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Research Article

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Determination of Seed and Fertilizer Distribution Uniformity of Cereal Sowing Machine

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Abstract The aim of this research was to determine the seed and fertilizer distribution uniformity of the cereal sowing machine with toothed roller for different seeding and fertilization rates. The seed and fertilizer distribution of each furrow opener of the cereal sowing machine with toothed roller were investigated.

Materials were cereal sowing machine, wheat, chemical (mineral) fertilizer. In order to achieve the objectives of the study, the cereal sowing machine with toothed roller was tested in the laboratory and evaluated according the sowing machine test methods.

Coefficient of variations (CV) were determined as 2.35% for Scale-10, 2.79% for Scale-20 and 2.67% for scale-30 for seed distribution uniformity between furrow openers. Coefficient of Variations (CV) of fertilizer distribution for each furrow were calculated as 3.52% for scale-10, 5.19% for scale-20 and 3.56% for scale-30. Coefficient of variations for seed and fertilizer distribution uniformity were acceptable for different scale of seed and fertilizer metering system. According to the CV results, the tested cereal sowing machine was evaluated as "Good" for fertilizer distribution uniformity between furrow openers.

Increasing of the seeding rate for different scales of metering unit were good for the cereal sowing machine. But changing of the fertilizer rate was not regular. Differences between some properties such as friction coefficient, flow rate, size etc. of mineral fertilizer particles affected changing of the fertilization rate.

Keywords sowing machine, distribution uniformity, cereal, wheat, fertilizer

Introduction

Turkey has 23.473 million hectares arable land. Wheat production was approximately 17.65 million tonnes and area 6.744 million hectares for 2021 (Anonymous, 2022-a).

A high cereal yield requires a high yield emergence and a uniform development of each plant. To achieve this aim, there is a requirement for a uniform sowing depth as well as a uniform seed distribution over the area. Both depend on the techniques used for seed placement into the soil (Heege, 1993). Ozsert and Ulger (1985) reported that used coefficient of variation (CV %) and standard deviation values to evaluate longitudinal distribution between planting units. The nearest neighbour seed was used to evaluate horizontal seed distribution. Experimental working speeds of the cereal planting machines were 1.5 m/s, 1.76 m/s and 2.2 m/s in the research. In addition, effect of changing of seed height in the hopper on the seeding rate, broken seed rate and effect of seed distribution units on emerging rate were determined.

In a research, with the aim of determining seed distribution uniformity inter and intra rows, silt belt, ultrasonic counter method, opto-electronic method, fiber-optic method, camera measurement method, photocell perception methods were introduced (Üçer and Yalçın, 2008). Longitudinal and horizontal seed distributions were determined to compare planting machines by Aykas et al, (1989). An experiment unit with adhesive plate was used to determine seed distribution. Adhesive plate which had 50x50 mm squares and length was 2 m, was made from two sheet iron. The most suitable speeds were 1m/s, 1.5 m/s and 2 m/s for planting machines. The experiments were carried out different slope conditions (5%, 10% and 20% slope) (Aykas et al, 1989). Accuracy of distribution of plants on row, mean emergence date, field emergence rate, accuracy of distribution of planting depth were used to determine planting machine performance and to compare the machines (Aykas et al; 1989; Akdemir et al;1992). In this research, seed flow rate, seed flow regularity and accuracy of seed spacing of top delivery mini type straight fluted roller were examined in the laboratory experiments for the random seeding of uncoated onion, carrot, canola and coated canola seeds. The regression models developed in this study included the seed flow rate changes with "mini fluted roller's", active flute length, rates of revolution. Generally, seed flow regularity of mini type fluted roller indicated as a value of coefficient of variation (CV) was found below 4% for onion, carrot and canola seeds. When the results were examined from the point of λ goodness criteria and Vf factor of variation, it was found that seeding unit with top delivery type straight fluted roller considered in the study was capable of sowing of uncoated onion, carrot, and coated and uncoated canola seeds at desired quality(Önal and Ertuğrul, 2011). In a research study; planting machines were experienced in field and laboratory studies. The experiments were carried out for 0.5 m/s, 1.0 m/s and 1.5 m/s working speeds. In the laboratory experiments, seed which was distributed on the iron steel plate were counted. The iron steel plate was divided vertical and horizontal bands which dimension of the band was 50x50 mm. Coefficient of variations were calculated. In addition, the seed distribution was tested according to the Poisson Distribution by using X2 test. (Aykas et al, 1989; Önal, 1992). Seed placement accuracy of sowing machines influences field emergence, development of individual plants and hence yield. To evaluate seed placement the evenness of depth is of importance as well as the horizontal distribution over the area. The quality of horizontal overall distribution is influenced by row width and longitudinal distribution and of course plant or seed density as a non-technical parameter. A method is presented to describe the arrangement of plants in row crops by allocating a polygonal area of ground to each plant. This method is able to operate completely in a two-dimensional way (Griepentrog, 1998).

The aim of this research was to determine seed and fertilizer distribution uniformity of cereal sowing machine with toothed roller for different seeding and fertilization rates. In order to achieve the objectives of the study, the cereal sowing machine with toothed roller was tested in laboratory and evaluated according the sowing machine test methods.

Materials and Methods

Cereal sowing machine with toothed roller

Cereal sowing machine manufactured by a Turkish company was used to determine seed distribution uniformity. The semi-mounted type cereal sowing machine drills different seeds by using different tooth has 21 planting units. (Figure 1).

Figure 1: Cereal sowing machine with toothed roller

Seeds and fertilizers were distributed by toothed roller. Toothed roller has three sections, central, right and left. Central section is 60 mm diameter, 53 mm long. Tooth's height is 2 mm., placed in crosswise and double side position. The number of teeth is 12. As for the right section, the diameter is 63 mm, the number of teeth is 12, the height of tooth is 4.5 mm, tooth is placed in single side position. In case of the left section, the diameter is 63 mm, the number of teeth is 12, the height of tooth is 4.5 mm, tooth is placed in crosswise and double side position. Volume of seed and fertilizer hopper are 305 dm^3.

Table 1: Some technical specifications of cereal sowing machine

Width (mm)	2625
Length (mm)	1600
Height (mm)	1590
Distances between furrow openers (mm)	125
Wheel diameter (mm)	570
Seed hopper capacity (dm^3)	305
Fertilizer hopper capacity (dm^3)	305
Number of furrow openers	21

Wheat

Wheat variety was Sobald. Sobald Variety is winter wheat, short-medium height and earing time are mid-late. Some specifications of the Sobald variety were given in Table 2 (Anonymous, 2022-a).

Table 2: Some specifications of the Sobald variety

Criteria	Value
Hectoliter (kg/hl)	67.2-75.3
Weight of 1000 grains (g)	26.7-34.7
Protein (%)	10.5-13.4
Flour yield (%)	68.5-71.2
Energy (W)	59-187

Fertilizer

20-20-0 mineral fertilizer was used in the laboratory tests of the cereal sowing machine. Contents of the fertilizer were given in Table 3 (Anonymous, 2022-b).

Table 3: Content of Calcium Ammonium Nitrate (%26)

Content	% (weight/weight)
Total Nitrogen (N)	20
Phosphorus Pentoxide - Soluble in Neutral Ammonium Citrate and Water (P2O5	20

Determination of seed and fertilizer distribution uniformity

Seed and fertilizer distribution uniformity were determined for each seed and fertilizer metering unit, individually. For this purpose, seed were put in the seed hopper of the machine. Then, wheel of the planting machine was turned 20 times and then distributed seeds were collected in the plastic bags and weighted for each furrow openers. Seed distributions of each furrow openers were measured in three replications and mean values of the machines were evaluated. Descriptive statistics such as mean, standard deviation, coefficient of variation and seeding rate were calculated by using Excel programme. Same measurement method was used for fertilizer distribution uniformity between furrow openers. Coefficient of Variation values given in the Table 4 for evaluation of a sowing machine distribution uniformity. The results were compared with the CV values given in the Table 4. (Anonymous, 1999, Turgut et al, 1991, Ozsert and Ulger, 1985, Bayat et al, 1993, Tucer, 1996).

Table 4: Coefficient of Variation (CV) Limits to consider planting units

Coefficient of variation (CV, %)	Evaluation of sowing machine
1-3	Very good
3-5	Good
5-7	Acceptable
>7	Bad

Results & Discussion

Seed distribution uniformity

Seed distribution of the cereal sowing machine for each metering unit (seed furrow openers) was given in Table 5.

Table 5: Seed distribution of planting machine with toothed roller

	Seeding Rate Scale		
Furrow opener no	**10**	**20**	**30**
1	59	101	145
2	59	98	144
3	58	101	141
4	57	101	141
5	57	98	136
6	60	101	144
7	60	105	148
8	59	101	143
9	58	101	143
10	59	101	143
11	61	107	149
12	63	108	154
13	59	107	147
14	61	107	143
15	57	105	150
16	60	101	141
17	59	101	141
18	59	101	145
19	59	101	141
20	59	102	145
21	59	101	141
Total (g)	1252.00	2169.00	3055.00
Average (g)	59.14	102.33	144.05
Standard deviation (g)	1.39	2.85	3.85
Coefficient of variation (%)	2.35	2.79	2.67
Sowing rate (kg/ha)	125.9	218.1	307.2

According to the results for different seeding rates established by changing of scale of the machine;

-Standard deviation was 1.39 g for scale-10, 2.85 g for scale-20 and 3.85 g for scale-30. Standard deviations were increased by increasing scale.

-Coefficient of variations (CV) were determined as 2.35% for scale-10, 2.79% for scale-20 and 2.67% for scale-30. Coefficient of variations were almost stable and acceptable for different scale values. According to the CV results, the tested cereal sowing machine was evaluated as “Good” for seed distribution uniformity (Turgut et al, 1991, Ozsert and Ulger, 1985, Bayat et al, 1993, Tucer, 1996).

-Seeding rate were 125.9 kg/ha for Scale-10, 218.1 kg/ha for Scale-20 and 307.2 for Scale-30. Seeding rates were increased by increasing scale. The seeding rate were started from 125.9 kg per ha and increased 92.2 kg when the scale changed from Scale-10 to Scale-20. And then it increased 89.1 kg for Scale-30. In the practice it is not possible to increase linear. Even there are some differences for the seeding rate but it is quite acceptable because of the size, weight differences between increase of seeding rates, the results were acceptable because of differences between seeds.

Fertilizer distribution uniformity

Fertilizer distribution of the cereal sowing machine for each furrow openers (each fertilizer metering unit) was given in Table 6.

Table 6: Fertilizer distribution of planting machine with toothed roller

	Fertilizer Rate Scale		
Furrow opener no	**10**	**20**	**30**
1	70	88	162
2	70	90	162
3	66	90	162
4	70	91	166
5	67	84	154
6	67	85	154
7	65	85	153
8	67	85	155
9	70	82	155
10	68	87	154
11	66	84	154
12	64	80	150
13	64	81	150
14	66	79	150
15	67	79	149
16	65	78	145
17	64	80	146
18	66	81	149
19	65	80	149
20	64	79	149
21	61	75	155
Total (g)	1402.00	1763.00	3253.00
Average (g)	66.29	83.00	153.48
Standard deviation (g)	2.33	4.31	5.47
Coefficient variation (%)	3.52	5.19	3.56
Fertilization rate (kg/ha)	141.0	177.3	327.1

According to the results for different fertilization rates established by changing of scale of the machine;
-Standard deviation was 2.33 g for Scale-10, 4.85 g for Scale-20 and 5.47 g for scale-30. Standard deviations were increased by increasing scale.
-Coefficient of variations (CV) were determined as 3.52% for scale-10, 5.19% for scale-20 and 3.56% for scale-30. Coefficient of variations were acceptable for different scale values of fertilizer metering unit. According to the CV results, the tested cereal sowing machine was evaluated as "Good" for fertilizer distribution uniformity between furrow openers (Turgut et al, 1991, Ozsert and Ulger, 1985, Bayat et al, 1993, Tucer, 1996).
-Fertilization rate were 141.0 kg/ha for Scale-10, 177.3 kg/ha for Scale-20 and 327.2 for Scale-30. The fertilization rates were increased by increasing scale. The seeding rate were started from 141.0 kg per ha and increased 36.3 kg when the fertilization scale changed from Scale-10 to Scale-20. And then it increased 149.9 kg for Scale-30. Differences between fertilizer granules affected increasing of the fertilizer.

Conclusion

According to the seed and fertilizer distribution of the cereal sowing machine with toothed roller; seed distribution and fertilizer distribution uniformity between furrow openers were acceptable according to the sowing machine test standards. Increasing of the seeding rate for different scales of metering unit were good. But increasing of the fertilizer was not regular. Variation of the fertilization rate was affected by differences between size of mineral fertilizer particles. Further research should be done with different seeds and mineral fertilizers for different forward speeds.

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