Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca. Agriculture
Open Access

Determination of Qualitative Indicators of Work in the Application of Solid Chemical Fertilizers

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RESEARCH ARTICLE

Abstract
One main means of achieving a constant, reliable and high-value yield is by correctly applying the fertilizers. The correct use of fertilizers implies the scientific basis and the knowledge of all the factors that influence the efficiency of their application. The main aim of the experiment was to study the uniformity of fertilizer application at different travel speeds. In the present study, the machinery used was a Massey Ferguson tractor with a Rauch spreader that was working at the speeds of 6, 11, 17 km/h. The fertilizer was collected and measured with a Kern precision balance. The obtained results show that at the travel speed of 6 km/h, the distributed quantity of fertilizer was between 24.04 g/m^2 and 31.81 g/m^2 on the membrane verified on 3 different determinations. Using an 11km/h travel speed the results obtained were between 24.14 g/m^2 and 26.78 g/m^2, by using this results we could determine that this speed was the most appropriate for carrying out the fertilizing process. Lastly, the speed that was used was 17 km/h and the obtained quantity of fertilizer was between 16.85g/m^2 and 31.31 g/m^2.

Keywords: Agriculture; fertilizer; spreading.

Received: 15 September 2024
Accepted: 05 November 2024
Published: 15 November 2024

DOI:
10.15835/buasvmcn-agr:2024.0013

INTRODUCTION
According to all estimates, there is a need for an increase in the sector of food and crop production to accommodate a growing population. Some of the projections indicate that overall food production must increase by 70% from 2005 to 2050 and in developing countries, the production has to double (Stewart and Roberts, 2012). For plants to be able to prepare their food via photosynthesis they need nutrients from the soil, which is not able to provide enough essential macro and microelements on its own. Therefore, another source of nutrition is required to fulfill those needs, which in agriculture is the use of manures and fertilizers (ALnaass et al., 2021). For plants to have healthy growth they require at least 16 essential elements, of which three are acquired from air and water, these are oxygen, carbon, and hydrogen, while the others are extracted from the soil (Gellings and Parmenter, 2020). It is well known that in a performant agricultural system, one main means of achieving a constant, reliable, and high-value yield is by correctly applying fertilizers. The correct use of fertilizers implies the knowledge of the scientific basis, and also the knowledge of all the factors that can influence the efficiency of the application (Vidican et al., 2017). Fertilizers can be classified as straight or mixed/complex, which is based on the presence of one or multiple primary plant nutrients, those being nitrogen, phosphorus, and potassium (Ugoli et al., 2020). Some of the current restraints on the agricultural sector are connected to the soil and farmland altogether, these restraints include the shrinkage of farmland, imbalanced fertilizer application, and the lack of organic carbon in the soil

(Chaitra et al., 2021). Considering all these aspects it is important to make a field study about the quality of the fertilizing process. Therefore the main aim of the study was to determine the main quality indicators of this process.

MATERIALS AND METHODS

The experiment was carried out on a field near the village of Suatu, the county of Cluj and it was done in July of 2022. For the spreading of the fertilizer, the used machinery was the Massey Ferguson 3080 tractor with the Rauch MDS 935 solid fertilizer broadcaster which was equipped with the M1 type spreading discs with a range of 18 meters. The tractor equipped with the broadcaster can be observed on Figure 1.

Figure 1. Spreading of fertilizer using the Rauch MDS 935 solid fertilizer broadcaster over the collecting points.

The spreading was done in three variations: at the speeds of 6, 11, and 17 km/h, every one of which was done in three different determinations. At all the velocities the chosen norm was 250 kg/ha. To achieve the same norm at all the velocities the following adjustments had to be made on the fertilizer broadcaster: at the speed of 6 km/h the metering slide was set at the position of 110, the spreader vanes were at the position of A3-C3, in which the A and C are the length adjustments and 3 is the angle adjustment, the hopper height used was 50 cm, the tractor was working on the third gear of turtle at an RPM of 2000 with the PTO at 540 RPM. For the speed of 11 km/h, the following settings were made: the metering slide was set on the position of 288, the spreader vanes were at the position of A3-C3, the hopper height was at 50 cm, the tractor was running on the first gear of hare setting at 2000 RPM with the PTO working at 540 RPM. Lastly, for the speed of 17 km/h the metering slide was set at the position of 372, the spreader vanes were at the position of A3- C3, the set hopper height was 50 cm and the tractor was working on the second gear of the hare setting at 2000 RPM with the PTO set at 540 RPM. The quantity of the spread fertilizer was collected by using a high-density polyethylene waterproofing membrane, which was covered by alveoli with a depth of 8mm (Figure 2).

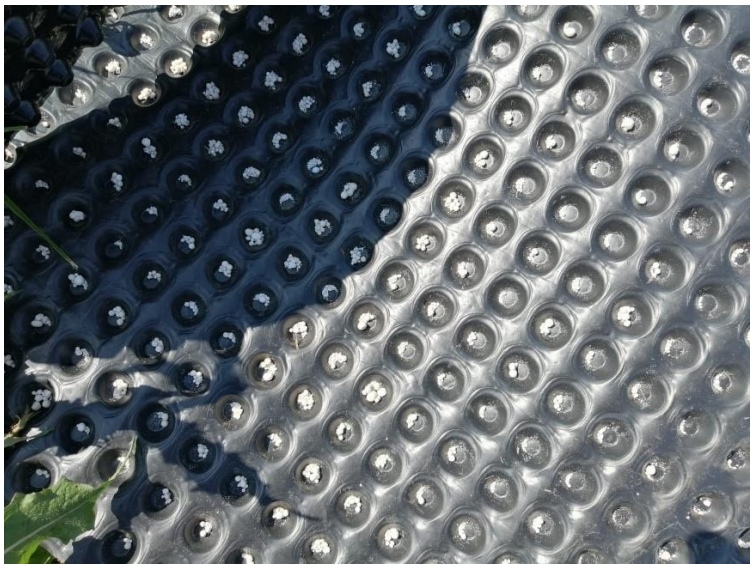

Figure 2. Alveoli of the HDPE membrane containing fertilizer.

On the surface, the alveoli had a diameter of 16.5 mm, in the depth the diameter decreased to 8mm. This membrane was laid out as a 12m long and 1m wide stripe of which the middle two meters were discarded.

All the measuring of the fertilizer quantities was done by using a Kern EMB 600-2 entry-level laboratory balance with a reproducibility of 0.01 g. As for the type of fertilizer that was used in the experiment it was the M1 granulation type nitrogen fertilizer with a density of 1 kg/l.

After the field study was done the effective rate of spreading was determined using the specified formula below:

$$\text{Effective rate}=10*\frac{\sum_{i=1}^{n} qi}{n}$$

where: qi- the quantity of fertilizer collected at the i point of interest, in g
n- the number of points of interest at which the fertilizer was collected

The uniformity of distribution was determined by using the formula below:

$$UD=[1-\frac{\sqrt{\frac{\sum_{i=1}^{n}(qi-qm)^2}{n-1}}}{qm}]*100[\%]$$

where: qi- the quantity of fertilizer collected at the i point of interest, in g
qm- the average quantity of fertilizer collected at a point of interest, in g ($qm=\frac{\sum_{n=1}^{i} qi}{n}$)
n- the number of points of interest at which the fertilizer was collected

To determine the equipment's flow stability coefficient the next formula was used:

$$FSC=[1-\frac{\sqrt{\frac{\sum_{i=1}^{n}(Qi-Qm)^2}{p-1}}}{Qm}]*100[\%]$$

where: Qi- the quantity of fertilizer collected at the i point of interest, in kg
qm- the average quantity of fertilizer collected at a point of interest, in kg
p- the number of determinations

RESULTS AND DISCUSSIONS

In the first determination of the first variant of the experiment conducted at the velocity of 6 km/h, the collected amount of fertilizer fluctuates between 24.04g at R3-4 and 27.88g at L1-2 which is a difference of 15.97% between the lowest and the highest amount captured, the average quantity in this determination being 26.191g, this average being the closest to the desired quantity of 25g in this variant (Table 1). In the second determination, there were higher amounts of fertilizer collected in most of the points of interest compared to the first determination. In this determination, the amounts of fertilizers that were spread were between 25.50g and 31.81g with an average of 28.726g. The highest amount was recorded at the L4-5 point, meanwhile, the lowest amount that was spread was collected at the R4-5 point of interest, there was a 24.74% difference in the collected fertilizer. In the last determination of the first variant, the quantity fluctuated between 24.32g at L4-5 and 28.75g at R1-2, with a difference of 18.21% between those values. The average of this determination was 26.694g. Between the three different determinations, the highest difference recorded on the same point of interest was at L4-5, where the difference was 24.32g in the third determination to 31.81g in the second determination, the difference being 30.79%.

Table 1. Collected fertilizer at the velocity of 6 km/h at the designated areas of the polyethylene membrane (L5-6, L4-5, L3-4, L2-3, L1-2, R1-2, R2-3, R3-4, R4-5, R5-6) and the number of the determination (D1, D2, D3)

	L5-6	L4-5	L3-4	L2-3	L1-2	R1-2	R2-3	R3-4	R4-5	R5-6
D1	25.95g	26.17g	26.53g	26.13g	27.88g	26.46g	25.59g	24.04g	26.39g	26.77g
D2	30.98g	31.81g	31.58g	30.72g	27.36g	27.13g	27.75g	28.67g	25.50g	25.76g
D3	25.43g	24.32g	27.33g	26.43g	27.53g	28.75g	27.67g	27.64g	26.10g	25.74g

The second variant was chosen to be the velocity of 11km/h, in the first determination of which the quantities were situated between 24.39g at the L2-3 point of interest and 26.12g at the R2-3 point, with a difference of 7.09%. The average of this determination was 25.417g (Table 2). In the second determination of the same variant, the lowest amount of fertilizer was collected at the R4-5 point at which 24.14g was captured, while the highest amount of 26.78g was found at the L5-6 point of interest. In this determination, the difference between the highest and lowest amounts was 10.93% and the average of all 10 points of interest was 25.355g. In the last determination of this variant, there were values registered between 24.86g and 26.34g, meaning that the difference was only 5.95%.

In this determination were recorded the lowest fluctuations of any other determination from this experiment. The average amount of spread fertilizer in this determination was 25.659g. In this variant, the highest difference on the same point of interest between the determinations was found on the R4-5, where the recorded values were 24.14g in the second determination and 25.96g in the third determination the difference being 7.53%.

Table 2. Collected fertilizer at the velocity of 11 km/h at the designated areas of the polyethylene membrane (L5-6, L4-5, L3-4, L2-3, L1-2, R1-2, R2-3, R3-4, R4-5, R5-6) and the number of the determination (D1, D2, D3)

	L5-6	L4-5	L3-4	L2-3	L1-2	R1-2	R2-3	R3-4	R4-5	R5-6
D1	25.75g	25.44g	25.20g	24.39g	25.30g	25.96g	26.12g	25.02g	25.36g	25.63g
D2	26.78g	26.22g	25.17g	25.62g	24.30g	24.46g	25.53g	25.44g	24.14g	25.89g
D3	25.93g	24.94g	25.25g	26.17g	25.72g	24.86g	25.29g	26.13g	25.96g	26.34g

In the last variant in which the velocity was 17 km/h, in the first determination, the collected amount of fertilizer was between 16.85g at L4-5 and 31.31g at L2-3, in which the difference was the highest achieved in the experiment of 85.81% (Table 3). The average of this determination was 24.858g which was lower than the desired amount of 25g. The fluctuation of the second determination was lower than in the first one. The amounts are between 22.37g at R3-4 and 28.34g at L2-3, which is a difference of 26.68%, the average of this determination being 25.283g. The values in the last determination of this variant were found between 22.63g at R3-4 and 28.93g at the L2-3 point of interest. The average quantity of fertilizer that was collected in this determination was 25.52g and the difference between the highest and the lowest value was 27.783g. The highest fluctuation on the same point was recorded on L4-5 where the lowest amount captured was 16.8g in the first determination and the highest was 24.15g in the last determination, which was a difference of 43.32%.

Table 3. Collected fertilizer at the velocity of 17 km/h at the designated areas of the polyethylene membrane (L5-6, L4-5, L3-4, L2-3, L1-2, R1-2, R2-3, R3-4, R4-5, R5-6) and the number of the determination (D1, D2, D3)

	L5-6	L4-5	L3-4	L2-3	L1-2	R1-2	R2-3	R3-4	R4-5	R5-6
D1	28.23g	16.85g	27.30g	31.31g	22.17g	21.90g	27.61g	21.43g	23.23g	28.55g
D2	25.19g	22.96g	25.95g	28.34g	25.23g	24.13g	26.92g	22.37g	24.23g	27.51g
D3	27.51g	24.15g	25.28g	28.93g	24.34g	23.17g	27.14g	22.63g	25.09g	26.96g

There can be observed a fluctuation of the effective rate of spreading in the different variants (Figure 3) and the determinations of those. In most of the cases, the quantity that was distributed was higher than the desired quantity of 250 kg/ha. The highest amount was spread in the second determination of the first variant, the amount being 287.26 kg/ha. The lowest amount that was distributed was 248.58 kg/ha in the first determination of the third variant. The closest variant to the desired amount was the third with an average amount of distributed fertilizer of 252.20 kg/ha.

From the perspective of the uniformity of distribution (Figure 4) it can be observed that all values are situated above the minimal threshold of 75%, which is the minimal index accepted for an optimal work of fertilization. The values are situated between 82.27%, this value being registered on the first determination of the third variant, and 98.04%, this value is recorded at the second determination of the second variant. It can be observed that all the values recorded in the second variant are superior to the other two variants.

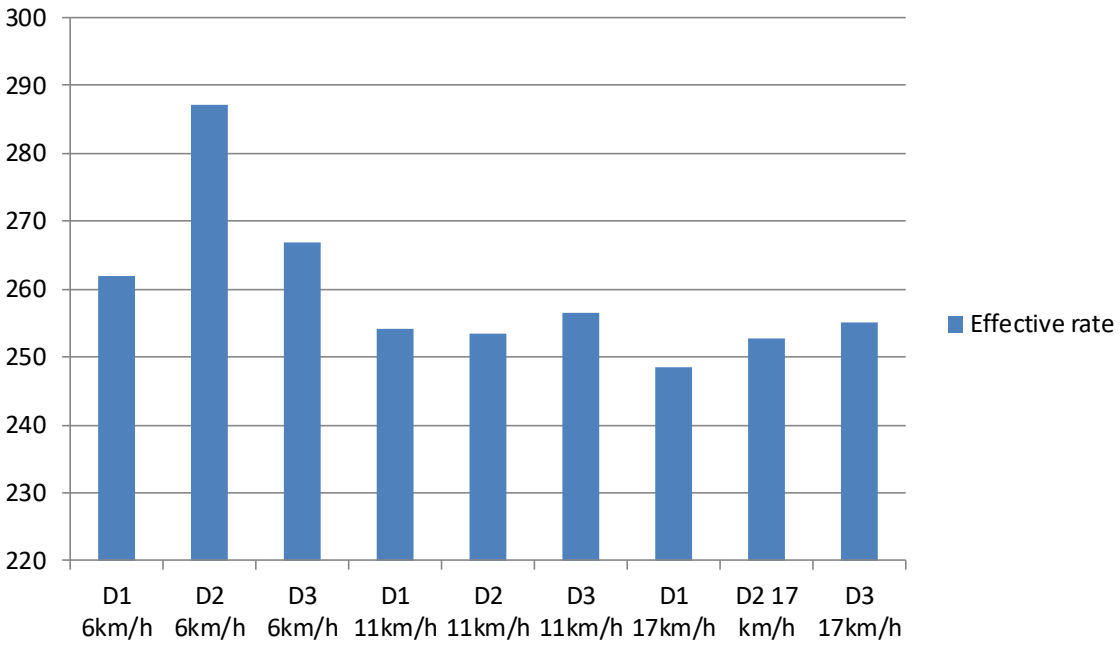

Figure 3. The result of determining the effective rate of spreading in the different determinations of the variants (D1 6km/h, D2 6km/h, D3 6km/h, D1 11km/h, D2 11km/h, D3 11km/h, D1 17km/h, D2 17km/h, D3 17km/h).

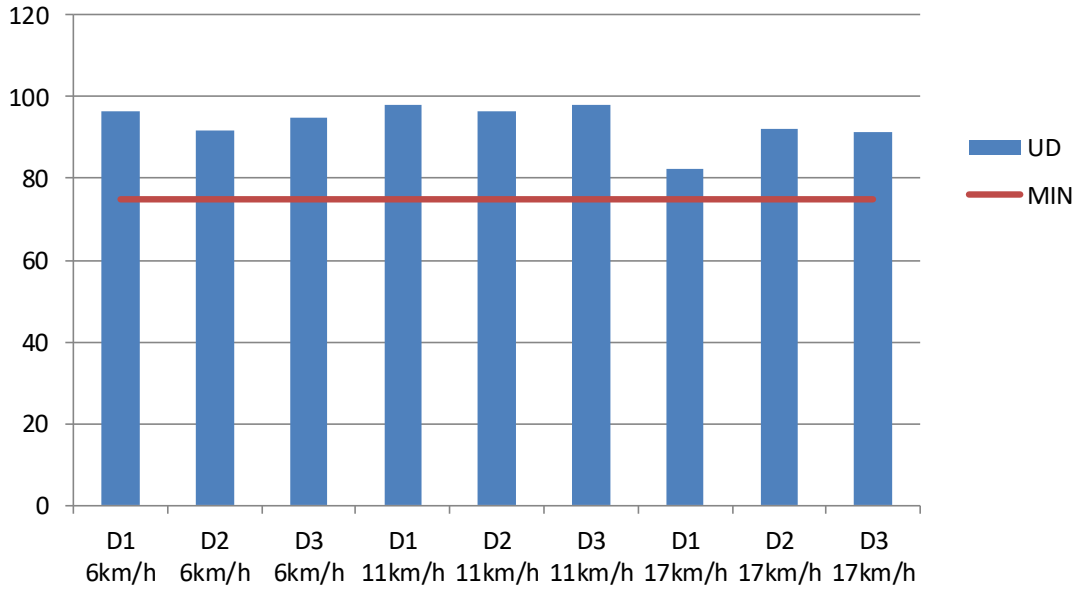

Figure 4. The uniformity of distribution (UD) compared to the minimal accepted value (MIN) at the different determinations of the variants.

The equipment's flow stability coefficient was obtained at the end of the experiment for each variant and determination (Figure 5). This work to be considered appropriate from the point of view of quality, has to record an index of over 85%. The recorded values are found between 62.4% and 95.85%. The variant of 11km/h velocity differs from the others, as it can be seen that at all the determinations record an appropriate value. Even the lowest value of 92.83% of that variant, which was recorded in the second determination is higher than any of the determinations of the other variants. It can be seen that the lowest values were recorded in the third variant, where the lowest value of 62.4% was recorded.

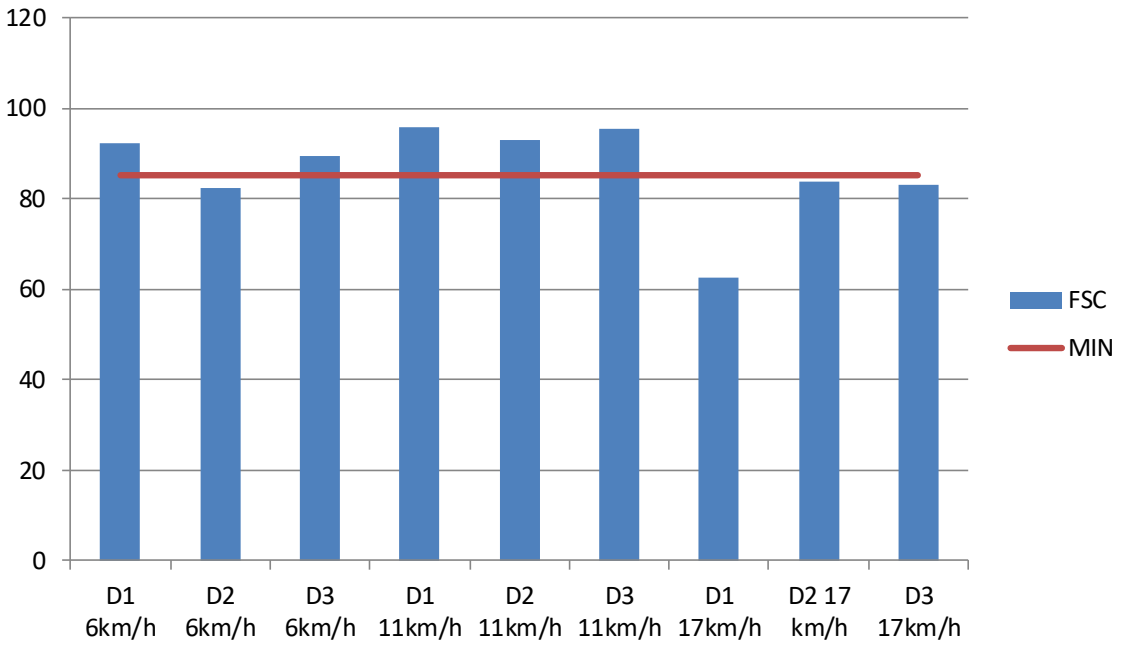

Figure 5. The equipment's flow stability coefficient (FSC) compared to the minimal accepted value at the different determinations of the variants.

CONCLUSIONS

In the present study, it was determined that the most suitable velocity at which the process of fertilizing should be done is 11 km/h, at which the qualitative indicators are optimal. From the point of distribution uniformity, the values fall into the range of 96.62%-98.04%. The flow stability coefficient was also the highest at this velocity at the values of 92.83%-95.85%.

Author Contributions: R.D., O.M. Conceived and designated the analysis; R.D., O.M., A.G. Collected the data; O.R. Contributed data or analysis tools; R.D., O.M. Performed the analysis; R.D. Wrote the paper.

Acknowledgments

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflicts of Interest

The authors declare that they do not have any conflict of interest.

REFERENCES

1. ALnaass NS, Agil HK, Ibrahim HK. Use of fertilizers or the importance of fertilizers in agriculture. International Journal of Advanced Academic Studies. 2021; 3(2):52-57.
2. Bulgakov V, Adamchuk O, Pascuzzi S, Santoro F, Olt J. Experimental research into uniformity in spreading mineral fertilizers with fertilizer spreader disc with tilted axis. Agronomy research. 2021; 19(1):28-41. https://doi.org/10.15159/ar.21.025
3. Chaitra P, Kalia A, Ahuja R, Sidhu SPK, Sikka R. Importance of Nano Fertilizers in Sustainable Agriculture. Environmental Sciences and Ecology: Current Research. 2021; 2:1029.
4. Gellings CW, Parmenter KE. Energy efficiency in fertilizer production and use. In Gellings CW, editor. Efficient Use and Conservation of Energy Volume II. Oxford: Eolss. 2016; 123-136.
5. Laghari M, Laghari N, Shah AR, Chandio FA. Calibration and Performance of Tractor Mounted Rotary Fertilizer Spreader. International Journal of Advanced Research. 2014; 2(4): 839-846.
6. Mihaiu I, Droca ș I, Ranta O, Molnar A. Adjustment of Agricultural Machinery. Cluj-Napoca. Risoprint; 2004.
7. Przywara A, Santoro F, Kraszkiewicz A, Pecyna A, Pascuzzi S. Experimental Study of Disc Fertilizer Spreader Performance. Agriculture. 2020; 10(10):467. https://doi.org/10.3390/agriculture10100467

8. Stewart WM, Roberts TL. Food Security and the Role of Fertilizer in Supporting it. Procedia Engineering. 2012; 46: 76-82. https://doi.org/10.1016/j.proeng.2012.09.448
9. Ugolini R, Caldognetto E, Trotti F. Use of Fertilizers in Agriculture: Individual Effective Dose Estimate. Environments. 2020; 7(1):7. https://doi.org/10.3390/environments7010007
10. Vidican R, Rusu M, Ranta O. 4 Rules for correct application of fertilizers. Cluj-Napoca. 2017.