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INFLUENCE OF THE GEOMETRY OF THE TRANSFORMABLE RUNNING GEAR ON THE TURNING CHARACTERISTICS OF A UNIVERSAL ROW-CROP TRACTOR

Akhmedov Sherzodbek Anvarhon o`g`li

National Research University "Tashkent Institute of Irrigation and Agricultural Mechanization Engineers", department of tractors and automobiles, 39 Kari Niyazov Street, Tashkent

E-mail: sh_akhmedov@tiiame.uz

Abstract. This paper presents an experimental study of the turning characteristics of the universal row-crop tractor TTZ-1033M equipped with a transformable running gear. Tests were carried out for different track widths, ground clearance settings and wheelbase lengths, and at three tyre inflation pressures (1.2, 1.7 and 2.2 MPa). Inner and outer turning radii were measured with the steering at full lock, and maneuver execution time and trajectory were recorded. The results were processed statistically (mean, standard deviation, coefficient of variation, standard error of the mean). Based on the experimental data, the influence of chassis geometry and tyre pressure on maneuverability is analyzed and practical recommendations for adjusting the transformable running gear for row-crop operations are provided.

Keywords: turning radius; transformable running gear; track width; wheelbase; ground clearance; maneuverability; TTZ-1033M.

Аннотация. В статье представлено экспериментальное исследование поворотных качеств универсально-пропашного трактора ТТЗ-1033М с трансформируемой ходовой системой при различных значениях колеи, агротехнического просвета и базы, а также при трёх уровнях давления в шинах (1,2; 1,7; 2,2 МПа). Выполнены измерения внутренних и внешних радиусов разворота при рулевом механизме в положении «полный вывод» (full-lock), зафиксировано время выполнения манёвра и пройдённая траектория. Результаты подвергнуты статистической обработке (среднее значение, среднеквадратическое отклонение, коэффициент вариации, стандартная ошибка среднего). На основании полученных данных обсуждаются влияние геометрии шасси и давления в шинах на манёвренность и даются практические рекомендации по настройке трансформируемой ходовой части для междурядной обработки.

Ключевые слова: поворотный радиус; трансформируемая ходовая система; колея; база; агротехнический просвет; манёвренность; ТТЗ-1033М.

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Annotatsiya. Ushbu maqolada transformatsiyalanadigan yurish tizimi bilan jihozlangan TTZ-1033M universal chopiq traktorning burilish ko`rsatkichlari bo‘yicha eksperimental tadqiqot yoritilgan. Sinovlar turli g‘ildirak oralig‘i, agrotexnik tirqish va g‘ildirak bazasi konfiguratsiyalari hamda g`ildiraklardagi bosimi uchta darajada (1,2; 1,7; 2,2 MPa) o`zgartirilib sinovlar o‘tkazildi. Rul to‘liq burilish holatida ichki va tashqi burilish radiuslari o‘lchab olindi, manevr bajarish vaqti va trajektoriyasi qayd etildi. Olingan natijalar statistik jihatdan qayta ishlanib (o‘rtacha qiymat, standart og‘ish, variatsiya koeffitsienti, o‘rtacha xataning standart xatosi) tahlil qilindi. Eksperimental ma’lumotlarga asoslanib, shassi geometriyasi va g`ildiraklardagi bosimining manevr qobiliyatiga ta’siri muhokama qilinadi hamda qator oralariga ishlov berishda transformatsiyalanadigan yurish tizimini sozlash bo‘yicha amaliy tavsiyalar beriladi.

Kalit so‘zlar: burilish radiusi; transformatsiyalanadigan yurish tizimi; g‘ildirak oralig‘i; baza; agrotexnik klirens; manevr qobiliyati; TTZ-1033M.

Introduction

One of the principal performance indicators in the use of agricultural machinery is their maneuverability; this characteristic is a key factor that influences the execution of mechanized tasks by tractors. A tractor’s maneuverability is one of the most important operational parameters determining the efficiency of agrotechnical operations, especially under conditions of narrow-row crops (for example, cotton)[1–3]. A transformable running gear enables adjustment of track width, wheelbase and ground clearance to suit varying field conditions. However, changes in chassis geometry affect turning characteristics, lateral slip and the risk of soil compaction. The aim of this study is an experimental assessment of the influence of the adjustable track width, ground clearance and wheelbase settings on turning radii and related maneuverability metrics.

MATERIALS AND METHODS

Object of study. The subject of the study was the TTZ-1033M tractor, mass 4680 kg, four-wheel layout, tested without towed or mounted implements [4].

Tested parameters. The following parameters were varied:

track width (front/rear): 1200/2400 mm; 1520/1520 mm; 1800/1800 mm;

ground clearance: at the front-axle beam — 650 and 870 mm; at the rear axle half-shaft housings — 810 and 870 mm;

wheelbase: 2678 mm and 2498 mm;

tyre inflation pressure: 1.2, 1.7 and 2.2 MPa.

Measurement methods. Tests were performed according to the prescribed programme and in accordance with applicable regulatory documents and standards in the test laboratory. Field trials were conducted on a flat site with a hard surface

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(Fig. 1). Turning radii were measured using marking cones, measuring tapes and video recording of the maneuvers. Standard instruments were used to monitor test parameters (pressure gauges, spirit level, moisture meter, etc.). Each test configuration was repeated at least five times to obtain statistically significant mean values. Measured quantities included the inner and outer turning radii with the steering at full lock, the time required to complete a 360° turn, and the vehicle trajectory during the maneuver.



a) b)

Fig. 1. Test laboratory procedures: a) general side view of the tractor; b) view of the test area where the trials were conducted.

Data processing. For each configuration the mean value, standard deviation, coefficient of variation, and standard error of the mean were calculated. The statistical processing made it possible to assess the reproducibility of the results and to estimate confidence intervals.

RESULTS

The averaged results (Table 1) for the minimum turning radii for all parameter combinations are presented in tabular form. The experimental data show the following general trends:

- When the track width is increased (from 1200 mm to 1800 mm), the minimum inner turning radius decreases substantially (for example: at a wheelbase of 2678 mm and tire pressure of 1.2 MPa the mean inner radius is ≈ 5.09 m for a 1200 mm track, ≈ 2.89 m for a 1520 mm track, and ≈ 2.76 m for an 1800 mm track). This is explained by the wider support surface and the wheels' greater ability to enter the turn more sharply.
- Reducing the tractor wheelbase (from 2678 mm to 2498 mm) also leads to a reduction of the minimum turning radius (for example: for a 1200 mm track and tire pressure of 1.2 MPa the inner radius decreases from ≈ 5.09 m to ≈ 4.34 m).
- Increasing tire inflation pressure tends to increase the turning radius under otherwise equal conditions. The difference when changing pressure from 1.2 MPa

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to 2.2 MPa is noticeable but smaller compared with the effect of changing track width or wheelbase.

• Ground clearance (agrotechnical clearance) affects the tractor's turning behavior indirectly; in combination with a reduced wheelbase or a changed track width it can reduce or slightly alter the inner turning radius due to mass redistribution and changes in wheel alignment angles.

Table 1

Example of selected mean values (averaged over 5 repetitions):

Configuration	Pressure, MPa	Wheelbase, mm	Track (front/rear), mm	Average inner radius, m	Average outer radius, m
A	1,2	2678	1200/2400	5,09	5,71
B	1,2	2678	1520/1520	2,89	4,09
C	1,2	2678	1800/1800	2,76	4,25
D	1,2	2498	1200/2400	4,34	5,05

Discussion

The experimental results show that the geometric parameters of the transformable running gear exert a more significant influence on the minimum turning radii than tire inflation pressure or ground clearance within the ranges considered. In practice, this means that for operations requiring high maneuverability (for example, turning at the end of a row), configurations with a wider track and a shortened wheelbase are preferable.

On the other hand, increasing the track width and reducing the wheelbase may affect stability and energy efficiency when operating on uneven terrain or in heavy soil conditions. In addition, tire pressure adjustment remains an important factor in terms of wheel–soil interaction and the risk of soil compaction: reducing pressure decreases the turning radius while increasing the tire–soil contact area, which may reduce soil compaction but at the same time increase lateral slippage.

Considering the practical requirements of cotton inter-row cultivation, it is recommended to select track width and wheelbase configurations that ensure the necessary maneuverability while minimizing soil damage. For field applications, the optimal configuration should be chosen with regard to soil conditions, required operating speed, and the type of agricultural operation performed.

CONCLUSIONS

1. Increasing the track width leads to a significant reduction in the minimum inner turning radius of the TTZ-1033M tractor.

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2. Reducing the wheelbase also decreases the minimum turning radius; the effect of wheelbase reduction is noticeable and comparable in significance to that of track width.

3. Increasing tyre inflation pressure in the range of 1.2–2.2 MPa shows a tendency to enlarge the turning radius, but its influence is weaker than that of geometric parameters.

4. In the design and operation of transformable running gear systems, it is necessary to consider the trade-off between maneuverability and stability/soil impact..

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