Univerzitet u Beogradu
Poljoprivredni fakultet
Institut za poljoprivrednu tehniku
Naučni časopis
POLJOPRIVREDNA TEHNIKA
Godina XXXVIII
Broj 1, 2013.
Strane: 15 – 22

University of Belgrade
Faculty of Agriculture
Institute of Agricultural Engineering
Scientific Journal
AGRICULTURAL ENGINEERING
Year XXXVIII
No. 1, 2013.
pp: 15 – 22

UDK: 631.3: 629.056.84

Originalni naučni rad
Original scientific paper

EFFECT OF AGRICULTURAL NAVIGATION WITHOUT RTK CORRECTION ON SPRING SOWING

Petar Petrov*, Stoyan Ishpekov, Georgy Komitov, Teodora Kachorova

Agricultural University, Department of Agricultural Machinery, Plovdiv, Bulgaria

Abstract: It is carried out a comparative investigation of seed drill guiding accuracy in two ways. In the first way the drill is guided by a conventional disk marker and in the second way - by agricultural navigation without RTK correction. It is found that the usage of agricultural navigation lead to more straight rows and reduction of the fuel consumption, but the distance between drill tracks exceeds the row width about 26 %, because of low level of navigation accuracy.

Key words: *seed drill, agricultural navigation, sowing, fuel consumption*

INTRODUCTION

The sowing, spraying and soil fertilizing need of precisely machinery guiding on the field. For the purpose are used conventional disk markers. Unfortunately, their usage is inefficient on machinery with big working width, even it is impossible in majority of cases.

The GPS technology offers another way of machinery guiding on the field. The existing navigation systems have the following level of accuracy: 15-20 cm; 7,5-12,5 cm; 5-10 cm and 2,5 cm [1]. The navigation guiding without RTK correction ensures only the low level of mentioned accuracy and is free of charge for the farmers. They have to pay for higher levels of accuracy, but no every one may afford it.

The purpose of the investigation is to determine the real effect of an agricultural navigation without RTK correction on guiding accuracy of a seed drill.

* Corresponding author. E-mail: poliev@abv.bg

We would like to express our gratitude to farmer Venelin Dillgiansky, who created excellent conditions for conducting the experimental work ensuring fields and equipment.

MATERIAL AND METHODS

The investigation is carried out during sowing of an earth-up crop, because this operation requires the highest accuracy of seed drill guiding. It is compared the seed drill guiding in two running ways. In the first way the seed drill is running as it is shown on Figure 1. The drill is guided by agricultural navigation with "*Ag*GPSAutopilot™" [1]. In the second way the machine is guiding through a disk marker and the runs follow one after another (Fig. 2).

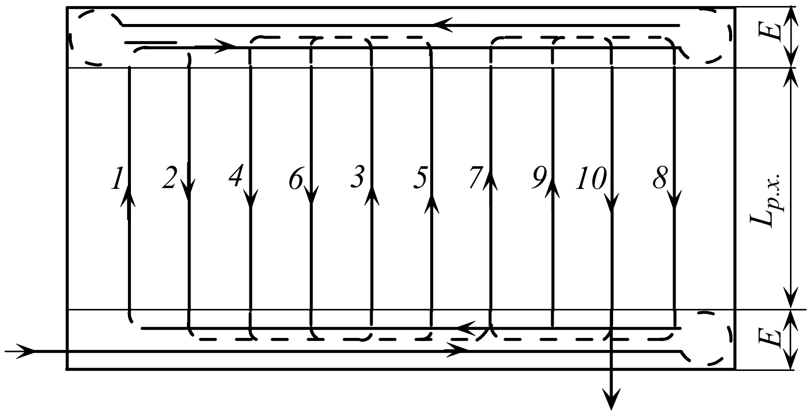

Figure 1. First running way

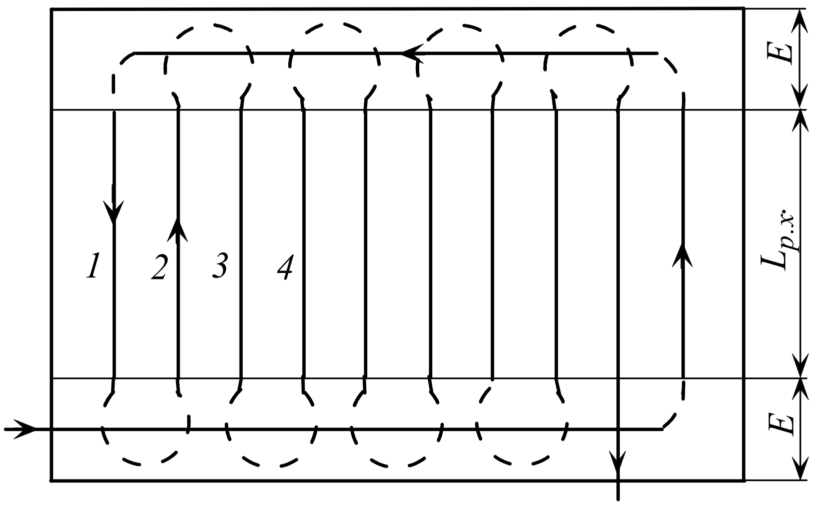

Figure 2. Second running way

It is measured the durations of every working runs and the turns on both sides of the field. The fuel consumption for indicated running ways is also registered [2, 3].

After crop sprouting it is measured the distance between drill tracks in more than 100 points along the working run. In that way are formed samples for calculating statistical and quality indices of the investigated process. The measurements are doing in three replications on different drill tracks for the both running ways.

The experimental data are used for calculating both statistic estimations:

- Mean value - $\bar{x}$;
- Standard deviation - σ.

For each experimental sample is drawn the autocorrelation function. For the process quality evaluation are calculated the following indices [4]:

- Potential capability:

$$C_p = \frac{USL - LSL}{6\sigma} \tag{1}$$

where:
USL is the upper specification limit

$$USL = \bar{x} + 0{,}729\left(x_{max} - x_{min}\right) \tag{2}$$

LSL - the lower specification limit

$$LSL = \bar{x} - 0{,}729\left(x_{max} - x_{min}\right) \tag{3}$$

- Lower potential capability:

$$C_{pl} = \frac{\bar{x} - LSL}{3\sigma} \tag{4}$$

- Upper potential capability:

$$C_{pu} = \frac{USL - \bar{x}}{3\sigma} \tag{5}$$

- Demonstrated excellence

$$C_{pk} = \left(1 - k\right)C_p \tag{6}$$

where:
k is the non-centring correction

$$k = \left[\frac{2\left(D - \bar{x}\right)}{\left(USL - LSL\right)}\right] \tag{7}$$

$$D = \frac{USL + LSL}{2} \tag{8}$$

There are calculated the following operational indices [5]:

- Portion of working runs

For the first running way is applied the formula

$$\varphi = \frac{L_p}{L_p + 0{,}5C_{д} + 1{,}14R_{за} + 2l_a} \tag{9}$$

For the second running way

$$\varphi = \frac{L_p}{L_p + 6R_{за} + 2l_a} \tag{10}$$

where:
L_p [m] - distance of the working run,
l_a [m] - length of the seed drill aggregation,
$R_{за}$ [m] - turn radius,
$C_{д}$ [m] - distance between two contiguous working runs.

- Productivity of the seed drill unit [ha h^{-1}]:

$$W_h = \frac{3{,}6.L_p.B_a}{t_p + t_{зав}} \tag{11}$$

where:
B_a [m] - working width of the machine,
t_p [s] - duration for implementation of working runs,
$t_{зав}$ [s] - duration for turn's implementation.

- The portion of working time

$$\tau = \frac{t_p}{t_p + t_{зав}} \tag{12}$$

- The fuel consumption for a unit of area [kg ha^{-1}]:

$$g_c = \frac{1000G}{S} \tag{13}$$

where:
G [kg] - expended fuel,
S [ha] - cropping area.

RESULTS AND DISCUSSION

The experiments are carried out with tractor Jon Deer DJ-6530 and seed-drill Monoseed - RABE 8230 during sunflower sowing.

In the table 1 is seen that the mean distance between boundary rows and the assigned value is 26,2 % for navigation guiding. This deviation is 0,7 % for guiding through markers. The great difference is due to the low accuracy level of used navigation system mainly.

Table 1. Descriptive statistics for the distance between boundary rows

Indices	*Seed-drill guiding way*	
	through navigation	*through markers*
Mean value, $\bar{x}$, [cm]	*88,34*	*69,50*
Minimal value, x_{min}, [cm]	*77*	*25*
Maximal value, x_{max}, [cm]	*110*	*84*
Standard deviation - σ, [cm]	*6,6731*	*17,8024*

However, the standard deviation of the same distances is 2,67 times lower for navigation guiding, in comparison with marker guiding. This means that navigation guiding causes more rectilinear rows.

This conclusion is also confirmed by autocorrelation functions for the drill tracks distances (Fig. 3 and 4). The function gets quiet more lightly for first way of guiding and does not grow quiet at all for second guiding way. These results prove that the navigation assists to more sustainable way of seed-drill guiding.

The potential capability C_p is the simplest and most straightforward indicator of the process capability. Its value for navigation guiding is 49 % higher than for guiding with markers (Tab. 2). The potential capability values also show that about 20 % of measured drill tracks distances for guiding with markers are out of the range between *USL* and *LSL*. Those conclusions are valid only if the investigated processes are centred, which have to evaluate.

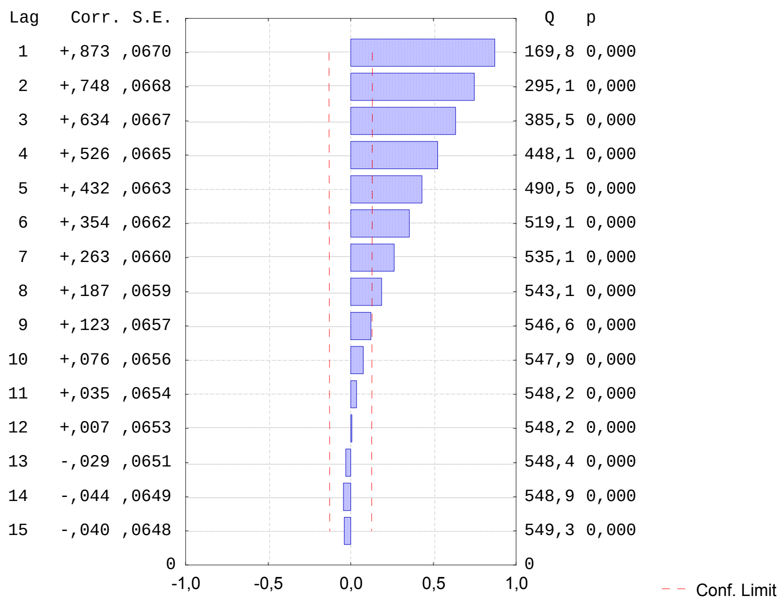

Figure 3. Autocorrelation function of seed-drill tracks distances for navigation guiding.

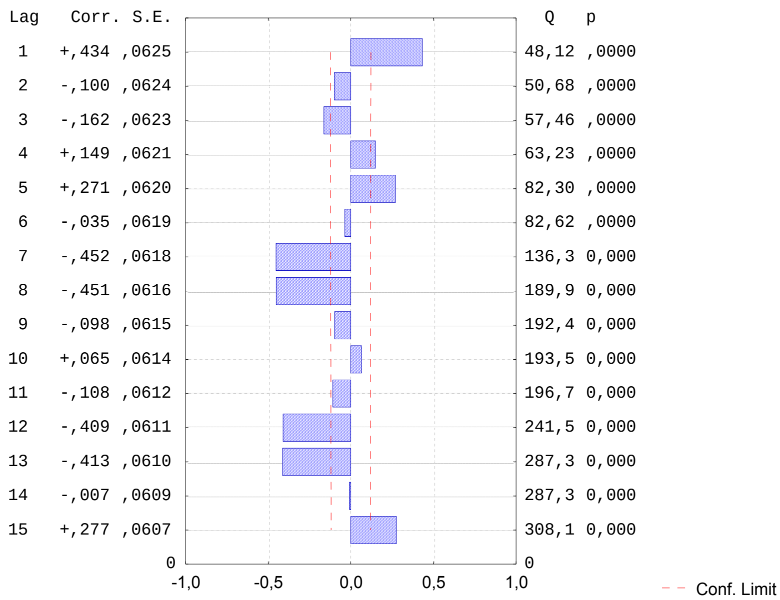

Figure 4. Autocorrelation function of seed-drill tracks distances for guiding with markers.

Table 2. Qualitative indices for the distance between boundary rows

Sample Indices	*Seed-drill guiding way*	
	through navigation	*through markers*
Potential capability - C_p	*1,202*	*0,805*
Upper potential capability - C_{pu} for different samples	*0,42 ÷ 2,82*	*0,36 ÷ 3,68*
Lower potential capability - C_{pl} for different samples	*0,42 ÷ 0,65*	*0,36 ÷ 0,68*
Demonstrated excellence - $C_{pк}$	*1,08*	*0,76*

The lower and upper potential capability C_{pl}, C_{pu} allow to evaluate whether the observed investigated process is centred or not. The formulas above show that, if these values are not identical each other, then the process is not centred. Results in table 2 show that the processes are not centred.

The non-centring correction k allows adjusting C_p for the effect of non-centring. If the process is perfectly centred, then k is equal to zero, and C_{pk} is equal to C_p. However, as the process drifts from the target specification, k increases and C_{pk} becomes smaller than C_p. Demonstrated excellence values - $C_{pк}$ for navigation guiding are higher than guiding with markers (Tab. 2). Thus the navigation guiding has better capability of the quality for the investigated processes.

Operational indices through marker guiding are better than navigation guiding (Tab. 3). This is because of accepting the shuttle running way. Obviously, the usage of agriculture navigation without RTK correction, for machines with small working width, does not change the operational indices considerably. Its positive effect consist of decreasing the fuel consumption with 18,7 %. That is because the markers are not used, which decrease the seed-drill resistance. Moreover, they require additional time for lifting and dropping. The fuel consumption at the second running way is higher, because of steering with smaller turn radius, which increases the draw resistance of the seed-drill unit.

Table 3. Operation indices

Indices	*Seed-drill guiding way*	
	through navigation	*through markers*
Average length of the working run, [m]	*289,07*	*247,92*
Average length of the turn, [m]	*56,23*	*34,58*
Portion of working runs φ	*0,802*	*0,987*
Productivity W_h *, [ha/h]*	*4,63*	*4,962*
Portion of working time, τ	*0,690*	*0,745*
Fuel consumption, g_c *, [kg/ha]*	*3,0*	*3,56*

Obviously, the precisely agriculture operations, such as the sowing of the earth-up crops, require more accurately seed-drill guiding. This could be accomplished with earth ground RTK network or local stations with 2,5 cm accuracy level achieving.

CONCLUSIONS

1. The smaller deviations of the boundary row space during navigation guiding, determine more straight rows. They give the opportunity to decrease the protection zone during the earth up processing.
2. The usage of agriculture navigation decreases the fuel consumption, because of the opportunity of applying runways that are more rational and dropping out the necessity of disk markers.
3. The boundary row space is wider than the assigned value with 26 % for navigation seed-drill guiding. This is because of the low accuracy level of used navigation system mainly. If it is used a earth ground RTK network or local stations with 2,5 cm accuracy level, the results would be better.

BIBLIOGRAPHY

[1] Trimble Agriculture Product Portfolio, 2013, *Trimble GPS, guidance, and precision agriculture solutions for all seasons, crops, terrains, and vehicles.* Trimble. VA WEB: http://www.trimble.com/agriculture (Accessed February 10, 2013).

[2] Трендафилов К. 2011. Теоретично определяне на дължината на завоя при совалково движение на симетричен машинно-тракторен агрегат в поле с неправилна форма. *Механизация на земеделието,* № 2, pp 8-11.

[3] Трендафилов Кр. 2011. Теоретично определяне на дължината на разтегнатите завои, извършвани от симетричен машинно-тракторен агрегат в поле с неправилна форма, *Механизация на земеделието,* № 3.

[4] StatSoft, Inc. (2013). *Electronic Statistics Textbook.* Tulsa, OK: StatSoft. VA WEB: http://www.statsoft.com/textbook/

[5] Колев К. 1999. *Експлоатация на машинно-тракторния парк*. София: Дионис.

EFIKASNOST POLJOPRIVREDNE NAVIGACIJE BEZ RTK KOREKCIJE U PROLEĆNOJ SETVI

Petar Petrov, Stoyan Ishpekov, Georgy Komitov, Teodora Kachorova

Poljoprivredni Univerzitet, Institut za poljoprivredne mašine, Plovdiv, Bugarska

Sažetak: Uporedno ispitivanje preciznosti setvene navigacije je izvedeno na dva načina. U prvom testu sejalica je navođena konveniconalno upotrebom diskosnog markera, a u drugom testu putem poljoprivredne navigacije bez RTK korekcije. Utvrđeno je da upotreba poljoprivredne navigacije vodi do pravilnijih redova i smanjenja potrošnje goriva, ali i da razmak između prohoda sejalice prekoračuje širinu između redova za oko 26% zbog niske preciznosti navigacije.

Ključne reči: sejalica, poljoprivredna navigacija, setva, potrošnja goriva

Prijavljen: *Submitted:*	05.03.2013.
Ispravljen: *Revised:*	
Prihvaćen: *Accepted:*	23.03.2013.