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Influence of some herbicides and herbicide combinations on the structural elements of yield and some quality indicators in common wheat grain

Mitko Georgiev

Trakia University, Faculty of Agriculture, Stara Zagora 6000, Bulgaria
E-mail: mgeorgiev74@gmail.com

Abstract

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During the period 2009-2012 a field experiment with common wheat cultivar Diamond was conducted. The effect of five leaf herbicides and one soil herbicide and some combinations between them was studied at the main structural elements of the yield: plant height, productive tillers per plant, spike length, number of spikelets per spike, number of grains per spike, grain weight per spike. Some qualitative yield indicators were also determined: weight of 1000 grains and hektoliter weight.

The highest plants (88.9 cm) were observed in the variant with the manual weeding control. The largest number of productivity spikes was in the variant with Stomp New 330 EC (630.8 pcs/m$^{2)}$. The longest classes (9.37 cm) were in the variant with wheat plants treated with Secator OD. The highest number of spikelets per spike (19.28) was observed in the plants treated with Stomp New 330 EC. The highest number of grains per spike (33.8 pcs), the largest grain weight per spike (1.45 g) and the highest weight of 1000 grains (43.15 g) were observed for the combination of Granstar 75 DF + Axial 050 EC. The hectoliter weight of the grain is highest in the variant treated alone with Granstar 75 DF.

*Keywords***:** wheat; herbicides; elements of yield; grain quality; indicators

Introduction

The provision of plant food products to the ever-growing population of the Earth is one of the most important problems of plant production. An important stage in wheat growing technology is plant protection, in particular the control of weeds (Georgiev, 2015). Key element in modern technologies for the protection of crops from weeds is the use of herbicides with high selectivity and efficiency, which guarantees high and quality yields (Marinov-Serafimov et al., 2017). Stoyanova (2017) and Georgiev (2014) established an increase in yields, respectively, elements of yields when applying herbicides to the wheat.

In field experiment with untreated and herbicide-treated spring barley, Boatman (1992) found an increase in grain yield of 50 to 120 kg/da-1 in variants with chemical weed control agents. Martin et al. (1989) examined the effect of several herbicides introduced in different phenophases on winter wheat and found a proven decrease in plant height without affecting the number and mass of the grains in the spike.

Martin et al. (1989), Ahmed et al. (1993), Khan (1994, 2002), Khan et al. (1999), Hashim et al. (2002), Cheema and Akhtar (2005), Sangi et al. (2012) reported for high efficacy of the herbicides Arelon, Graminon, Tribunyl, Buctril, Dikuran, Tolcan and Dozanex. The increase in grain yield is due to the increase in productive tillering, number of grains in the spike and 1000 grain mass.

Tottman (1978) found that the introduction of herbicides containing *dicamba*, MCPA and *mecoprop* in wheat through the phenophase spraying proved to reduce the yield of grain and respectively negatively affect the yield components.

There are no proven differences in the values of the 1000 grain mass, specific weight and glassiness between the various herbicides and herbicide mixtures. The reservoir mix-

tures of fenoxaprop-ethyl with triasulfuron + dicamba or 2,4 D + dicamba reduce the amount of protein, wet and dry gluten on the durum wheat (Delchev, 2009).

Material and Methods

A field experience with common wheat (*Tritucum aestivum* L.) variety Diamond was conducted in the period 2009-2012 in the experimental field of the Department of Plant Science at the Faculty of Agriculture of Trakia University - Stara Zagora. The experiment is based on the block method with 4 replications. Six herbicides (5 post-emergency and 1 pre-emergency) and 4 herbicide combinations were tested: variant 1 – without weeding (control); variant 2 – with manually weeding (control); variant 3 – Axial 050 EC (90 ml/da); variant 4 – Granstar 75DF (2 g/da); variant 5 – Derby Super WG (3.3 g/da); variant 6 – Secator OD (10 ml/da); variant 7 – Lintur 70 WG (15 g/da); variant 8 – Granstar 75DF (2 g/da) + Axial 050 EC (90 ml/da); variant 9 – Derby Super WG (3.3 g/da) + Axial 050 EC (90 ml/da); variant 10 – Secator OD (10 ml/da) + Axial 050 EC (90 ml/da); variant 11 – Lintur 70 WG (15 g/da) + Axial 050 EC (90 ml/da); variant 12 – Stomp New 330 EC (0.5 l/da).

The treatment with the foliar herbicides Axial 050 EC, Granstar 75 DF, Derby Super WG, Secator OD and Lintur 70 WG was carried out in tillering phenophase. The treatment with the pre-emergency herbicide Stomp New 330 EC was applied in the post-sowing period.

The following indicators are defined: productive tillers per m^2; plant height (cm); spike length (cm); number of spikelets per spike; number of grains per spike; grain weight per spike (g); weight of 1000 grains (g) (BDS 13358-76); hectoliter weight (kg) (BDS 13381-76).

Results and Discussion

In the first year of the investigation the *plant height* of wheat ranged from 98.8 to 110.5 cm (Table 1). The plant height is greatest in the variant 2 (with manually weeding), respectively 110.5 cm, and the lowest is in the variant 1 (without weeding) – 98.8 cm. The variation of the indicator in the treated variants is negligible, indicating that this year the herbicides and combinations tested do not have a significant impact.

During the second year of the study, in the spring, the plants formed a lower above ground mass. The highest is in the variant with the manually removed weeds control and treated with Axial 050 EC (90.5 and 90.6 cm, respectively), and the lowest – in the variant treated with Secator OD and in control with weeds, respectively 85.6 and 85.9 cm, and the differences are not statistically proven.

In the third year of the experiment, the height of the plants in the experiment is even lower due to less favorable weather conditions during the booting phase. The highest indicator in this year is the plants of the variants treated with Derby Super and Stomp 330 EC New, respectively with a height of 66.2 and 66.0 cm. The lowest plants are the variants treated

Table 1. Influence of herbicides and their combinations on the height of plants

Variants	2010	2011	2012	Average*
1. Unweeded control	98.8a	87.7a	65.5b	84.0a
2. Hand weeded control	110.5b	90.5a	65.9b	88.9a
3. Axial 050 EC	103.0a	90.6a	60.7a	84.7a
4. Granstar 75 DF	110.2b	86.4a	62.9b	86.5a
5. Derby Super WG	109.2b	86.2a	66.2b	87.2a
6. Secator OD	109.5b	86.5a	60.8a	85.6a
7. Lintur 70 WG	102.9a	89.7a	64.7b	85.7a
8. Granstar 75 DF + Axial 050 EC	109.9b	87.9a	60.9a	86.2a
9. Derby Super WG + Axial 050 EC	101.0a	85.6a	62.2b	82.9a
10. Secator OD + Axial 050 EC	103.0a	86.5a	60.3a	83.2a
11. Lintur 70 WG + Axial 050 EC	105.3a	85.9a	63.3b	84.8a
12. Stomp New 330 EC preemergency	109.6b	89.5a	66.0b	88.3a
Average	106.1	87.7	63.3	85.71
Min	98.8	85.6	52.7	79.03
Max	110.5	90.6	70.5	90.53
SD	6.6	4.3	3.8	4.9
SEE	0.9	0.6	0.6	0.7

*Differences are statistically proven at $P < 0.05$ if they do not have the same letters

with the combination of Secator OD + Axial 050 EC and the variant treated with Axial 050 EC alone - with height 60.3 and 60.7 cm, respectively (Table 1).

Average for the study period, the highest plants were in the control with manually weeding (88.9 cm), and the lowest were the plants treated with Secator OD (82.9 cm). The results show that this herbicide has some retarding effect on the crop. As opposed to Newhouse et al. (1992), the applied soil herbicide Stomp New 330 EC does not have a negative influence on the height of the wheat plants.

Table 2 shows the results for *productivity tillering*. In the first year, the highest values were observed in the variant with manually removed weeds and the variant with the soil herbicide Stomp New 330 EC – 738.5 and 708.0 psc/m², respectively. With the smallest number of productivity tillers is the combination of Derby Super WG + Axial 050 EC and Secator OD + Axial 050 EC – 510.8 and 512.0 pcs/m², and the difference between these variants being statistically proven. In the second year of experiment, the largest number of productive tillers was observed in the combination of Granstar 75 DF + Axial 050 EC and Stomp New 330 EC with 628.5 and 607.5 pcs/m², respectively. With the smallest number of productive tillers is the variants treated with Derby Super WG and Lintur 70 WG, with 419.8 and 432.8 pcs/m², respectively. In the third year of the study, with the highest value for this indicator are combinations Derby Super WG + Axial 050 EC and Granstar 75 DF + Axial 050 EC. The lowest values are observed in the variants with Derby Super WG and Secator OD – 497 and 514 psc/m², respectively.

Average for the study period with the largest number of productive tillers was the variant with Stomp New 330 EC and the combination of Granstar 75 DF + Axial 050 EC – 630.8 and 615.5 pcs/m², respectively (Table 2). This is explained by the reduced density of weeds in these variants. For the study period, there is a tendency to reduce productive tillers in plants treated with the combination of Secator OD + Axial 050 EC.

During the all period of the study the variation for the *number of spikelets per spike* is low (Table 3).

In the first year the highest number of spikelets per spike was observed in the variant with manually weeding, the combination Lintur 70 WG + Axial 050 EC and Stomp New 330 EC, Derby Super WG and Secator OD, respectively with 19.8, 19.6 and 19.3 for the last three variants. The lowest values for this indicator are in the combination with Derby Super WG + Axial 050 EC (18.2).

In the second year of the study, the highest number of spikelets per spike was observed in the plants treated with Stomp New 330 EC (20.0 pcs), and the least – in the variant with Lintur 70 WG (18.9). In the third year of the study, the lowest values of this indicator were observed. The highest grade spikelets per spike is in the variant with Stomp New 330 EC – 18.5, and the lowest was in the control without weeding – 17.4.

On average, for the period of the study with the highest number of spikelets per spike were the plants treated with

Table 2. Influence of herbicides and their combinations on the number of productive tillers (number/m²)

Variants	2010	2011	2012	Average*
1. Unweeded control	525.8a	470.3a	527.0a	507.7a
2. Hand weeded control	738.5b	500.0a	573.0a	603.8a
3. Axial 050 EC	629.3a	585.0a	533.0a	582.4a
4. Granstar 75 DF	616.8a	511.5a	642.0a	590.1a
5. Derby Super WG	662.8a	419.8a	497.0a	526.5a
6. Secator OD	590.0a	534.0a	514.0a	546.0a
7. Lintur 70 WG	628.0a	432.8a	520.0a	526.9a
8. Granstar 75 DF + Axial 050 EC	616.0a	628.5a	602.0a	615.5a
9. Derby Super WG + Axial 050 EC	510.8a	567.5a	644.5a	574.2a
10. Secator OD + Axial 050 EC	512.0a	490.0a	578.0a	526.6a
11. Lintur 70 WG + Axial 050 EC	663.3a	510.5a	535.0a	569.6a
12. Stomp New 330 EC preemergency	708.0a	607.5a	577.0a	630.8a
Average	616.8	521.4	561.9	566.7
Min	511	419.8	392.0	440.9
Max	739	628.5	748.0	705.0
SD	133	132	85	116.8
SEE	19	19	12	16.8

*Differences are statistically proven at $P < 0.05$ if they do not have the same letters

Stomp New 330 EC and the combination Lintur 70 WG + Axial 050 EC (19.28 and 19.00 pcs). At least are the values in the control without weeing and in the combination Derby Super WG + Axial 050 EC (18.48 pcs). During the three years of the study, the differences between these variants were not statistically proven (Table 3).

In the first year of the study, the *spike length* indicator has the highest values for the control with manually weeding and for the variant with Secator OD – 8.74 cm and 8.59 cm, respectively. With the shortest length of the spike were plants from the variants treated alone with Lintur 70 WG and with Axial 050 EC, respectively 7.80 and 7.90 cm, and from the control with manually weeding –7.94 cm (Table 4).

In the second year the spike length varies within very low limits. The difference between plants with the longest and shortest spikes was 0.7 cm. The longest spikes were in the variant with the Lintur 70 WG – 8.80 cm, and the shortest is in the variant with Granstar 75 DF – 8.10 cm. In the third year of the study, the longest spikes were observed for the variants with Stomp 330 EC New, the combination of Granstar 75 DF + Axial 050 EC and the combination of Secator OD + Axial 050 EC (10.92; 10.80 and 10.78 cm, respectively). The shortest spikes were in the variant with Derby Super WG and the control without weeing – 10.11 and 10.21 cm, respectively (Table 4).

Average for the study period the longest is the wheat plants treated with Secator OD – 9.37 cm. In this variant, there was a reduction in plant height on average over the study period, but the length of the spike is greatest. The Stomp New 330 EC and Granstar 75 DF + Axial 050 EC treated are 9.31 and 9.30 cm respectively. The control without weeding and combination of Derby Super WG + Axial 050 EC with 8.79 and 8.92 cm respectively (Table 4) were with the shortest spikes. The differences in the different options are not statistically proven. The results obtained show that the herbicides used and their combinations do not significantly affect the values of this indicator.

In the first year of the study with the highest *number of grains per spike* were the control with manually weeding (36.2), the variant treated with the combination of Granstar 75 DF + Axial 050 EC (36 pcs) and the combination Lintur 70 WG + Axial 050 EC (35 pcs). The lowest values of this indicator were control without weeding (28.7), followed by the variant treated separately with Axial 050 EC and the preemergence applicated with Stomp New 330 EC, which are respectively 31.4 and 32.9 grains per spikes. The results of the statistical analysis show that there are no significant variations in the number of grains in the spike (Table 5).

In the second year, the number of grains in the spike in all variants is lower than in the first year. With the highest number of grains per spike is the variants treated with Secator OD (35.2) and Axial 050 EC (34.3), followed by the combination Granstar 75DF + Axial 050EC (34.2) and the combination Secator OD + Axial 050 EC (33.3). Differences are statistically proven. The control with weeds (24.6) and the options treated with Lintur 70 WG and Derby Super WG are

Table 3. Effect of herbicides and their combinations on the number of spikelets per spike

Variants	2010	2011	2012	Average*
1. Unweeded control	18.9a	19.2a	17.35a	18.48a
2. Hand weeded control	19.8a	18.9a	18.1a	18.93a
3. Axial 050 EC	18.7a	19.9a	17.7a	18.79a
4. Granstar 75 DF	19.0a	19.9a	17.8a	18.90a
5. Derby Super WG	19.3a	19.1a	18.3a	18.91a
6. Secator OD	18.8a	19.6a	18.2a	18.88a
7. Lintur 70 WG	18.9a	18.8a	18.2a	18.64a
8. Granstar 75 DF + Axial 050 EC	18.8a	19.6a	18.1a	18.85a
9. Derby Super WG + Axial 050 EC	18.2a	19.6a	17.6a	18.48a
10. Secator OD + Axial 050 EC	18.8a	19.6a	18.2a	18.88a
11. Lintur 70 WG + Axial 050 EC	19.6a	19.3a	18.1a	19.00a
12. Stomp New 330 EC preemergency	19.3a	20.0a	18.5a	19.28a
Average	19.0	19.5	18.0	18.83
Min	18.2	18.8	16.2	17.73
Max	20.8	20.0	19.6	20.13
SD	0.6	0.7	0.7	0.67
SEE	0.09	0.1	0.1	0.10

*Differences are statistically proven at $P < 0.05$ if they do not have the same letters

ranked lowest in this year, with 25.7 and 27.6 grains respectively. But the differences are not statistically proven.

In the third year of the study with the largest number of grains per spike were the control with manually weeding (32.0), followed by the combination of Secator OD + Axial 050 EC (31.8) and variant treated separately with Lintur 70WG (31.6). The lowest values of this indicator were obtained from the control without weeding (25.4), variant with Granstar 75 DF (26.8) and the combination Derby Super WG + Axial 050 EC (26.9). And these year's results from the statistical analysis show that there is no proven variation in the number of grains per spike (Table 5).

On average, for the period of study with the most grains per spike were the combinations Granstar 75 DF + Axial 050 EC (33.8), Lintur 70 WG + Axial 050 EC (33.7) and control with weeding (33.1). In general, the number of grains per spike of all variants treated with combinations of herbicides is high, except the combination Derby Super WG + Axial 050 EC. With the least number of grains per spike are the control without weeding, followed by the combination of Derby Super WG + Axial 050 EC and the variant with Lintur 70 WG (26.2, 29.8 and 30.1, respectively). On average, over the study period, there were no statistically proven deviations from the control without weeding (Table 5), which did not confirm Tottman (1978) studies for *dicamba*-containing herbicide (Lintur 70 WG).

The variation in *grain weight per spike* during the study period is significant. In the first year of the study, the highest grain weight per spike was observed for variants treated with the Granstar 75 DF + Axial 050 EC (1.97 g), Lintur 70 WG + Axial 050 EC (1.83 g) and Granstar 75 DF (1.87 g). With the lowest grain weight per spike this year were the variants control without weeding (1.34 g), Derby Super WG + Axial 050 EC (1.41 g) and Axial 050 EC (1.47 g) (Table 6).

In the second year the weight of grains per spike was significantly lower. The highest values in this year are the combination of Granstar 75 DF + Axial 050 EC (1.18 g), the variant treated alone with Axial (1.16 g) and the combination Secator OD + Axial 050 EC (1.14 g). The lowest values for this indicator are the control without weeding (0.77 g), the variant with Granstar 75 DF (0.86 g) and the control with manually weeding (0.89 g) (Table 6).

In the third year, the values obtained for the grain weight per spike are similar to those obtained in the first year of the survey. The herbicidal combination of Secator OD + Axial 050 EC has the highest grain weight per spike (1.36 g), followed by the combination of Granstar 75 DF + Axial 050 EC (1.32 g). With the lowest grain weight per spike was the control without weeding (1.00 g), the variant treated alone with Granstar 75DF (1.10 g) and the variant treated alone with Axial 050 EC (1.17 g).

For the study period, the highest values for the grain weight per spike were observed in the variants with the herbicide combinations Granstar 75 DF + Axial 050 EC (1.45 g), Secator OD + Axial 050 EC (1.39 g) and Lintur 70 WG + Axial 050 EC (1.30 g) due to the broad spectrum herbicidal action of these combinations. The high weed density in the control without weeding and the un-

Table 4. Influence of herbicides on the length of the spike

Variants	2010	2011	2012	Average*
1. Unweeded control	7.94a	8.23a	10.21ab	8.79a
2. Hand weeded control	8.74b	8.48a	10.41ab	9.21a
3. Axial 050 EC	7.90a	8.73a	10.82ab	9.15a
4. Granstar 75 DF	8.65b	8.10a	10.32ab	9.02a
5. Derby Super WG	8.35a	8.34a	10.72ab	9.13a
6. Secator OD	8.59a	8.80a	10.72ab	9.37a
7. Lintur 70 WG	7.80a	8.40a	10.66ab	8.96a
8. Granstar 75 DF + Axial 050 EC	8.55a	8.56a	10.80ab	9.30a
9. Derby Super WG + Axial 050 EC	8.29a	8.36a	10.11c	8.92a
10. Secator OD + Axial 050 EC	8.56a	8.43a	10.78ab	9.25a
11. Lintur 70 WG + Axial 050 EC	8.30a	8.45a	10.60ab	9.11a
12. Stomp New 330 EC preemergency	8.33a	8.69a	10.92b	9.31a
Average	8.33	8.46	10.6	9.13
Min	7.80	8.1	8.6	8.17
Max	8.74	8.8	11.6	9.71
SD	0.5	0.5	0.5	0.50
SEE	0.07	0.07	0.07	0.07

*Differences are statistically proven at P <0.05 if they do not have the same letters

disturbed broadleaf weeds in the Axial treated variant determined their lowest grain weight per spike – 1.03 g and 1.26 g, respectively. The differences between all variants and the control without weeding are statistically proven (Table 6). The results obtained confirm the studies of Martin et al. (1989).

The qualitative indicators – 1000 grains weight and hectoliter weight of the grain were determined. The results for the 1000 grains weight are shown in Table 7.

In the first year, the largest *weight of 1000 grains* was observed in the combination of Granstar 75 DF + Axial 050 EC, as well as the variant with Secator OD (50.92 g) fol-

Table 5. Influence of herbicides on the number of grains per spike

Variants	2010	2011	2012	Average*
1. Unweeded control	28.7a	24.6a	25.4a	26.2a
2. Hand weeded control	36.2a	31.2a	32.0a	33.1a
3. Axial 050 EC	31.4a	34.3b	30.4a	31.0a
4. Granstar 75 DF	35.1a	28.5a	26.8a	31.1a
5. Derby Super WG	33.2a	27.9a	29.5a	30.2a
6. Secator OD	33.2a	35.2b	31.4a	33.2a
7. Lintur 70 WG	33.1a	25.7a	31.6a	30.1a
8. Granstar 75 DF + Axial 050 EC	36.0a	34.2b	31.2a	33.8a
9. Derby Super WG + Axial 050 EC	32.8a	29.7a	26.9a	29.8a
10. Secator OD + Axial 050 EC	33.6a	33.3b	31.8a	32.9a
11. Lintur 70 WG + Axial 050 EC	35.0a	31.9b	28.4a	33.7a
12. Stomp New 330 EC preemergency	32.9a	30.6a	30.1a	31.2a
Average	33.5	31.1	29.6	31.39
Min	28.7	24.6	25.4	26.50
Max	36.2	34.3	37.6	36.00
SD	3.9	4.9	3.3	3.70
SEE	0.2	0.2	0.2	0.20

*Differences are statistically proven at P <0.05 if they do not have the same letters

Table 6. Influence of herbicides on grain weights per spike (g)

Variants	2010	2011	2012	Average*
1. Unweeded control	1.34a	0.77a	1.00a	1.03b
2. Hand weeded control	1.69a	0.89a	1.28a	1.28a
3. Axial 050 EC	1.47a	1.16b	1.17a	1.26a
4. Granstar 75 DF	1.87b	1.00a	1.10a	1.32a
5. Derby Super WG	1.63a	0.86a	1.28a	1.25a
6. Secator OD	1.48a	1.11b	1.24a	1.27a
7. Lintur 70 WG	1.51a	1.03a	1.32a	1.28a
8. Granstar 75 DF + Axial 050 EC	1.97b	1.18a	1.22a	1.45a
9. Derby Super WG + Axial 050 EC	1.41a	1.04a	1.21a	1.28b
10. Secator OD + Axial 050 EC	1.67a	1.14a	1.36a	1.39a
11. Lintur 70 WG + Axial 050 EC	1.85a	1.08a	1.19a	1.30a
12. Stomp New 330 EC preemergency	1.54a	0.92a	1.30a	1.25a
Average	1.65	1.04	1.25	1.31
Min	1.51	0.86	0.88	1.08
Max	1.91	1.26	1.63	1.60
SD	0.20	0.10	0.18	0.26
SEE	0.03	0.02	0.02	0.02

*Differences are statistically proven at P <0.05 if they do not have the same letters

Table 7. Influence of herbicides and herbicide combinations on the mass of 1000 grains (g)

Variants	2010	2011	2012	Average*
1. Unweeded control	48.49a	28.91a	40.35a	39.25a
2. Hand weeded control	49.20	31.86b	44.95b	42.00a
3. Axial 050 EC	48.76a	32.59b	42.17ab	41.17a
4. Granstar 75 DF	50.70	31.01a	43.49ab	41.73a
5. Derby Super WG	48.81a	30.91a	45.50b	41.74a
6. Secator OD	50.92	33.07b	45.46b	43.15a
7. Lintur 70 WG	46.65	32.09b	41.61ab	40.11a
8. Granstar 75 DF + Axial 050 EC	50.92	33.07b	45.46b	43.15a
9. Derby Super WG + Axial 050 EC	47.04	35.86b	42.73ab	41.87a
10. Secator OD + Axial 050 EC	48.18a	31.19a	42.57ab	40.64a
11. Lintur 70 WG + Axial 050 EC	45.29	33.05b	44.85ab	41.06a
12. Stomp New 330 EC preemergency	47.70	30.53a	42.69ab	40.30a
Average	48.20	31.82	43.27	41.10
Min	45.29	28.91	39.60	37.93
Max	50.92	35.86	56.20	47.66
SD	1.62	2.3	3.2	2.37
SEE	0.23	0.3	0.5	0.33

*Differences are statistically proven at P <0.05 if they do not have the same letters

lowed by Granstar 75 DF (50.7 g). Due to its stressful effect, the herbicide Lintur 70 WG and its combination with Axial 050 EC have the lowest absolute weight of 46.65 g and 45.29 g, respectively.

In the second year of the study, the weight of 1000 grains ranged from 28.91 to 35.86 g. The variants with the highest values of this indicator are Derby Super WG + Axial 050 EC and Granstar 75DF + Axial 050 EC – 35.86 and 33.07 g, respectively. The lowest values are the control without weeding and the variant treated with Stomp 330 EC New with 28.91 and 30.53 g, respectively. The difference between these and the variants with the highest values of the indicator is statistically proven.

In the third year, the indicator ranges from 40.35 to 45.50 g. With the largest weight of 1000 grains are the variants treated with Derby Super WG + Axial 050 EC and Granstar 75 DF + Axial 050 EC – 45.50 and 45.46 g, respectively, and the lowest values are the control without weeding and the Lintur 70 WG, respectively 40.35 and 41.61 g. The difference between the highest values for this indicator and those with the lowest is statistically proven (Table 7).

Average for the study period, the variation of the indicator ranges from 40.11 to 43.15 g. With the highest weight of 1000 grains are the herbicide combination of Granstar 75 DF + Axial 050 EC and Secator OD (43.15 g), as well as the control with manually weeding (42 g), and the lowest are the control without weeding (39.25 g), Lintur 70 WG (40.11 g) and Stomp New 330 EC (40.30 g) (Table 7). The largest weight of 1000 grains is the combination of Granstar 75 DF and Axial 050 EC, as well as the variant with Granstar 75DF (50.7 g). Due to its stressful effect, the herbicide Lintur 70 WG and its combination with Axial 050EC have the lowest absolute weight of 46.65 g and 45.29 g, respectively.

The *hectoliter weight* of the wheat grain during the first year of the study ranged between 70.08 and 71.33 kg and was highest in the Stomp New 330 EC, Granstar 75 DF and Secator OD. The lowest value is in the control without weeding and the combination Granstar 75 DF + Axial 050 EC and the variant with Granstar 75 DF. The difference between variants in the first year was not statistically proven (Table 8).

In the second year the values of this indicator are between 70.03 and 75.38 kg. With the highest hectoliter weight, unlike the previous year, is the combination of Granstar 75 DF + Axial 050 EC, followed by the combination Lintur 70 WG + Axial 050 EC (74.68 kg) and the control with manually weeding (74.48 kg). The variants with the lowest weight of 100 dm^3 grain is that of the Stomp New 330 EC, after which a 70.03 kg specific gravity was obtained, followed by the control without weeding (73.70 kg) and the variant of the Secator OD (73.75 kg). The difference between the highest value and the lowest is statistically proven (Table 8).

In the third year of the study with the highest hectoliter weight were the variants with Granstar 75 DF (80.17 kg), the combination of Secator OD + Axial 050 EC (79.30 kg)

Table 8. Effect of herbicides on hectoliter weight (kg)

Variants	2010	2011	2012	Average*
1. Unweeded control	70.08a	73.70a	76.4a	73.54a
2. Hand weeded control	70.18a	74.48a	77.4a	74.02a
3. Axial 050 EC	70.18a	73.83a	77.72a	73.91a
4. Granstar 75 DF	71.11a	74.33a	80.17a	75.20a
5. Derby Super WG	70.35a	74.00a	77.1a	73.81a
6. Secator OD	70.90a	73.75a	76.60a	73.75a
7. Lintur 70 WG	71.13a	74.43a	75.67a	73.74a
8. Granstar 75 DF + Axial 050 EC	70.10a	75.38b	77.05a	74.17a
9. Derby Super WG + Axial 050 EC	70.53a	73.95a	79.1a	74.52a
10. Secator OD + Axial 050 EC	70.53a	74.13a	79.3a	74.65a
11. Lintur 70 WG + Axial 050 EC	70.58a	74.68a	77.72a	74.32a
12. Stomp New 330 EC preemergency	71.33a	73.06a	76.85a	73.59a
Average	70.58	74.14	77.59	74.10
Min	70.08	73.70	74.00	72.59
Max	71.33	75.38	81.20	75.97
SD	0.9	0.90	1.69	1.16
SEE	0.13	0.10	0.24	0.16

*Differences are statistically proven at $P < 0.05$ if they do not have the same letters

and the combination of Derby Super WG + Axial 050 EC (79.10 kg). The lowest hectoliter weight is in variants with Lintur 70 WG (75.67 kg), the control without weeding (76.4 kg) and the variant with Stomp New 330 EC (75.86kg). The differences between the different options this year are statistically reliable (Table 8).

Average for the three years of the experiment, the values varied between 73.54 and 75.20 kg. The highest grain mass is in the variant treated with Granstar 75 DF, followed by the combination Secator OD + Axial 050 EC and Derby Super WG + Axial 050 EC – 74.65 and 74.52 kg respectively. The lowest values for this indicator are the control without weeding followed by the Stomp New 330 EC (73.5 kg) and the variant with Lintur 70 WG (73.74 kg) (Table 8).

Conclussions

The tested herbicides and combinations influence the height of the wheat plants. The highest plants are in the variant with manually removed weeds. The productive tillering is highest when treated with herbicide Stomp New 330 EC. With the highest number of spikelets per spike is variant with Stomp New 330 EC, but the differences in the individual variants are not statistically proven. The longest wheat spikes were in the variant treated with Secator OD. The largest number of grains per spike was recorded in wheat treated with the combination of Granstar 75 DF + Axial 050 EC.

Average for the study period, the highest values of grain weight per spike are variants treated with the herbicide combinations Granstar 75 DF + Axial 050 EC and Secator OD + Axial 050 EC, with the difference between the weights in both variants being 0.06 g. With the highest weight of 1000 grains is the herbicide combination of Granstar 75 DF + Axial 050 EC. The highest hectoliter weight is in the variant treated with Granstar 75 DF, followed by the combination Secator OD + Axial 050 EC and Derby Super WG + Axial 050 EC.

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