**International Refereed Journal of Engineering and Science (IRJES)**
*ISSN (Online) 2319-183X, (Print) 2319-1821*
*Volume 3, Issue 6 (June 2014), PP.25-30*

# Effect of potassium bicarbonate (Armicarb) on the control of apple scab (Venturia inequalis) in the region of Puka in Albania

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**Abstract:-** Scab is the most important disease of apples. Its primary effect is reduction of the quality of infected fruit. Scab also reduces fruit size or results in premature fruit drop, defoliation, and poor fruit bud development for the next year, and it reduces the length of time infected fruit can be kept in storage. Armicarb® is a bio-fungicide being developed across Europe by Agronaturalis Ltd. for use in a wide range of crops; grapevines, hops, pome fruit, soft fruit, stone fruit, vegetables and ornamentals. Armicarb® is a specially optimized formulation of potassium bicarbonate; the result of extensive testing by researchers at Cornell University, USA, for use as an agricultural fungicide. Potassium bicarbonate is now included in Annex I of Directive 91/414/CEE for use as a fungicide, and is authorized for use in organic production by the European Commission ruling no. 404/2008. Indistinguishable from natural potassium and bicarbonate, residues are considered not to be relevant, and the product is exempt from MRLs in the EU. All potassium bicarbonate treatments significantly reduced the apple scab (Venturia inequalis) severity in leaves and fruits compared to the untreated controls. The preventive strategies were very successful. However, the number of spray applications was high.

The objective of this study was to reduce apple scab (Venturia inequalis) incidences on pome fruit and shoots with potassium bicarbonate (as Armicarb) spray applications

**Keywords:-** alternative fungicides, Armicarb, organic production, small fruits, efficacy

## I. INTRODUCTION

Apple tree is one of the most importance fruit tree and at least 55 million ton has been the yield of apple in the world, with a value by 10 milliard dollars for the year 2005. Between the countries, USA are the first one with 7.5 % of the world apple production Turkey, France, Italia, Iran are the most importance apple production exporter in the world **(FAO 2008).** In Puka region, comparing with the other fruit trees, apple tree is the most importance. Based on the data of Regional Directorate of Agriculture, Food and Consumer Protection in Albania in this region are planted 16800 apple trees. In blokes there are about 122 ha with 9400 plants. The most importance apple varieties are Golden Delicious, Starking, Jonathan, Idaret, Rennet, Granysmith etc. In fruit trees, besides of other problems, plants protection is the main, especially in the apple tree, because of it can be infected by many diseases such are apple scab, powdery mildew, fire blight, as well as by codling moth, aphids, mites. Comparing with the other diseases, apple scab (Venturia inaequalis) is more problematic (**G.N.Agrios. 2005).**

The fungicidal activity of bicarbonate salts has been known for at least 80 years (**Marloth, 1931**). Specific control of numerous different fungi has been reported subsequently (**Palmer et al., 1997; Jamar et al., 2007**). The mode of action of bicarbonate salts is linked to the perturbation of pH, osmotic pressure and the bicarbonate/carbonate ion balance of sensitive fungi. Bicarbonate acts by contact to fungi in aqueous solution and inhibits the development of fungal mycelium and spores. Due to its multi-site mode of action it is thought that the risk of resistance developing is low. Available commercially in Switzerland since 2008, Armicarb®, a soluble powder containing 85 % (w/w) potassium bicarbonate, is being developed by Agronaturalis Ltd. and its partners across Europe for use against target diseases in a wide range of fruit and vegetable crops. Efficacy of bicarbonates can be improved when bicarbonates are used in combination with horticultural oils (**Horst et al., 1992**). Formulated potassium bicarbonate (Armicarb) was more effective in the control of apple scab (Venturia inequalis) than bicarbonate alone (**Jamar et al., 2007**).

## II. MATERIAL AND METHODS

### 2.1. Experimental field

The experiment is carried out at Qerret (Puka region), during the years 2012 at the Islam Djaloshi farm. The super faces of the parcel were 2.6 ha. The distance from the city of Puka is 5 km and the distance from the main axe of the road is 1.8 km. The parcel is at these geographic coordinates: 42° 07’ 03’’ Nord and 19° 49’

36'' East as well as 465 m above the level sea. Average annual temperatures are from 2.8° C on January at 17.7° C on June.

The experiment is set up in randomised block where the main effects factor (Factor A is the cultivar) are seen in two levels (cv. Starking and Golden Delicious). Second factor (application time- the factor B) in two levels (taking in consider traditional treatments and table of Mills). Third factor (fungicidal treatment – the factor C) in four levels (1. Amicarb 100; 2. Kresoxim – metil; 3. Pencozeb DG; 4. Control).

Two cultivars are included in the study; Starking and Golden Delicious. Data about the fungicides used are in the tab.1

**Table. 1 Fungicides used on apple scab (Venturia inaequalis) controlling**

| No | Commercial name | Active ingredient (%) and Manufacturer | Rate of application |
|---|---|---|---|
| **1** | Armicarb® 100 | 85% KHCO3 from Helena Chemical Company, USA | 600gr/100 l |
| **2** | Kresoxim-methyl (Stroby WG) | methyl (E)-2-methoxyimino-2-[2-(o-tolyloxymethyl) phenyl] acetate. BASF, Belgium | 250gr/100 l |
| **3** | Pencozeb DG | Etilenbisditioarbamat i Zinkut dhe Magnezit from UNITED PHOSPHORUS LIMITED UK | 250gr/100 l |
| **4** | Control | No treatments | - |

### 2.2. Scab severity assessment

Each year, disease assessments on the leaves and fruits were made. For leaf severity assessments, 10 shoots per tree were recorded about 60 days after flowering. Observations were made on 10 older leaves per shoot. A 1-9 global scab intensity scale was used whereby: 1 = no scab lesions; 2 = ≤ 1% infected leaves with at least one lesion; 3 = ≤ 5% infected leaves with at least one lesion; 4 = 5-50% infected leaves with at least one lesion; 5 = ≥ 50% leaves with lesions and with ≤ 5% leaf area spotted; 6 = 5-25% leaf area spotted; 7 = 25-50% leaf area spotted; 8 = 50-75% leaf area spotted; and 9 = maximum infections, leaves black with scab[5]

Severity and diffusion of infection were obtained by resorting to the McKinney index (**H.H.McKinney 1923**) modified from Cooke, B. M. (**B.M. Cooke 2006**). The McKinney index (Imc) was obtained by using the following formula:

$$DI\,(Imc)\,\% = \frac{\Sigma\,(f \times v)}{N \times X} \times 100$$

Where: f = infection class frequencies; v = number of plants of each class; N = total of observed plants; X = highest value of the evaluation scale.

### 2.3. Statistical analyse of the data

For all the experiment data variance analyse (ANOVA) is used. Three factorial analyse is done using statistical programme ASSISTAT (2013) – Website http:/www.assistat .com by Francisco de A.S. e Silva DEAG-CTRN-UFC (**Assistat 2013**)

Comparisons of averages of the disease index with control plot (without treatment) is done using Tukey Kramer[9] for two levels of probability p=0.05 and p= 0.001. For this aim statistical program SAS 2009 is used (**SAS 2009**)

## III. RESULTS AND DISCUSSIONS

Average climatic data, temperature and rainfall, for the year 2012 which have happened at the Qerret,Puke Albania are at the figure.1.

From the figure 1 results that the weather has been warm during April as well as with a considerable rainfall at the second decade of the month, while it is reduced during the third decade of the April. At the first decade of May there was not rainfall while at the second decade of this month there was a lot of rainfall. Less rainfall there were at first part of June.

On the figure 1 are also data about temperatures (min., max., aver.) as well as period treatments for the two used methods, Traditional and Mills table during the months April - October, 2012.

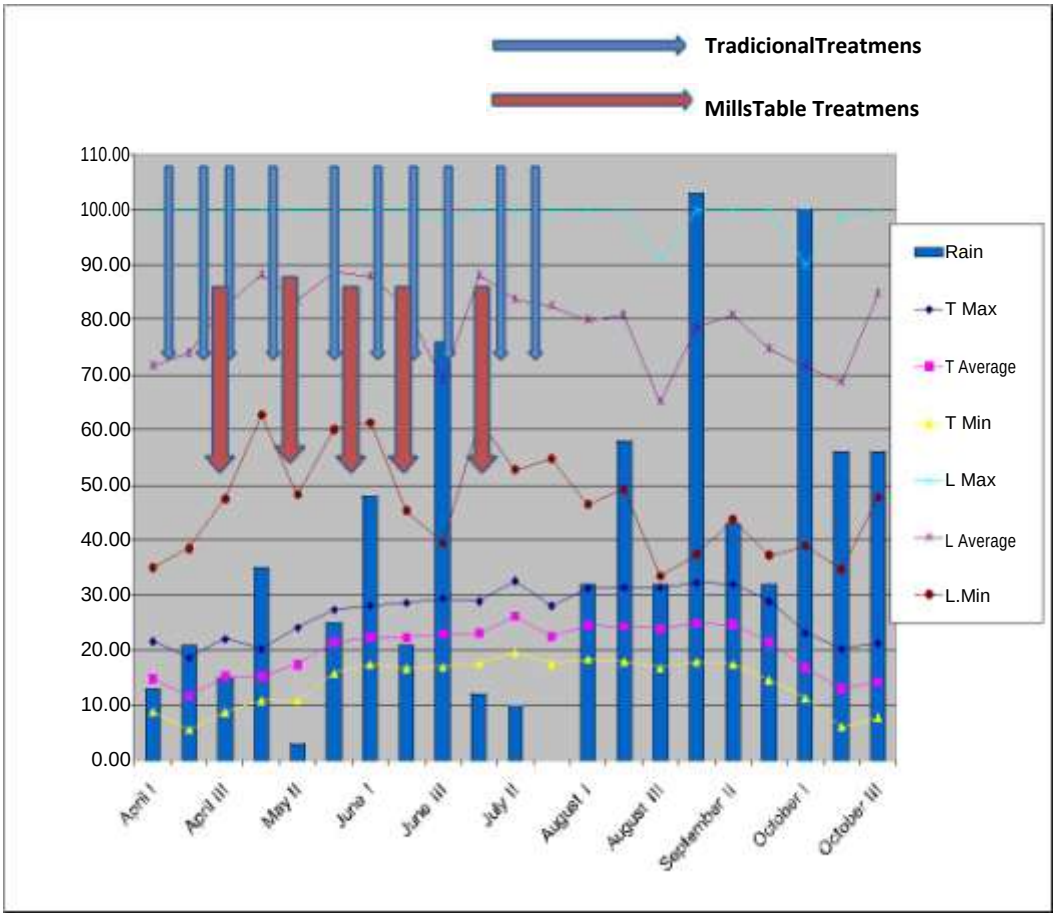


**Figure 1 The data about temperatures (min., max., aver.) as well as period treatments for the two used methods, Traditional and Mills table during the months April - October, 2012**

### 3.1. Results about disease index

Data about disease index for the year 2012 are presented at table 2. The data on the table 2 show that at the traditional treatment, for the cv. Starking, disease index (%) was from 18.5 % at the plot treated with Armicarb to 11.5 % at the plot treated with Kresoxim-methyl. At the plot treated with Pencozeb disease index was 13.2 % while at the Control plot it was 52.5 %. For the Golden Delicious cultivar disease index was 22.25 % at the plot treated with Armicarb while at the plot treated with Kresoxim-methyl it was 10.89 %. At the plot which was treated with Pencozeb disease index was 13.9 % while at the control it was 48.25 %. Looking on the table.2, for the treatments by means of the Mills prediction table also for the year 2012, disease index for Starking cultivar at the plot treated with Armicarb was 17.5%,while it was 9.75 % at the plot treated with Kresixim –methyl. At the plot treated with Pencozeb, disease index was 12.5 % while at control it was 52.5 %. For the Golden Delicious cultivar, disease index, at the plot treated with Armicarb was 17.5 % while at the plot treated with Kresoxim –methyl was 9.5 %.

**Table.2 Disease index (%) on leave caused by V. inaequalis (Cook) Wint for the year 2012**

| *Cultivars Factori (A)* | *TREATMENT Factori (C)* | TIME OF TREATMENT Factori (B) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | TRADICIONAL TREATMENT Imc in % | | | | | MEANS OF MILLS TABLE TREATMENT. Imc- in % | | | | |
| | | P1 | P2 | P3 | P4 | Mes | P1 | P2 | P3 | P4 | Mes |
| *Starking* | Armicarb® 100 | **21** | **17** | **20** | **16** | **18.5b** | **19** | **17** | **18** | **16** | **17.5b** |
| | Kresoxim-methyl | **10** | **11** | **11** | **14** | **11.5b** | **9** | **10** | **8** | **12** | **9.75b** |
| | Pencozeb DG | **14** | **12.5** | **15** | **11** | **13.12b** | **13** | **12** | **14** | **11** | **12.5b** |
| | Kontroll | **45** | **63** | **52** | **50** | **52.5a** | **45** | **63** | **52** | **50** | **52.5a *** |
| | Means | **90** | **103.5** | **98** | **91** | | **86** | **102** | **92** | **89** | |
| | Average | **22.5** | **25.8** | **24.5** | **22.75** | **23.9** | **21.5** | **25.5** | **23** | **22.25** | **23** |
| | | **Smd** =2.96880per @=0.05 %** | | | | | **smd =2.96880per @=0.05 %** | | | | |
| *Golden delicious.* | Armicarb® 100 | **24** | **23** | **20** | **22** | **22.25b** | **25** | **23** | **21** | **16** | **21.25 b** |
| | Kresoxim-methyl | **8** | **10.5** | **12** | **13** | **10.87b** | **8** | **10** | **11** | **9** | **9.5bc** |
| | Pencozeb DG | **15** | **12.6** | **11** | **17** | **13.9b** | **10** | **9.5** | **11** | **16** | **11.62 c** |
| | Kontroll | **52** | **50** | **36** | **55** | **48.25a** | **52** | **50** | **36** | **55** | **48.25 a** |
| | Means | **99** | **96.1** | **79** | **107** | | **95** | **92.5** | **79** | **96** | |
| | Average | **24.75** | **24** | **19.75** | **26.75** | **23.81** | **23.75** | **23.1** | **19.75** | **24** | **22.65** |
| | | **smd =2.96880per @=0.05 %** | | | | | **smd** =2.96880**per @=0.05 %** | | | | |

* a = Levels not connected by same letter are significantly different **smd = Significative minimum difference the Tukey Test at a level of 5% of probability

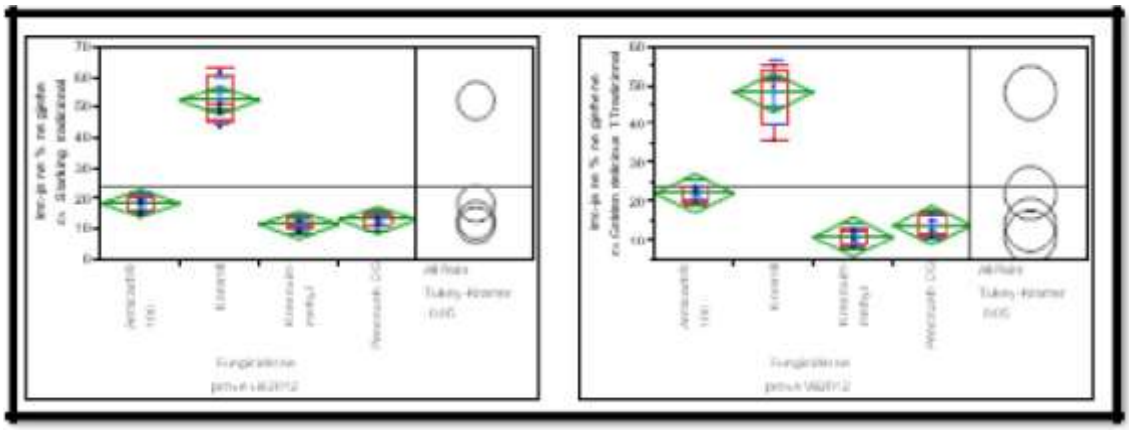

**Figure 2. The diagram of bookplates (variance, standard deviation, average of disease index) of apple scab on leave the year 2012 for treatments traditional**

Differences between fungicides treatments used on apple scab controlling for the year 2012 are at the above figure, where for the traditional variant on Starking cultivar is showed on the left of the boksplots diagram. Fungicides, blue rings, have significant differences for the probability P=0.05 (Tukey Kramer test) and they are under the average value, in our case it is 23.9%.

Similar differences, between fungicides treatments on apple scab controlling for Golden Delicious cultivar is shoed on the right of the above diagram. Fungicides (Kresoxim-methyl, Pencozeb and Armicarb), blue rings, have statistical significant differences (Tukey Kramer test) for a probability by 23.81 %. Differences between fungicides treatments used on apple scab controlling by means of table of Mills, for the year 2012, at Starking cultivar, are on the diagram figure 3.

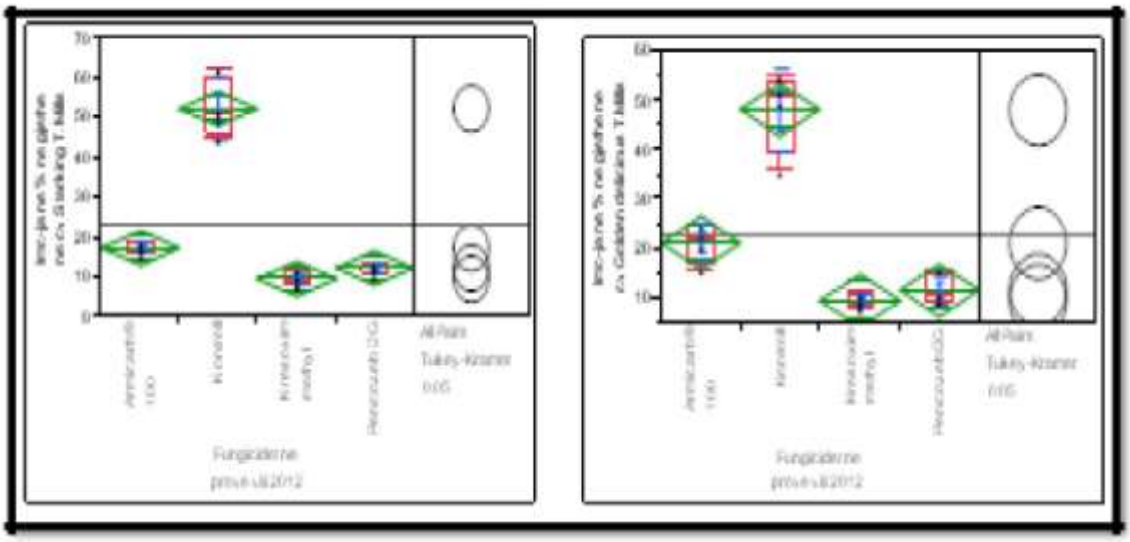

**Figure 3. The diagram of bookplates (variance, standard deviation, average of diseases index) of apple scab on leave the year 2012 for table of Mills treatments**

On the left of the above diagram, used fungicides, blue rings, have statistical significant differences for the level of the probability 0.05 (Tukey Kramer test) whish are under the general average value, 23 %.

Similar differences between the fungicidal treatments used for apple scab controlling at the Golden Delicious cultivar can be seen on the right of the above diagram (fig 3). Fungicides (Kresoxim –methyl, Pencozeb and Armicarb), blue rings, have statistical significant differences for the probability 0.05 % (Tukey Kramer test) which are under the general average value, 22.65 %.

**Table 3. Three factorial analyse (MANOVA) on apple scab index disease (%) for the year 2012**

| VS | DF | SS | MS | F | Probability |
|---|---|---|---|---|---|
| **Cultivars A** | 1 | 0.97516 | 0.97516 | 0.0495 | >0.050 |
| **Time Treatments B** | 1 | 16.10016 | 16.10016 | 0.8172 | >0.050 |
| **Treatments ( Fungicides) C** | 3 | 16344.5254 | 5448.17516 | 276.5184 ** | <0.001 |
| **Interactions AxB** | 1 | 0.40641 | 0.40641 | 0.0206 | >0.050 |
| **Interactions AxC** | 3 | 128.30047 | 42.76682 | 2.1706 ns | 0.1037 |
| **Interactions BxC** | 3 | 6.07547 | 2.02516 | 0.1028 | >0.050 |
| **Interactions AxBxC** | 3 | 2.45672 | 0.81891 | 0.0416 * | **0.0228** |
| **Total** | 15 | 16498.8398 | 1099.92266 | 55.8258 ** | <0.001 |
| **Error** | 48 | 945.73250 | 19.70276 | | |
| **Total VS** | 63 | 17444.5723 | | | |

** 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) VS = Variation Source, DF = Degree of freedom, SS = Square Sum, MS = Mean Square, F = Statistics of the test

Using Statistical Program ASSISSTAT (2013) there are the results of the three factorial analyse for the three factors on the study: Culticars at two levels (Cv. Starking and Cv. Golden Delicious), time of the treatments (traditional treatments and by means of table of Mills), and fungicides treatments at four levels. these data are showed at the above table. From these data it can be concluded that the effects of the fungicide factor statistically significant for the level $p \leq 0.01$. This is proved from the factic value " F " for the fungicides =276.51 84 which results to be higher than teoric value "F" taking in consider Fisher table, where 276.5184 is more than 4.2192 for the level < 0.01. Also for the probability level by 0.05 is statistical significant the

interaction effect of Cultivar x Fungicide (BxC) as well as interaction AxBxC. Taking in consider that the fungicides effect as well as interaction BxC ( treatment time x fungicide) and AxBxC are significant, it means different effect of the fungicides for cv. Starking and cv. Golden Delicious cultivar as well as treatment method (Traditional treatment and by means of Mills table.

## IV. CONCLUSIONS

The data of the experiment we are studying, bring the effects of two factors (Fungicides (C) and Interaction (AXC) are statistically proven high level of veracity ($p \leq 0:01$). BxC interaction effect (time x treatment Fungicides) confirmed the 5% level of probability ($01 = < p < 0 .05$). From the results obtained for 2012 it appears that Fungicide as (Kresoxim-methyl and DG Pencozeb give good results against Apple scab (Venturia inaequalis (Cooke) Wint) by applying the method SIPA treatment session Mills.

The result has given Bio fungicide as Armicarb ® 100 (85% KHCO3 from Helena Chemical Company which is able to control better Apple scab (Venturia inaequalis (Cooke)

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