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GUIDING ACCURACY OF THE AGRICULTURAL NAVIGATION WITH RTK CORRECTION ON SPRING SOWING

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Abstract: They are carried out two comparative experiments for determining the real guiding accuracy of a seed drill during spring sowing an earth-up crop. At the first one the seed drill is running with circle turns. The juxtaposition is made for the guiding accuracy by conventional disk markers and by agricultural navigation with RTK correction. At the second experiment the seed drill is running with stretch turns. The guiding accuracy of both navigation without RTK and RTK navigation are compared. The agricultural navigation with RTK ensures better statistical estimations, better qualitative indices for the boundary row distance and higher operational indices of the tractor with a seed-drill during sowing of the earth-up crop.

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

INTRODUCTION

Many field operations require precise farm machinery guiding [4, 5]. Nowadays this leads to wide usage of different kinds of agricultural navigation systems, which ensure various levels of the accuracy guiding. The common GPS has a nominal accuracy of 10" (25,4 cm), whereas for GPS with RTK (Real Time Kinematic) it is ten times higher and equals to 1" (2,54 cm) [3]. The purpose of the investigation is to determine the real effect of two types agricultural navigations - the common one and navigation with RTK correction on guiding accuracy of a seed drill during the spring sowing.

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MATERIAL AND METHODS

There are carried out two comparative experiments for determining the real guiding accuracy of a seed drill during spring sowing an earth-up crop.

At the first one the seed drill is running with circle turns as it is shown on Fig. 1. The juxtaposition is made for the guiding accuracy by conventional disk markers and by agricultural navigation with RTK correction.

At the second experiment the seed drill is running with stretch turns as it is shown on Fig. 2. It is compared the guiding accuracy of both navigation without RTK and RTK navigation.

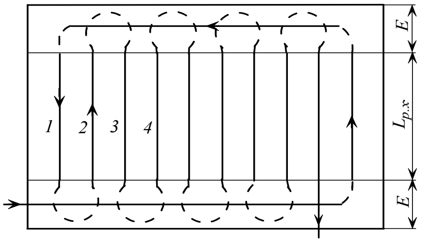


Figure 1. Seed drill running way with circle turns

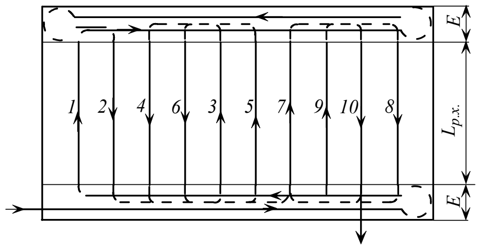


Figure 2. Seed drill running way with stretch turns

It is measured the durations of both every working runs and every turn at the ends of the field. After crop sprouting it is measured the distance between two boundary rows of the neighbor drill tracks, shortly *boundary row distance*. The measurements are implemented in three replications on different drill tracks at both experiments. Thereby are formed enough samples each one with more than 100 measurements along the working run. They are used for calculating statistical estimations, indices for process quality evaluation, operational indices, as well as for drowning autocorrelation functions [1, 2].

The experiments are carried out with seed-drill Monoseed - RABE 8230 linked to tractor Jon Deer DJ-6530 at sunflower sowing. At a navigation guiding mode the tractor is driven by built-in FarmSight™ equipment.

RESULTS AND DISCUSSION

In the Tab. 1. are shown descriptive statistics for the boundary row distance at the running circle turns way. The difference between the assigned and the mean value is 3,57 % for the markers guiding and 2,64 % for RTK navigation. The standard deviation - σ for markers guiding is 4,53 times more, which evidences for significantly more stable guiding by RTK navigation. This result is due not only to the way of guiding, but also to the difference of the driving precision of both autopilot and the tractor driver. For this reason the navigation guiding with autopilot causes more rectilinear rows than the markers guiding.

In Tab. 2. are presented descriptive statistics of the boundary row distance for the stretch turns running way. The difference between assigned value and the mean $\overline{x}$ is 26,2 % for navigation without RTK guiding and 5,9 % for RTK navigation. The standard deviation - σ for RTK guiding is 2,20 times less than navigation without RTK. This is due to the lower level of guiding accuracy of navigation without RTK.

Table 1. Descriptive statistics of the boundary row distance for running way with circle turns

Indices	*Unit*	*Tractor and seed-drill guiding way*	
		by markers	*by RTK navigation*
Assigned value	*[cm]*	*70*	*70*
Mean value, $\overline{x}$	*[cm]*	*67,50*	*68,15*
Minimal value, x_{min}	*[cm]*	*25,0*	*56,5*
Maximal value, x_{max}	*[cm]*	*84,1*	*76,5*
Standard deviation, σ	*[cm]*	*17,8024*	*3,9319*

Table 2. Descriptive statistics of the boundary row distance for running way with stretch turns

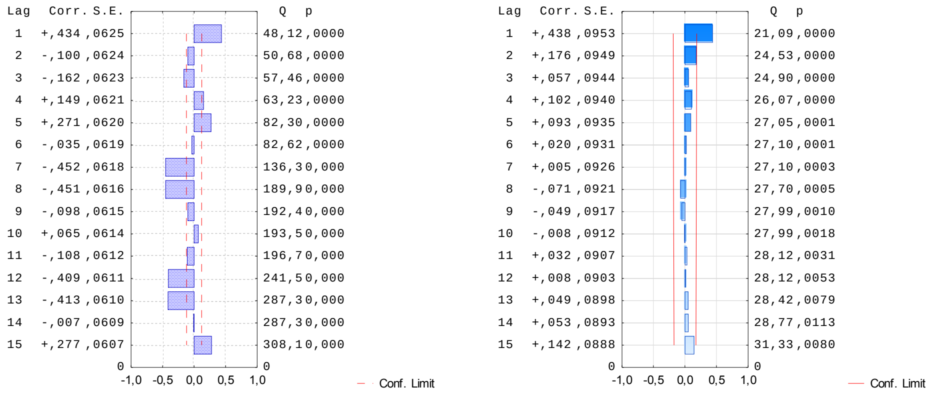
Indices	*Unit*	*Tractor and seed-drill guiding way*	
		by navigation without RTK	*by RTK navigation*
Assigned value	*[cm]*	*70*	*70*
Mean value, $\overline{x}$	*[cm]*	*88,34*	*74,16*
Minimal value, x_{min}	*[cm]*	*77*	*67,0*
Maximal value, x_{max}	*[cm]*	*110*	*81,1*
Standard deviation - σ	*[cm]*	*6,6731*	*3,0321*

Autocorrelation functions for the boundary row distances for the circle turns running way are given on Fig. 3. Obviously, the function for marker's guiding comes out the confidential interval very often. While the function for RTK guiding gets quiet very fast and all values are in the confidential interval, which means stable seed-drill guiding.

Autocorrelation functions for the stretch turns running way evidences for a significant influence of the RTK navigation on the variation of boundary row distance (Fig. 4). The function values do not come out confidential limit, therefore this type of guiding ensures stable boundary row distance. Obviously, this is the most suitable guiding for stretch turns running way, which is the only possible for large-size farm machinery in many cases. While, the navigation without RTK assists mainly to more sustainable way of seed-drill guiding, but the real precision is not enough [1].

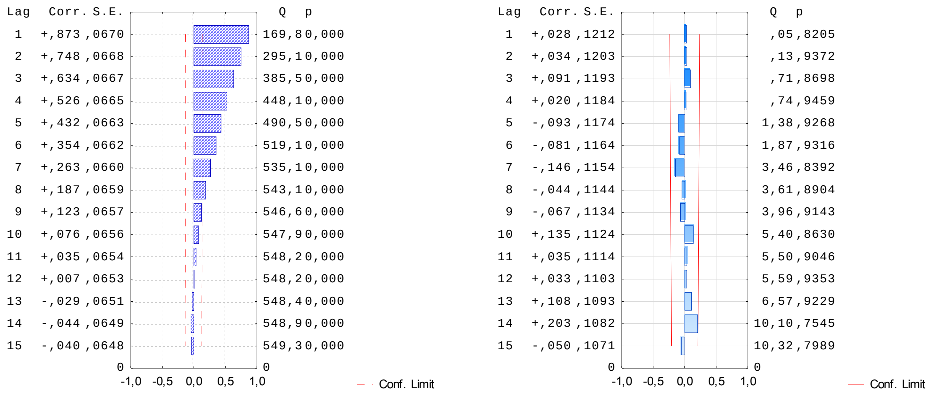
The coefficient C_p is widely used indicator of the capability of an investigated process [1, 2]. For the circle turns running way and RTK guiding its value is 10,9 % higher than for the markers guiding (Tab. 3). The investigated processes are not centered, because the lower and upper potential capability C_{pl}, C_{pu} values are not identical each other. The demonstrated excellence value - $C_{p\kappa}$ for RTK navigation guiding is 1,96 times higher than for the markers guiding. Thus the navigation guiding has better qualitative capability for the circle turns running way.

Qualitative indices for the stretch turns running way also evidence better process quality for RTK guiding (Tab. 4). Its values for C_p and $C_{p\kappa}$, are higher 6,6 % and 43,5 % accordingly. More over the investigated process for RTK guiding is more centered.



a) guiding by markers *b) guiding by RTK navigation*

Figure 3. Autocorrelation functions of the boundary row distance for the circle turns running way



a) guiding by navigation without RTK *b) guiding by RTK navigation*

Figure 4. Autocorrelation functions of the boundary row distance for the stretch turns running way

Table 3. Qualitative indices of the boundary row distance for the circle turns running way

Sample Indices	Tractor and seed-drill guiding way	
	by markers	by RTK navigation
Potential capability - C_p	0,805	0,892
Upper potential capability - C_{pu} for different samples	0,36 ÷ 3,68	2,470
Lower potential capability - C_{pl} for different samples	0,36 ÷ 0,68	1,490
Demonstrated excellence - $C_{pк}$	0,76	1,490

Table 4. Qualitative indices of the boundary row distance for the stretch turns running way

Sample Indices	Tractor and seed-drill guiding way	
	by navigation without RTK	by RTK navigation
Potential capability - C_p	1,202	1,281
Upper potential capability - C_{pu} for different samples	0,42 ÷ 2,82	0,55
Lower potential capability - C_{pl} for different samples	0,42 ÷ 0,65	0,63
Demonstrated excellence - $C_{pк}$	1,08	1,55

In Tab. 5 are presented the operational indices for both running ways at an approximately equal length of the working runs and with RTK navigation guiding. The results show that the tractor with a seed-drill has 27,8 % higher productivity W_h when it applies the stretch turns running way. This is due to the turning speed $v_{n.x}$, which is 53,5 % higher than the speed at the circle turns. The average working speed $v_{p.x}$ is also higher at the stretch turns running way, because of the loss of time for the tractor acceleration after each turn, despite it runs in one and the same gear. The other operational indices do not differ considerably for both running ways.

Obviously, the agricultural navigation with RTK ensures better statistical estimations, better qualitative indices for the boundary row distance and higher operational indices of the tractor with a seed-drill during sowing of the earth-up crop. The received results give us an assumption that the seed-drill which is guided by RTK navigation can works with reduced protection zone and increased working speed during the earth up field operations. Of course this assumption should be investigated.

Table 5. Operation indices of tractor and seed-drill with RTK navigation

Indices	*Unit*	*Seed-drill running way*	
		First (Fig. 1)	*Second (Fig. 2)*
Average length of the working run	*[m]*	*492,67*	*493,5a*
Average length of the turn	*[m]*	*25,17*	*33,16*
Portion of working runs φ	*[-]*	*0,95*	*0,94*
Productivity W_h ,	$[ha \cdot h^{-1}]$	*60,64*	*77,52*
Portion of working time, τ	*[h]*	*0,90*	*0,89*
Average working speed $v_{p.x.}$,	$[m \cdot s^{-1}]$	*2,24*	*2,89*
Average turning speed $v_{n.x.}$,	$[m \cdot s^{-1}]$	*0,99*	*1,52*

CONCLUSIONS

1. At the experimental conditions and runs with stretch turns, the guiding accuracy of RTK navigation achieves 5,9 % (4,16 cm) average deviation from the assigned boundary row distance. It means that the real guiding accuracy is 63 % lower from the nominal accuracy of the RTK navigation. The real guiding accuracy of the navigation without RTK is 4,4 times lower than of the RTK navigation.

2. When the seed drill runs with circle turns, the guiding accuracy of the agricultural navigation with RTK correction does not differ significantly from the markers guiding.

3. When the seed-grill runs with stretch turns and is guided by the RTK navigation it's productivity is higher than compared with the runs with circle turns. This is due to 53,5 % higher turning speed, which increases the average machinery speed of the machinery. This inference is important for large size machinery, because the run with stretch turns is the only possible in many cases.

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TAČNOST NAVOĐENJA POLJOPRIVREDNE NAVIGACIJE SA RTK KOREKCIJOM U PROLEĆNOJ SETVI

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Sažetak: Sprovedena su dva komparativna ogleda za određivanje stvarne tačnosti vođenja sejalice tokom prolećne setve. Sejalica se u prvom ogledu kretala sa kružnim okretima. Tačnost navođenja pri slaganju prohoda je određivana korišćenjem konvencionalnih diskosnih markera i poljoporivrednom navigacijom sa RTK korekcijom. U drugom ogledu sejalica se kretala sa produženim okretima. Poređena je tačnost navođenja kod obe navigacije, sa i bez RTK. Poljoprivredna navigacija sa RTK obezbeđuje bolje statističke procene, bolje kvalitativne pokazatelje za ivični prohod i više operativne pokazatelje agregata traktora sa sejalicom tokom setve.

Ključne reči: *sejalica, poljoprivredna navigacija, setva*

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