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Effect of Different Sprayers in order to Chemical Control of *Eurygaster Integriceps*

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ABSTRACT

Nowadays, controlling herbal pest and spraying operation are considered as important and inevitable activities in agriculture. In case the mentioned operation is performed in a proper manner and chosen a suitable sprayer, the cost of spraying and following operation will decrease and the yield will increase. Given the fact that *Eurygaster Integriceps* has been known as the most important pest of wheat which is a strategic product throughout the world, farmers use different sprayers in order to control this pest. In this study, micronair, electrostatic atomizer, atomizer, lance, and simple backpack sprayers were compared in the form of randomized complete blocks with four iterations, for controlling the *Eurygaster Integriceps*. The obtained data were analyzed through SPSS software. The results of the evaluation at the level of 5% revealed that, regarding the operation effect grade for controlling *Eurygaster Integriceps* pest, micronair sprayer with a 82.09% of died pest was at the highest rank, and electrostatic atomizer sprayer with a 75.88%, atomizer sprayer with a 72.40%, lance sprayer with a 66.60%, and simple backpack sprayer with a 62.58 % of died pests are at the next ranks. Given the obtained results in this study, for controlling *Eurygaster Integriceps* in the region of Kermanshah, micronair, electrostatic atomizer, atomizer, lance, and backpack sprayer were recommended, respectively.

Introduction

Bug and grasshopper have been important issues in Iran farms and old literatures show sever damages of these pests which, sometimes, caused famine in some regions. Spreading and inundation of *Eurygaster Integriceps* in Iran are good examples for spreading and inundation of insects due to the human interference in a natural environment. Uncontrolled spraying against *Eurygaster Integriceps* and destroying its natural enemies are the reasons for *Eurygaster Integriceps* to be considered as the most important pest for the agriculture of the country (Safari and Hedayatipour, 2009).

Controlling *Eurygaster Integriceps* mothers in view of quantitative damage, destroying the pollution source, and decreasing the subsequent costs may have an important role in increasing the wheat production efficiency. However, the chemical controlling of *Eurygaster Integriceps*, as an efficient method, is at the top priority of plans, choosing a proper technique for spraying, in view of having more efficiency and decreasing the environmental risks, plays a significant role in the proper use of this method. Afshari (1991) shows that *Eurygaster Integriceps* has been sensitive to Fenitrothion, Fenthion, and Trichlorfon insecticides and has shown no resistance to the mentioned poisons. These experiments revealed that Trichlorfon has a traumatism effect and Fenthion has a slow and superficial effect. The comparison of different doses of Fenitrothion and Trichlorfon insecticides revealed that the minimum lethal dose of Fenitrothion is 0.25 µgr of pure toxic for each bug and for Trichlorfon is equal to 1 µgr of pure toxic, which presently the using amount is 6 and 10 µgr respectively, that is more than the required amount. The mentioned studies show that in case the poisons usage has no desired results in controlling the pest, the related reasons may be found in not-using proper spraying techniques and commercial insecticide formulation. Using pesticides via aircrafts in order to control cereals bug has been reported in many studies which is mainly related to the Soviet Union and focused on the manner of sprayer calibration and using ULV (Ultra-Low-Volume) formulation (Areshnikov and Kostyukovskii, 1991; Simirnova and Kalabina, 1991).

One of the main factors which widely affect the effectiveness of a chemical (such as poison) is the manner of its distribution. Uniformity of distribution in the boom width or in the spraying row is a necessary factor for achieving the maximum efficiency of chemicals with the minimum costs and pollution. Another main factor is the quality of distributing these materials. The quality of spraying means the uniformity of the particle size which is determined by sensitive cards. If the size of particles will be widely different, the spraying will enjoy a low quality, because very small particles will evaporate or be carried away by the wind, then they exit from the intended target and cause environmental pollution. In other hand, the larger particles impact the target and fall into the ground and cause to the poisonous wastes and environmental pollution, also this matter likely causes burning of different parts of the plant (Safari and Kafashan, 2005). In addition, in case the diameter of the particles will be closer to each other, the quality of spraying would be better.

One of the indexes used for investigating the quality and size of the particles is the median diameter. Median diameter is an index that divides particles into two equal halves, according to their number, length, area or volume. Median diameters for the number and volume are determined from the cumulative

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probability images. It has been recommended that "*DxF*" is used for median diameters, where "V" as volume, "A" as area, "L" as length, or "N" as number will be put instead of "x", and "f" is the percentage of cumulative frequency (Kepner et al., 1978). For example, volume median diameter (VMD) = DV 0.5 means that 50% of particles volume is more than the median diameter and 50% of particles volume is less.

As mentioned before, uniformity of distribution of poison particles on the target, diameter and density of particles are very important issues on the biological effect of poison on pests, plant diseases, and weeds. On the other hand, using proper methods of poisons is as important as the diagnosis of the intended pest and proper recommendation of the poison for clearing pests. Therefore, it is necessary to make sure about the sprayer adjustment before starting the spraying operation, so that the amount of used solution in hectare as well as the quality and quantity of droplets coming out from the sprayers would be definite. In order to calibrate and adjust the sprayer for distributing a particular amount in a hectare, three main factors, i.e. angle and outflow of nozzles, tractor moving-forward speed, and spraying pressure, should be considered. The amount of used poison in hectare is calculated as below (equation 1):

$$V = \frac{K \times 1000}{W \times D} \quad (1)$$

where "V" is the amount of used poison in a hectare (liter), "K", amount of use poison in the sprayer tank (liter), "W", sprayer's work width (meter), and "D" is the covered distance or sprayed length (meter).

In general, in view of spraying techniques, the work base of all existing sprayers is under-pressure poison, severe airflow, using heat, and electrostatic spraying. In addition, the liquid chemicals spraying tools are classified into four groups of non-pressure, low-pressure, high-pressure, and aerial sprayers, according to their pressure. On the other hand, spraying methods are divided into the following methods based on the amount of used poison (Safari et al., 2007):

U.L.V (Ultra-Low-Volume Spraying) method:

In this method, the amount of used poison in hectare is 0.5 to 5 liter. Since the particles are very small and are less than 100 microns. If the toxic solution is used, the particles will evaporate and will not sit on the target. Therefore, a pure oil poison with the particular weight is used. U.L.V method was used only in an exhaust sprayer (using heat) in Iran.

In investigating the effect of land U.L.V sprayer in controlling *Eurygaster Integriceps* in rain-fed farms, it was found that land ULV spraying will be efficient in some conditions that the wind speed is fixed and its range is not in the extent that causes a decrease in the width of spraying band. Generally, the efficiency of this method has been estimated about 70% (Afshari and Mahjoob, 2000).

L.V (Low Volume Spraying) method:

In this method, the amount of toxic solution changes from 5 to 50 l/ha, which, in Iran, this method is applied in aircraft sprayers.

M.V (Medium Volume Spraying) method:

In this method, the amount of toxic solution is 50 to 150 l/ha. For example, motorized atomizer sprayers are used M.V method for controlling cotton pests in the beginning of the season.

H.V (High Volume Spraying) method:

This method includes most of spraying methods in Iran. In this method, the used toxic solution changes from 150 to 200 l/ha.

Given the undeniable importance of the issue, researchers performed a variety of experiments on different sprayers and some of them are discussed below.

The effect of using micronair sprayer on *Eurygaster Integriceps* nymph revealed that with the Fenitrothion dosage of 0.5 l/ha, causes 86% loss on *Eurygaster Integriceps* nymph, which has the less efficiency in proportion with other treatments. However, the other treatments of micronair sprayer were similar in comparison to the lance sprayer regarding the efficiency (Sheikhi Gorjan, 2004). Nevertheless, the pollution probability of the users working with micronair sprayer is less than those working with lance sprayer. The amount of used solution of micronair sprayer is 10 to 40 l/h, whereas for lance sprayer is 200 to 400 l/ha.

In a report about an investigation of the performance of common sprayer for wheat product, it was stated that the lance sprayer has the most consumption of the poison solution (854.4 l/ha) and micronair sprayer has the less consumption amount (35.4 l/ha) (Safari et al., 2007). The turbo - liner sprayer has the highest capacity regarding the theoretical and efficient capacity (11.3 and 7.1 ha/h, respectively), and atomizer and micronair sprayers have the lowest theoretical capacity (1.02 and 1.3 ha/h, respectively). In micronair and turbo-liner sprayers, VMD was 389 and 441 µ, and median diameter was 189 and 123.2 µ, respectively. These data showed spraying quality coefficient for micronair sprayer was 2.1 and for turbo-liner were 3.57. Therefore, considering these factors and parameters, micronair sprayer has better spaying quality regarding the uniformity in proportion than turbo-liner, and these two sprayers have the superiority over atomizer and boom sprayers. The highest percentage of product bearing was related to the tractor-mounted boom sprayer.

A study was carried out in order to investigate and determine the most proper spraying methods for decreasing and optimizing the consumption of poison in sugar beet. Experiments treatments were micronair sprayer (with the work width of 6 and 4 m), atomizer motorized backpack sprayer, tractor-mounted boom sprayer, and treatment without spraying (Mehranzadeh, 2002). The average yield of sugar beet tuber in different treatments were 17734.4, 5507.8, and 5976.6 kg/ha, respectively. The results of analyzing variance for different characters showed that the sprayer equipped with micronair, with the highest tuber yield, was in the first place and other treatments are in a same group.

Mozafari (2009) was shown that micronair sprayer, has the smallest amount of droplet size, the highest density, uniformity of its drop size, and the highest effect on controlling onion thrips. The results showed that micronair, electrostatic, atomizer, and lance sprayers are in ascending order regarding the consuming toxic solution. The economic investigation of sprayers revealed that there is no meaningful statistical difference between them regarding the cost and profit obtained from the operation. Also, the investigation showed that the costs incurred through the spraying operation, in comparison to the income resulted from increasing the function, is very low and the resulted profit is significantly high.

In another study, Howard et al. (1994) were reported that atomizer sprayers enjoy the highest coverage percentage in comparing with the other normal sprayers. Biometric test of leaf revealed that the atomizer sprayer has the ability to distribute poison particles in the bush and provides a good coverage for the upper, lower, and middle of the leaves of the bush. The best coverage of the leaf happens by the atomizer sprayer in the lower part of the bush. Using the sprayer with the controlled droplets (diameter of 250 µm) has been effective for decreasing herbicide drifts. However non-penetrating of droplets into the crown is one of the main problems of these sprayers, because in this status, the poison droplets leave on the upper part of the crown and, except the gravity, there is no other force to lead them downward the crown.

Safari and Hedayatipour (2009) were evaluated three factors of the amount of losses of the bugs, drift, and volume of consuming poison. The boom atomizer sprayer was at the top place in the amount of bugs losses, and the micronair sprayer was the lowest rank. The micronair sprayer and boom atomizer sprayer enjoyed the highest and the lowest drift amount, respectively. However, the atomizer sprayer was at the lowest rank in consuming amount of poison.

Also Mahjoub and Heidari (2010) was considered the factor of mother bug losses in wheat farms under different spraying techniques. The results revealed that the micronair sprayer has the highest percentage of losses and the atomizer sprayer, lance-trailing sprayer and electrostatic atomizer sprayer are in the next ranks.

The objective of this paper is to compare different sprayers and recommend the highest efficiency one in controlling *Eurygaster Integriceps*.

Materials and Methods

This study was performed based on the data gathered in Mahidasht Town, Kermanshah City. Mahidasht region is one of the most important regions for the cultivation of cereals and *Eurygaster Integriceps* pollution. In this region, a piece of land, with an area of about one hectare, was chosen and rain-fed wheat was cultivated therein. All stages of selecting the land, plotting, and spraying were done in spring 2011. Five different sprayers, which they are likely to use in the region, were evaluated. The investigated sprayers include lance sprayer, atomizer backpack motorized sprayer, atomizer backpack motorized sprayer with an electrostatic head, micronair motorized backpack sprayer, and simple backpack sprayer. All sprayers were calibrated, before starting the evaluation.

The evaluation of sprayers was done in biological evaluation method. In this method, the effect of each sprayer was evaluated in controlling the pest. The poison used in all tests was Fenitrothion. Time of performing the experiments was determined when winter bugs completely settle on the farm and reach to an approximate balance. The sampling was carried out one day before and one day after spraying and the percentage of bug losses was calculated through Henderson-Tilton's method. The Henderson-Tilton's formula is used in order to obtain the modified bugs losses percentage, so that the natural losses percentage or decreasing the population of witness treatment (treatment without spraying) would be removed. The obtained data were analyzed through SPSS statistical software. Size of testing plots was chosen based on the type of sprayer, width of work and drift possibility, in a way that the treatments have no effect on the adjacent plots, movement of tractors between plots would be easy and necessary sampling would be possible. Based on Amir-moafi (1997) sampling with the sweep net method was a proper method for estimating the density of pest that was used in this research.

The experimental design used in this research was randomized complete blocks, which was performed with six treatments (five sprayers + witness) and four iterations. In order to execute the plan, the following actions were done:

1-This test was carried out in terms of a statistical plan of randomized complete blocks including six treatments and four iterations. Therefore, twenty-four plots, with the dimensions of 10×10 meters, were formed. Hence, each plot had an area of about 100 m^2.

2-The distance between plots is five meters and between blocks is about five meters, too. In order to separate plots from each other, long wooden beam and other proper signs were used.

3-The test treatments include: backpack micronair sprayer (treatment A), electrostatic atomizer sprayer (treatment B), normal atomizer sprayer (treatment C), lance tractor-mounted sprayer (treatment D), simple backpack sprayer (treatment E), and witness (treatment F).

4- The test plan is shown in Figure 1:

North	Wasteland							East
Cultivated fields	Iteration 1	A	C	B	E	F	D	Cultivated fields
	Iteration 2	C	B	F	D	A	E	
	Iteration 3	D	A	E	B	C	F	
	Iteration 4	E	F	C	A	D	B	
West	Road							South

Fig. 1. Implementation plan of experimental design

5- After plotting, sweep net was carried out every second day in the testing farm and the farms around it in order to determine the exact time for controlling the pest.

6- After precipitations of mother bug into the farm, gathering data and measuring density were started in each plot. This was performed until the end of executive operation at the specified times.

7- In order to perform the experiments and use poisons in the related treatments, necessary tools and equipment were provided.

8- One day before test implementation, the density of the pest in each plot was determined and recorded. In addition, sprayers were calibrated and necessary amount of poison for each treatment and plots were determined. Spraying was performed the next day before the weather became warm.

9- Because of movement possibility of bugs between different plots, the distance between plots and blocks were sprayed with Fenitrothion insecticide.

10-Sampling was performed again one day after spraying.

11-Sampling was done in the sweep net method according to the time and status of bushes.

12-After gathering data and summarizing results obtained from each test plot, the information obtained from each treatment was extracted, calculated and compared. Finally, the extracted data were analyzed statistically.

The obtained data were corrected through Henderson-Tilton's formula (equation 2):

Losses Percentage =

$$(1-\frac{Ta}{Ca}\times\frac{Cb}{Tb})\times 100 \quad (2)$$

where "Tb" is the pollution in treatment plot before spraying, "Ta" is the pollution in treatment plot after spraying, "Cb" is the pollution in witness plot before spraying, and "Ca" is the pollution in witness plot after spraying. Then, the conversion was carried out using $ArcSin\sqrt{x}$ (Amir-moafi, 1997), and statistical analysis and mean comparisons were done through corrected data.

Results and Discussion

The number of bugs existing in twenty nets in each plot (one day before and one day after spraying) and their average was measured. The data for each sprayer are presented in Table 1.

The average of the corrected bug losses percentage was calculated by Henderson-Tilton's formula and converting data obtained by $ArcSin\sqrt{x}$ in a day after spraying. These data are summarized in Table 2.

A significant difference was observed between sprayers, based on the analysis of variance and amount of *F-test* (for the day after spraying). In other words, using different sprayers had definite and meaningful effects in pest pollution (Table 3).

Then, comparing the means was made using Duncan's multiple range tests, at the 5 % level. Results were reported in Table 4. The results revealed that micronair sprayer has the highest effect in decreasing the insects and pests.

Analyzing data by the poison solution consumption revealed that the sprayers were ranked in descending order, micronair sprayer (17 to 22 l/ha), electrostatic atomizer sprayer (25 to 30 l/ha), atomizer sprayer (25 to 30 l/ha), lance sprayer (250 to 350 l/ha), simple backpack sprayer (400 to 500 l/ha). Also in view of *Eurygaster Integriceps* losses percentage, the sprayers were ranked as follows: micronair sprayer with the losses average of 82.09%, electrostatic atomizer sprayer with the losses average of 75.88%, atomizer sprayer with the losses average of 72.40%, lance sprayer with the losses average of 66.60%, and simple backpack sprayer with the losses average of 62.58%.

The amount of losses related to micronair sprayer is 82.09% that have no significant difference with electrostatic atomizer sprayer at the 5 % level. However, micronair sprayer has a significant difference with atomizer sprayer, lance sprayer, and simple backpack sprayer in the level of 5%. The electrostatic atomizer sprayer with the losses average of 75.88% has no significant difference with micron air sprayer and atomizer sprayer at the 5 % level. Although, the electrostatic atomizer sprayer has a meaningful difference with lance sprayer and simple backpack sprayer.

The atomizer sprayer with the losses average of 72.40% has no significant difference with electrostatic atomizer sprayer and lance sprayer at the level of 5%. Albeit, atomizer sprayer has a significant difference with micronair sprayer and simple backpack. The lance sprayer with the losses average of 66.60% has no meaningful difference with atomizer sprayer and simple backpack at 5% level. However, lance sprayer has a significant difference with micronair sprayer and electrostatic atomizer sprayer. Finally, the simple backpack sprayer with the losses average of 62.58% has no significant difference with lance sprayer at the level of 5%. Howbeit, simple backpack sprayer has a meaningful difference with other sprayers.

Choosing a proper sprayer has a noticeable importance in spraying operation. In following the results of this research were compared with the results of some previous researches. The investigations done on the effect of ULV land spraying for controlling *Eurygaster Integriceps* in rain-fed farms revealed that the U.L.V spraying method has an efficiency of 70%, in general (Afshari and Mahjoub, 2000). Because the fact that micronair, electrostatic atomizer, and atomizer sprayers are in U.L.V spraying methods, the result of this research is in harmony with the results of mentioned investigations. However, Sheikhi Gorjan's study (2004) shows that micronair and lance sprayers have a similar efficiency on affecting *Eurygaster Integriceps*, and reveals that in micronair sprayer the amount of consuming solution is better. As it has been proved in this research, micronair sprayer has the highest effect on *Eurygaster Integriceps*. Therefore, results of Sheikhi Gorjan (2004) on the same effect of micronair and lance sprayer are in conflict with the present research.

Afshar and Fallah Jeddi (1995) showed different spraying methods have no meaningful statistical difference with each other, which it is in conflict with the results obtained from the present research. On the other hand, Safari et al. (2007) shown that lance sprayer and micron air sprayer have the highest and the lowest poison solution consumption, respectively. Turbo-liner sprayer enjoys the highest field capacity and micronair and atomizer sprayers have the lowest. In addition, regarding the spraying quality, micronair sprayer has the highest quality in comparing with other sprayers. These results are similar to the results of our research.

In sugar beet cultivation Mehranzadeh (2002), revealed micronair sprayer has the highest efficiency and other sprayers are in the same group. These results are consistent with this paper results. In addition, Howard et al. (1994) reported that atomizer sprayer is better than the normal sprayers. In another research, Mozafari (2009) revealed that micronair sprayer has the highest effect in controlling onion thrips. Also regarding the consuming solution, micronair, electrostatic, atomizer, and lance sprayers are in an ascending order. The results obtained from the said research are similar to those obtained from the present study. Furthermore, Mahjoub and Heidari (2010) shown that the micronair sprayer has the highest percentage of losses and the atomizer, lance trailing, and electrostatic atomizer sprayers are at the next places for controlling mother bug. Therefore, the results obtained from the mentioned study are similar to our research, except results related to the electrostatic atomizer sprayer. As the results were shown, the high consumption of poison solution, high losses of poison solution, and drift are the main problems of lance and simple backpack sprayers. In electrostatic atomizer sprayer, the charged particles of poison solution stick to all parts of the plant and cover all of it. Since in electrostatic atomizer sprayer the particles are charged, drift was rarely happened in comparing with the simple atomizer sprayer. Therefore, the electrostatic atomizer sprayer has the priority over the simple atomizer sprayer. Overall, for controlling *Eurygaster Integriceps*, micronair sprayer, electrostatic atomizer sprayer, simple atomizer sprayer, tractor-mounted lance sprayer, and simple backpack sprayer were recommended respectively.

Finally, it is necessary to avoid using pesticide continuously in long period. It was proven that an integrated management (e.g. using cultural and biological control) has the most effective results for control of many pests such as insects, mites, nematodes, diseases, and weeds. Pesticides must be used only if the other controlling methods could not decrease the pest pollution under economical loss level. Sheikhi Gorgan and Zand (2006) recommended the best method for pest controlling is the one that could be stable based on economical calculations and riskless for the environment.

Conclusion

In order to evaluate different sprayer in controlling *Eurygaster Integriceps* pest, an experiment was carried out at the design of randomized complete blocks with six treatments and four iterations. The interpretation of data and investigation of results revealed that the micronair sprayer has the priority over the other sprayers because of the uniform spraying, covering all parts of the farm, lowest amount of poison consumption and the highest percentage of losses.

Table 1. Number of bugs existing in nets in each plot

	One day before spraying						One day after spraying				
Sprayer	Iteration 1	Iteration 2	Iteration 3	Iteration 4	Mean of iterations		Iteration 1	Iteration 2	Iteration 3	Iteration 4	Mean of iterations
Micronair	22	18	18	22	20		1	0	0	1	0.5
Electrostatic Atomizer	20	20	22	22	21		1	0	1	2	1
Simple Atomizer	20	18	20	22	20		2	0	1	3	1.5
lancer	20	16	16	20	18		2	1	1	3	1.75
Drawback	20	20	20	20	20		2	2	2	4	2.5
Witness	22	18	18	22	20		12	10	10	14	11.05

Table 2. Average of the corrected bug losses percentage, a day after spraying

	Modified by Henderson-Tilton formula						Data conversion by $ArcSin\sqrt{x}$				
Sprayer	Iteration 1	Iteration 2	Iteration 3	Iteration 4	Mean of iterations		Iteration 1	Iteration 2	Iteration 3	Iteration 4	Mean of iterations
Micronair	91.66	100	100	93.45	96.27		73.221	90	90	75.174	82.09
Electrostatic atomizer	90.83	100	91.81	85.71	92.08		72.363	90	73.379	67.792	75.88
Simple atomizer	81.66	100	91	78.57	87.08		64.648	90	72.542	62.424	72.4
Lancer	81.66	88.75	88.75	76/42	83.89		64.648	70.402	70.402	60.953	66.59
Drawback	81.66	82	82	68.57	78.55		64.648	64.895	64.895	55.901	62.58
Witness	0	0	0	0	0		0	0	0	0	0

Table 3. Analysis of variance and F-test for a day after spraying

Sources of variation	Total squares	Degrees of freedom	Average of squares	F
Iteration	804.309	3	268.103	9.9199*
Treatment	939.944	4	234.986	8.694*
Error	324.339	12	27.028	
Total	2068.592	19		
* Significant Difference (at level of 5%)				

Table 4. Mean comparison using Duncan Method at the 5 % level.

Treatment	Mean	Ranking
Micronair	82.0988	A
Electrostatic atomizer	75.8835	AB
Simple atomizer	72.403	BC
Lancer	66.6013	CD
Drawback	62.5848	D

In addition, electrostatic atomizer sprayer and simple atomizer sprayer are better than lance and simple backpack sprayers, because the lower consumption of poison. It is suggested that for future research, the effect of other sprayers on *Eurygaster Integriceps* to be considered.

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