RESEARCH ARTICLE (Open Access)

Determination of most appropriate fungicide application time for controlling of Apple scab in the Region of Gjilan, Kosovo

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Abstract

Apple fruit cultivation is one of the most important cultivated fruit in the region of Gjilan in Kosovo and the cultivated areas are continuously increasing. There are 3-4 main cultivars Starking, Golden Delicious, Granny Smith, Gala that are being cultivated mostly and other cultivars Jonagold, Fuji and Jonathan that are being planted rapidly. One of the major problems for farmers in this region it remains the managing of fungus disease of Apple scab caused by *Venturia inaequalis* (Cooke) Wint.For this purpose, for the first time in Kosovo was used the decision support system RIM-pro (relative infection measure-program).This program simulates the development of pseudothecia, ascospore maturation, discharge, deposition and infection based on hourly received data of weather conditions and leaf wetness from weather station which is set up on the orchard. The aim of this study is to utilize the RIM-pro for best fungicide application time. The experiment is carried out in experimental orchard in Zhegra (Gjilan region) Kosovo, during the year 2015 and the experimental orchard was set up in randomized block, where the main effect factor is the treatment time (A) in 4 levels (RIM-pro time, Phenologicalphases, traditional treatment and control plants), second factor was the effectiveness of combined fungicides (B) in 4 levels. By analyzing the outcome data, it resulted that the treatments performed based on RIMpro had best results than other based performed treatments. The effectiveness of fungicides was determined by the disease index. This study emphasizes the importance of development of one management warning system for the local farmers.

Keywords: RIMpro; apple scab; infection; ascospores; treatments.

1. Introduction

Apple scab, caused by *Venturia inaequalis* (Cooke) Wint., results in symptoms on the aerial parts of the apple tree, including leaves, petioles, flowers, sepals, fruit, pedicels, young shoots, and bud scales. The symptoms are generally most noticeable and serious on leaves and fruit. The first lesions seen in the spring are usually on the underside of expanding leaves. Once the leaves open, the upper surfaces also become vulnerable to infection. A lesion first appears as an area which is a lighter shade of green than the surrounding leaf. The lesion is usually circular and as it increases in size it becomes olive-colored and velvety due to production of asexual spores (conidia) Lesions that form on young leaves may be quite large, some more than 1 cm in diameter. Lesions that form on expanded leaves are usually smaller because older leaves are more resistant to infection. Affected tissues eventually may become distorted and puckered, and the leaf lesions often become cracked and torn. Lesions on the leaves and fruit are generally blistered and "scabby" in appearance, with a distinct margin. The earliest noticeable symptom on fruit is water-soaked areas which develop into velvety, green to olive-brown lesions. Infections of young fruit will cause fruit distortion. Severely infected leaves or fruit will often drop from the tree. Infection which causes significant defoliation for two or three years in a row can result in weakened trees that are more susceptible to freeze damage, insect injury, and other diseases [10].

In the region of Gjilan in Kosovo, one of the major fruit that is cultivated in commercial orchards is the apple fruit. It almost represent the 60% of total number of fruit cultivars. The production is increasing every year. One of the major problems for farmers in this region it remains the managing of this fungus disease of Apple scab, especially in rainy seasons which causes the reduction of apple production

2. Material and Methods

The experiment was carried out in location of Zhegra at region of Gjilan in Kosovo, in one experimental apple orchard. The scheme of experiment is randomized block which is designed with Factor A for fungicide treatment time with 4 levels: level 1 as RIMpro treatment time, level 2 Phenological phases of apple cultivar Starking, level 3 traditional treatment with fungicides by local farmers and level 4 as control non treated apple plants.Factor B is effectiveness of combined fungicides in four levels. On the 16 August 2015, for every apple tree which was used in randomized block, were picked randomly by 50leaves on all sides of the tree. In the laboratory were analyzed 3200leaves. On 11 October of same year, areharvestedall the fruits from same trees for analysis. The apple scab tactiledegree was calculated with formula: P = n x 100/N. Where the: P = tactile degree; n = number of leaves/fruits infected by apple scab and N = total number of leaves/fruits analyzed for each variant.

For each variant the category was determined based on the leaf/fruit surface infected by apple scab. The infection assessment on leaves and fruits is classified in categories as per System Area Diagram (SAD), from 0 to 5 categories (total of 6 categories) and is presented in percentage from 0% up to 75% of surface infected area [4].

Table 1. Categories and levels of classification for Apple scan infection assessment

Category	*Intensity level*	*Infection level*
0	Nothing noticed	0% of leaf or fruit surface infected
1	Light intensity	0.1 - 10 % of leaf or fruit surface infected
2	Medium intensity	10.1 - 25 % of leaf or fruit surface infected
3	Strong intensity	25.1 - 50 % of leaf or fruit surface infected
4	Very strong intensity	50.1 - 75 % of leaf or fruit surface infected
5	Destructive intensity	> 75 % of leaf or fruit surface infected

The severity of infection (Imc %) is calculated with McKinney's index [8] which is modified by B.M Cooke [3]:

$$I = \frac{\sum (ni \times ki)}{N \times K} \times 100$$

I = disease index; Σ = output sum; ni = number of leaves or fruits in respective category; ki = number of each category; N = total number of leaves/fruits analyzed; K = total number of categories.

The statistical data analysis: all data processing for this study period, averages, variance and standard deviation are calculatedwith statistical program Assistat 2016, Version 7.7 [2].

3. Results and Discussion

The climatic conditions for the year 2015, for the months that Apple scab primary and secondary infections aremostly developed are measured on the orchard are presented in table 2.

A short outcome from climatic datas presented in table 2 is that the conditions for development of primary infection from ascospores and secondary infection from conidias of fungus Venturia inaequalis in the orchard were optimal.

On the table 3 are presented the results of assessment on the leaves for the disease of Apple scab (Venturia inaequalis) for the susceptible apple cultivarStarking of this study during the year of 2015. The disease index (Imc in %) varies from 15.5% listed in class C for the treatment time defined by decision support system RIMpro which was treated with Copper hydroxide 50WG followed by Dodine400SC and to 27% listed in class B in treatment time as per local farmers in the zone which was treated with Copper hydroxide 50WG followed by Mancozeb 80WP, comparing to the control variant which has the

index of 40.2% and is listed in class A. Also, the other treatment times on the variants from 5 to 8, the apple trees were treated all at the same day but with different combination of fungicides, as shown in below table, hadpretty much same index average and followed by same letter of classification meaning that they do not differ statistically between each other

Table 2. Weather conditions measured on experimental orchard by individual weather station (i-METOS-Pessl Instruments).

Months	Rain (mm)	Leaf Wetness inside tree	Leaf Wetness outside tree	Temperature °C			Relative Humidity %			Dew °C	Point
	Sum	*Time (min)*	*Time (min)*	*Avg.*	*Min*	*Max*	*Avg.*	*Min*	*Max*	*Avg.*	*Min*
March 2015	112	18980	19580	5.1	-6	18.4	75.8	10.1	100	1	-16.5
April 2015	49.2	8490	8785	10	-4.8	25.3	59.9	12.4	99.5	1.4	-14.7
May 2015	44.6	10555	9605	17	3.5	34.5	66.9	18.6	100	9.6	2.1
June 2015	60.6	11570	8125	18.7	6.6	34.7	68	18	99.8	11.3	1.9
July 2015	12.4	3420	1545	23.6	8.9	38.8	57.9	16	99.8	13.1	2.5
August 2015	48	5440	4150	22.8	11.2	38	59	13.7	98.3	12.5	1.2

Table 3. Disease Index (Imc %) on leaves of cultivar Starking analyzed on August 2015

Nr.	Treatment Time *Factor A*	Combination of Fungicides *Factor B*	Disease Index (Imc %) per repetitions				Sum	Average
			R1	R2	R3	R4		
1	RIMpro time	Copper hydroxide 50WG, Dodine 400SC	14	17	16	15	62	15.5 C
2	Phenological phases of Apple	Copper hydroxide 50WG, Dodine 400SC	25	21	23	20	89	22.25 B
3	Local Farmers time	Copper hydroxide 50WG, Mancozeb 80WP	27	23	27	31	108	27.0 B
4	Control tree's	No treatment	40.5	38.5	40	42	161	40.25 A
5	As per fungicides manufacturers recommendation	Copper hydroxide 50WG, Tebuconazole 250EW, Captan 80WG	22	19	26	25	92	23.0 B
6	As per fungicides manufacturers recommendation	Copper hydroxide 50WG, Propineb 70WP, Difenconazole 250EC	25	22	21	26	94	23.5 B
7	As per fungicides manufacturers recommendation	Copper hydroxide 50WG, Trifloxystrobin 50WG Chlorothalonil 720SC	20	23	25	29	97	24.25 B
8	As per fungicides manufacturers recommendation	Copper hydroxide 50WG, Cyprodinil 50WG, Dithianon 700WG	24	24	22	23	93	23.25 B
Sum			197.5	187.5	200	211	796	-
Average			24.68	23.43	25	26.37	-	24.87
*Smd							Smd = 5.56467 for @=0.05%	

** Significative minimum difference. The Tukey Test at level of 5% of probability was applied. The averages followed by same letter do not differ statistically between themselves.*

Also, the table 4, represents the results of assessment on the fruits surface area for the infection by the disease of Apple scab (Venturia inaequalis) for the susceptible apple cultivarStarking of this study during the year of 2015. The disease index (Imc in %) varies from 8.25% listed in class C for the treatment

time defined by decision support system RIMpro which was treated with Copper hydroxide 50WG followed by Dodine400SC and to 11.9% listed in class B in treatment time as per local farmers in the zone which was treated with Copper hydroxide 50WG followed by Mancozeb 80WP, comparing to the control variant which has the index of 21.38% and is listed in class A. Also the other treatment times on the variants from 5 to 8, the apple trees were treated all at same day but with different combination of fungicides as shown in table below, had pretty much same index average and followed by same letter of classification meaning that they do not differ statistically between each other.

Table 4. Disease Index (Imc %) on fruits of cultivar Starking analyzed on October 2015

Nr.	Treatment Time *Factor A*	Combination of Fungicides *Factor B*	Disease Index (Imc %) per repetitions				Sum	Average
			R1	R2	R3	R4		
1	RIMpro time	Copper hydroxide 50WG, Dodine 400SC	8.1	9	8.4	7.5	33	8.25 C
2	Phenological phases of Apple	Copper hydroxide 50WG, Dodine 400SC	13.1	11.2	12.4	10.9	47.6	11.9 B
3	Local Farmers time	Copper hydroxide 50WG, Mancozeb 80WP	14.3	13.6	13	16	56.9	14.23 B
4	Control tree's	No treatment	22.5	20	21	22	85.5	21.38 A
5	As per fungicides manufacturers recommendation	Copper hydroxide 50WG, Tebuconazole 250EW, Captan 80WG	13	12	14	13	52	13.0 B
6	As per fungicides manufacturers recommendation	Copper hydroxide 50WG, Propineb 70WP, Difenconazole 250EC	13.5	11.7	11	12.5	48.7	12.18 B
7	As per fungicides manufacturers recommendation	Copper hydroxide 50WG, Trifloxystrobin 50WG Chlorothalonil 720SC	12.5	12	13	14	51.5	12.88 B
8	As per fungicides manufacturers recommendation	Copper hydroxide 50WG, Cyprodinil 50WG, Dithianon 700WG	14	12	12	11.5	49.5	12.38 B
Sum			111	101.5	104.8	107.4	424.7	-
Average			13.88	12.69	13.1	13.43	-	13.27
*Smd							Smd = 2.21813 for @=0.05%	

** Significative minimum difference. The Tukey Test at level of 5% of probability was applied. The averages followed by same letter do not differ statistically between themselves.*

Table 5. Analysis of variance (ANOVA) for the disease index(Imc %) from Apple scab on Starking cultivar.

Starking	*Source of Variation*	*Degrees of Freedom*	*Sum of Squares*	*Mean Square*	*F Values*		
					Factual	Theoretical	
						95%	99%
Leaves	Treatments time	7	1376.50	196.64286	35.7339**	3.0725	3.6396
	Repetitions	3	34.937	11.64583	2.1163ns	3.0725	3.6396
	Error	21	115.562	5.50299	-	-	-
	Variation Total	31	1527.000	-	-	-	-
Fruits	Treatments time	7	383.637	54.8053	62.6805**	3.0725	3.6396
	Repetitions	3	6.06594	2.0219	2.3125ns	3.0725	3.6396
	Error	21	18.36156	0.8743	-	-	-
	Variation Total	31	408.06469	-	-	-	-

***Significative at a level of 1% of probability (p < .01); *Significative at a level of 5% of probability (.01= < p < .05); ns: Non-significative (p >= .05).*

Analysis of variance (ANOVA) shown on table 5, provides the results of the disease index (Imc in %) on leaves and fruits of the Starking cultivar which were evaluated in August 2015 for leaves respectively in October for fruits. The averages of treatment times has proven statistically changes of two levels of authentication for p=0.05 and 0.01 (3.072 and 3.639).

From the data's listed on table 5 for variance analysis (ANOVA) for assessment of disease index (Imc %) of Apple scab on the leaves for the year 2015, shows the statistically proven differences between the treatment times. This can be verified from the factual F value for the treatments 35.7339** which results to be higher than theoretical F values as per Fishers table for the two levels of authenticity,respectively for p = 0.05 and p = 0.01. From the comparisonof factual F values of the repetitions2.1163ns with those from Fisher table values, it results that repetitions do not provide statistically proven differences for the two levels of authenticity, respectively for p = 0.05 and p = 0.01.

Also, based on variance analysis (ANOVA) for assessment of disease index (Imc %) of Apple scab on the fruits for the same year, shows the statistically proven differences between the treatment times. This can be verified from the factual F value for the treatments 62.6805** which results to be higher than theoretical F values as per Fishers table for the two levels of authenticity,respectively for p = 0.05 and p = 0.01. From the comparison of factual F values of the repetitions 2.3125ns with those from Fisher table values, it results that repetitions do not provide statistically proven differences for the two levels of authenticity, respectively for p = 0.05 and p = 0.01.

The factual F values for both assessments, results to be smaller than theoretical F values, meaning that our experiment was set up and carried out on correct parameters.

4. Conclusions

The treatment time of fungicides determined by DSS RIMpro proves to be the best scheme for controlling of the fungus of Apple scab *(Venturia inaequalis)*comparing to other treatment time variants.

The best effectiveness of combined fungicides for controlling of the Apple scab seems to be the combination in first variant with Copper hydroxide 50WGthan followed only with Dodine 400SC.

The local farmers in this zone remain with traditional fungicide treatments and they work independently from each other in reference to the integrated management for orchards plant protection. It would be very good if they can be organized and use this RIMpro platform which is set up already in their zone as decision support system which provides warnings and recommendation for management of their apple and other fruit orchards in reference to the best predictable time to use their plant protection products (PPP's) against the Apple scab and other fruits diseases.

5. References

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