well both mounted on unit coupler and mounted directly on tractor. Seeder ensures correct seed sowing and fertilizer application in tilled strips.

4. Soil exposures have shown proper placement of large and small fertilizer granules. Both on required depth and distance from corn seeds.

5. Based on research regular corn emergence have been found on tilled strip of soil cleaned out of crop residues.

6. References

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