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Stability of the Unit Movement Depending on the Agricultural Operations Performed on Slopes

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Annotation: The article outlines the dependence of the degree of mutual influence of an agricultural implement and a tractor, taking into account the factors affecting the balance of the tractor, and lists the types of maintaining the direction of movement of the unit during an agricultural operation.

Keywords: Tractor, degree, factor, movement, stability, agriculture, slope, machine.

Introduction. When performing various operations together with a tractor, an agricultural machine or tool is included in the unit. During operation, the agricultural implement, depending on the heterogeneity of external conditions, is subjected to disturbances of a random nature, and transmits them to the tractor, deflecting it from the given direction of movement. The tractor is also subject to accidental disturbances, which in turn affects the operation of the implement. Thus, during work, there is always a mutual influence of the tractor and agricultural implements. In some cases, along with random disturbances, the movement of the unit is influenced by constantly acting factors. For example, when working in the transverse direction of the slope, under the influence of the component force of gravity, the agricultural unit directed along the smallest slope continuously tends to turn down the slope. When the unit is operating on slopes, the tractor driver's intervention is manifested only in the fact that the tractor is periodically guided along the apparent horizontal of the terrain. On horizontal terrain, the tractor driver tries to maintain the given direction of movement of the unit. [1-3]

The degree of mutual influence of an agricultural tool and a tractor is largely determined by the type of interconnection between them performed by the agricultural operation, the design of the agricultural tool and other factors. For example, a mounted agricultural tool affects the balance of a tractor more directly than a trailed implement, the influence of plows on the movement of a tractor is stronger than that of cultivators, etc. [4-9]

Materials and methods. From the point of view of maintaining the direction of movement of the unit, the mutual influence of a tractor and an agricultural tool can be divided into the following types:

The tractor moves in a relatively straight line, no special efforts are required on the part of the tractor driver, while the agricultural tool seeks to disrupt the straightness of movement. In this case, the tractor in the unit is an element that stabilizes the movement. This can take place on horizontal terrain, when the tractor undercarriage is in good technical condition, the soil and vegetation cover of the field are relatively homogeneous, but the resulting resistance force of the agricultural tool is not in the longitudinal-vertical plane of symmetry of the tractor. The latter is due to improper adjustment, and in some cases to the design of the gun itself (fig.1.).

Fig.1. Plowing unit at work.

In this case, maintaining the straightness of the tractor's movement is usually not difficult, it is achieved by direct control of the tractor. Although this does not result in a strict straight line, the deviation of the tractor from the middle axis of the given direction of movement is also small. In practice, such a movement of the unit in most cases can be considered straight. In rare cases, especially when working with asymmetrical tillage implements, the result of all resistance forces can be significantly deviated from the longitudinal-vertical plane of symmetry of the tractor. Then, on horizontal terrain, the tractor tends to deviate from the given direction in the direction in which the resistance force of the gun is deflected. The tractor driver continuously straightens the direction of movement of the unit.

It is curious that this phenomenon on slopes can be used to reduce the spontaneous turning of the tractor that is part of the tillage unit. For this purpose, when working in the transverse direction of the slope, the resulting drag force of the tool must be deflected from the longitudinal-vertical plane of symmetry of the tractor in the direction of ascent. This compensates for the turning torque caused by the component of the tractor's gravity acting in a plane parallel to the field surface. However, the practical application of this technique encounters a number of difficulties of a technical nature.

The concept of deviation of the drag force of implements from the longitudinal-vertical plane of symmetry of the tractor should also include those cases when in the plane parallel to the surface of the field, the deviation of the traction resistance of the gun has a different character. Namely, when at a certain angle in relation to the longitudinal axis of the tractor it is deflected from the center of gravity of the unit. This is a more common phenomenon. However, for the sake of simplicity, both cases are considered together.

Results. A tractor deviates from a straight path, while an agricultural tool tends to maintain the originally set direction of movement. Obviously, in this case, the stabilizing element is an agricultural tool. This case can take place on horizontal terrain and is due to poor technical condition or improper adjustment of the tractor undercarriage. This phenomenon also occurs in tractors, the center of gravity of which is outside the longitudinal-vergical plane of symmetry. In this case, on horizontal terrain, the straightness of movement is maintained due to the control of the tractor, and the trajectory of the movement of the unit can practically be taken as straight (Fig.2.).

Fig.2. Surface treatment unit in operation.

This phenomenon almost always occurs when tillage units operate on slopes. A tractor moving in the transverse direction of the slope under the influence of a component of gravity directed parallel to the field surface along the smallest slope constantly tends to turn down the slope. A tillage implement, being buried in the soil, prevents such a turn of the tractor. For this reason, when moving in the transverse direction of the slope, uncontrolled tractors deviate from the terrain horizontals much more than uncontrolled tillage1 units.

A tractor and an agricultural tool simultaneously tend to deflect the unit from a straight path in the same direction. This is one of those difficult cases when there is no stabilizing element in the unit. It is quite difficult to control such a unit and at the same time maintain the straightness of the trajectory. In such cases, the tractor driver has to restore the original direction of movement of the tractor from time to time, and the path traveled by the unit turns out to be winding. However, it cannot be assumed that a tractor and an agricultural tool have the same intense effect on the violation of the straightness of movement. Usually, one of the elements deviates the unit from the given direction of movement less intensively, thereby reducing the deviation of the other element (Fig.3.).

Fig.3. Plowed field.

The case in question on horizontal terrain is observed quite rarely. It mainly occurs when working in the transverse direction of the slope and is typical for units that include agricultural machines or implements, the working bodies of which are not in direct contact with the soil. Note that in this case, even with very frequent adjustment of the direction of movement of the tractor, the trajectory of the hundredth movement turns out to be winding and only with reservations it can be taken as straight (Fig.4.).

Fig.4. Type of soil after surface treatment.

A tractor and an agricultural tool deflect the unit in different directions at the same time. Thus, for example, while a tractor tends to turn to the left, an agricultural tool not only prevents this turn, but itself tends to turn the machine back to the right, of course, the control of the unit does not require much effort in this case. This phenomenon can take place on horizontal terrain, and often on slopes. Maintaining the straightness of movement is also not difficult. And in this case, the trajectory of the tractor is practically not different from a straight one.

Conclusion. Thus, during the operation of an agricultural unit, there is a constant mutual influence of the tractor and the implement, which are separately subject to impacts, some of which are of a random nature, and this, in turn, leads to the fact that the unit never moves strictly in a straight line in a given direction. Its trajectory oscillates relative to a given line, having a random frequency and amplitude. It is obvious that the frequency and amplitude of oscillations of the trajectory of the unit relative to a given direction of movement depend on the type of mutual influence of the tractor and agricultural implement, the features of the design nature, the subjective characteristics of the tractor driver, etc.

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