THE INFLUENCE OF THE CLIMATIC CONDITIONS ON *FUSARIUM* SPP. ATTACK ON CORN HYBRIDS TESTED IN NATURAL AND ARTIFICIAL INFECTION CONDITIONS AT A.R.D.S TURDA IN THE PERIOD OF 2009-2011

Laura Maria ŞOPTEREAN[1], A. SUCIU,[2] E. NAGY[1] , V. HAŞ[1], I. HAŞ[1,2], C. PUIA[2]

1Agricultural Research-Development Station Turda, 27,Agriculturii Street, 401100 Turda, România
2University of Agricultural Sciences and Veterinary Medicine, Faculty of Agriculture, 3-5, Mănăştur Street, 400372, Cluj-Napoca, România
E-mail: ticulaura@yahoo.com

Abstract: *Maize is a host plant for a large number of pathogens, over 50, that invade all of the plant organs from the moment of germination to the moment of harvesting, and cobs and seeds infections continue most of the times during crops storage. Pathogen agents contributes to deterioration and decrease quantity and quality of yield contributes to productions decreasing, both quantitative and qualitatively, with an average percentage of 20 - 25% in our country. The most damaging in quantitative and qualitative point of view are diseases caused by genus Fusarium spp. The development of these fungi is favored by high temperature and humidity but also of the inoculum source. The objectives of this paper are establishing the influence of the climatic conditions and the way of testing the Fusarium spp. attack on maize hybrids. In 2009-2011 period at A.R.D.S TURDA was organized a bifactorial trial in three repetitions. The hybrids were tested in natural and artificial infection conditions. The artificial infection with Fusarium spp. suspension was made on grains, by hypodermic method. The inoculation was made on each cob using 4 ml of suspension. This paper aims the virulence of the Fusarium spp. under climate change conditions. Following research we can assert the following conclusions: the temperature and precipitation evolution in all the experimental years have considerable influenced the Fusarium spp. disease; the percentage of diseased seeds and yield were influenced by the testing mode in the climatic conditions of the trial years; in the 2009 – 2011 climatic conditions and the artificial infection condition the tested hybrids yield were less than in natural infection condition; from the yield point of view, the most favorable year was 2011, in A.R.D.S TURDA condition; the artificial infection with Fusarium spp. suspension caused an increase of protein content and decrease in starch and oil content. The obtained results can be used for a better recommendation for growing hybrids resistant to Fusarium attack.*

Key words**:** *Fusarium spp., corn hybrds, climatic condition, diseased seeds, yield*

INTRODUCTION

The Transylvania ecological environment is given by the existence in interaction of a large number of factors which two seem to show a dominant action for the agro-ecosystem. The first factor is the background heat at its relatively low temperature and large temporal variations, features that require significant restrictions for thermophilic plants such as maize, soybean, sunflower and others. The second is orography hilly land with many soils degraded by erosion or temporary excess humidity, imposing restrictions on crop structure and system of machines and tractors to ensure mechanization of the slope.

Maize is a host plant for a relatively large number of pathogens, over 50, that invade all of the plant organs from the moment of germination to the moment of harvesting, and cobs and seeds infections continue most of the times during crops storage (BAICU şi SĂVESCU, 1986). Pathogen agents contribute to yield decrease, both quantitative and qualitative, with an average percentage of 20 – 25 per cent in our country (BOBEŞ, 1983).

The most damaging from quantitative and qualitative point of view are diseases caused by genus *Fusarium* spp. These fungi caused two types of symptoms with different mode of expression.

Fusarium moniliforme (sin *Fusarium verticillioides*) causes rot on the maize cobs and the maize grains. Maize can be attacked in the early stages of development, so that seedlings immediately after springing can rot and die (CARMEN PUIA, 2006). The disease can also have a slower and delayed, plants reaching to capitalize. The first symptom in this case, is the appearance of a pink color on alveoli, grains or grain groups infected, passing then to red-brown, depending on their water content. On these seeds grows a powdery, cotton looking, pinkish color mold. The seed vessel cracks and starch becomes apparent, so the beans take the appearance of "popcorn", hence the name "white flowering parasitic" given to the phenomenon.

Fusarium graminearum strains causes rot on the stem and cobs of the maize. Economic importance of the disease depends on the period of the first infection and the number of secondary infections (BĂRBULESCU and col. 2002). Maize plant is infected in all stages of vegetation. On the cob appears a red mold which starts at the top. The specimens infected early, when moisture conditions are favorable, fully rot, maize husks and cobs remain stuck in a mold they develop abundant (POPESCU, 1993). Infection is more powerful on hybrids when maize husk are tightly in which case the cob at maturity no longer turns down, collecting the water at its base, favoring disease (ELENA NAGY, 2004).

Growth of fungi is favored by high temperature and humidity. Primary infection is realized through ascospores and during the vegetation period the pathogen transmits through conidia. The angoumois grain moth (*Sitotroga cerealella* Oliv.) helps to the spread of the pathogen, and the maize borer - *Ostrinia nubilallis* contribute to the infection.

MATERIAL AND METHODS

To establish the influence of climatic conditions from *Fusarium* diseases, eight maize hybrids created at ARDS Turda, have been tested under natural and artificial infection with *Fusarium* spp. To achieve the objectives of the paper it had been organized a bifactorial trial of A x B x n type, by subdivided parcels method, in three repetitions:

- A Factor = infection condition with *Fusarium* spp: natural and artificial
- B Factor= maize hybrids: Turda 145, Turda 165, Turda Mold 188, Turda 200, Turda 201, Turda Star, Turda Favorit, Turda SU 182.

The length of one row was 5 m, the distance between plants in the row was 22 cm and 70 cm between rows, ensuring the 25 plants harvested.

To test hybrids under artificial infection conditions with *Fusarium* spp on the eight hybrids in the trial artificial inoculations to the cob were made with *Fusarium* spp suspension. The inoculation was performed by injecting 2 ml of suspension, in the phenophase of full fecundation. The suspension is applied in the upper third of the cob in two places at 2 ml/hole therefore 4 ml/cob. The method of inoculation is the hypodermic method (CEAPOIU and FLOWER NEGULESCU, 1983).

Estimation of *Fusarium* spp attack was made at harvest, setting the percentage of diseased seeds on the cob.

Data from notations were processed using ANOVA program.

RESULTS AND DISCUSSIONS

Climatic conditions in the experiment zone 2009-2011.

The evolution of temperatures and rainfall in the three years of trial have considerable influenced the *Fusarium* spp illness. From the thermal conditions point of view we can say that

the year 2009 was characterized as a warm year, with an average maximum temperature in July (21,0^{0}C). In 2010 and 2011 recorded temperatures were close to normal, so we can say that these years were normal in terms of temperature (figure 1).

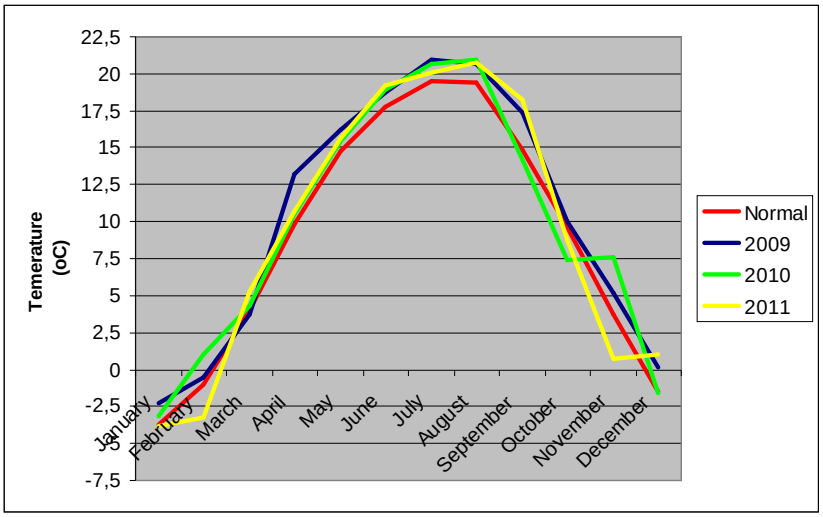

Figure 1. Temperature TURDA 2009 – 2011

The data presented in figure 2 show that the three years are different from rainfall conditions point of view.

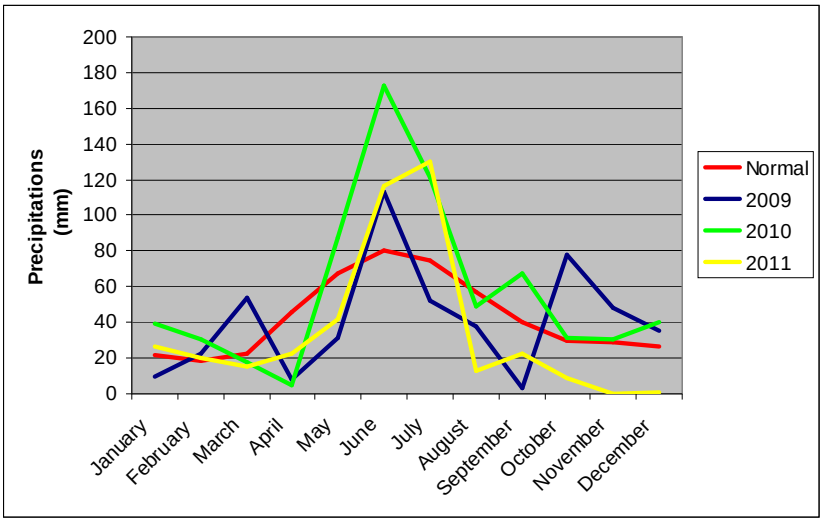

Figure 2. Rain chart in 2009-2011

The year 2009 is characterized as a normal year in terms of the rainfall (493.4 mm). In year 2010 the amount of rainfall recorded was 739.83 mm, and the excessively rainy conditions were conducive to the development of pathogens. Even if 2011 was characterized as a dry year,

rainfall in June and July haves favored the pathogens attack and yield.

It follows, therefore, years of the trial were performed have been particularly favorable to the occurrence and evolution of plant diseases in general and maize in particular.

The mode of infection effect and the behavior of maize hybrids on *Fusarium* attack (*Fusarium* spp) in the climatic conditions of the years 2009-2011

As with all plants and organisms in the case of phytopathogens agents conduct biological cycle that require a certain amount of degrees for completing each step. Also, for each parasite there is a minimum, optimum and maximum temperature at which different physiological and biological processes can take place. Outside the optimum temperatures interval, processes are slowed, phytopathogens agents adapting quickly enough to these conditions (FLORIAN, 2001). Along with temperature, the humidity is a determinant key for phytopathogens agents and plant life. The humidity effect is correlated with temperature. For most phytopathogen agents, it is important that they have a moist microclimate, in whatever form the humidity is presented (relative, precipitation, dew, fog, etc.) (FLORIAN, 2001).

The influence of climatic conditions and the way to testing on the percentage of diseased seeds of maize hybrids A.R.D.S. Turda 2009 - 2011

Following the observations performed in the three trials years it can be seen that an important role in the manifestation of *Fusarium* attack on the cob had the climate factors. The diseased seeds percentage was influenced by the climatic conditions but also by the testing mode.

Table 1

The influence of the climatic condition of diseased seed percentage 2009-2011

No.	Year	Disesed seeds arc sin √%	%	Difference	Signification
1.	2009	7,25	100,0	0,00	Mt.
2.	2010	25,39	350,2	18,14	***
3.	2011	19,18	264,5	11,93	***
LSD (p 5%)		1,56			
LSD (p 1%)		2,59			
LSD (p 0.1%)		4,84			

As shown by the data given in Table 1, the climatic conditions of the years 2010 and 2011 caused a very high percentage of diseased seeds, with very significant positive differences from the control. This difference is justified by the fact that in those two years the temperature and humidity conditions have been favorable to infection production.

In conditions of natural infection, the percentage of diseased seeds was low, in the three trials years, only the Turda 165 hybrid percentage was over 10 per cent in 2010 (figure 3).

Artificial infections, due to favorable climatic conditions have encouraged the development of pathogens, the percentage of diseased grains are very high. Because 2009 was a warm year, but with low precipitation, grain attack manifested itself in a lower percentage (3.16 per cent - 5.62 per cent). 2010 was a normal year in terms of temperature but rainy, were favorable to the attack of *Fusarium* spp. Among hybrids analyzed the most sensitive were Turda Star (53.87 per cent), with the highest percentage of diseased berries, followed by Turda Favorit (52.73 per cent) and Turda 145 (49.74 per cent) (figure 3). The most resistant in these conditions was Turda Mold 188 hybrid, with the lowest percentage of diseased berries (29.24 per cent). The hierarchy is maintained in 2011, year normal temperature and rich rainfall in June and July, but lower percentages of diseased grains than in 2010.

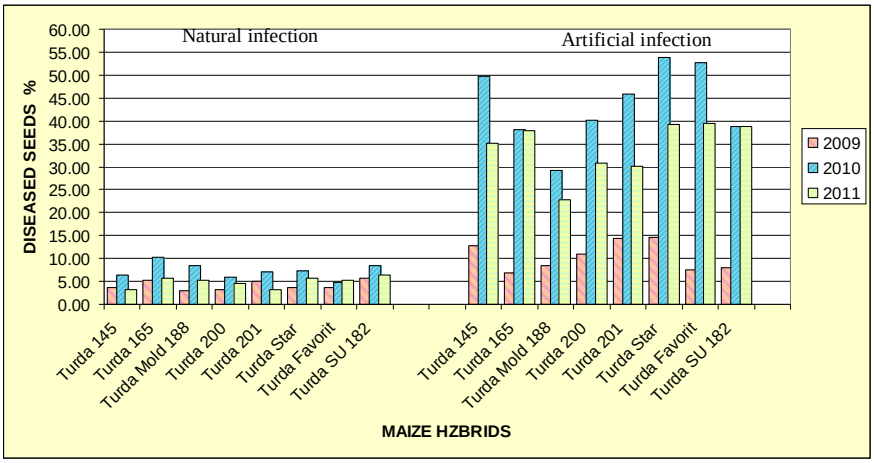

Figure 3. The influence of climatic conditions and the testing mode on the percentage of diseased seeds at maize hybrids

The influence of climatic conditions and the testing mode on the yield of maize hybrids A.R.D.S. Turda 2009 - 2011

The data presented in table 2 shows that the most favorable year for maize production, at least in the conditions of the A.R.D.S Turda was 2011, in 2010 production was lower compared to control, but no differences statistically provided.

Table 2

The influence of climatic conditions of the yield 2009 - 2011

No.	Year	Yield kg/ha	%	Difference kg/ha	Signification
1.	2009	6987	100,0	0,00	Mt.
2.	2010	5966	85,4	-1020	-
3.	2011	8143	116,5	1156	*
LDS (p 5%)		1134			
LDS (p 1%)		1877			
LDS (p 0.1%)		3513			

Data from the literature (NAGY, 2010), as well as the above presented data, shows that the maize hybrids reaction to infection with fungi of the genus *Fusarium* is influenced by the infection type and climatic conditions. These factors affect both quantitatively and qualitatively yield.

The data presented in figure 4 shows that production of hybrids is lower in artificial infections compared to natural infections in the three trials years.

In natural infection conditions most favorable year, of the production obtained point of view, was 2011, yields obtained in some hybrids have exceeded 10 t/ha - Turda Favorit (10,74 t/ha) and Turda Star (10,72 t/ha) (figure 4), the hybrids have a higher yield, of the genetic point of view. Although the percentage of diseased berries was lower in 2009, hybrids showed lower yield this year, this aspect is because the 2009 was a year with lower precipitation in July and August, during which take place the formation and grain filling.

Although 2011 was a favorable year for *Fusarium* spp attack (rainfall in June and July) was a favorable year also for yield, even in artificial infections resulting in the highest yields. Thus the most productive hybrids were Turda 165 (7.85 t/ha) and Turda Mold 188 (7.80 t/ha) (figure 4).

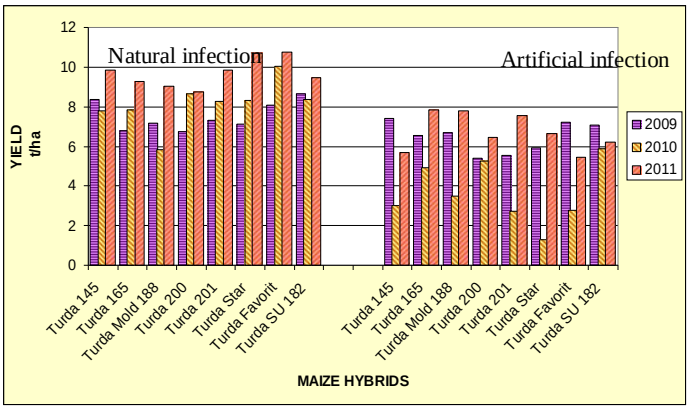

Figure 4. The influence of climatic conditions and the testing mode on yield

In 2010, frequent heavy rainfall have favored *Fusarium* attack - the highest percentage of diseased grains, this aspect correlates with the lowest yields, between yields obtained in the eight hybrids tested in the three trials years . It is noteworthy that the Turda Star hybrid had the lowest production (1.29 t/ha), correlated with the highest percentage of diseased grains (53.87 per cent).

The testing mode influence on the chemical composition of the grain

Data from the literature shows that infection with different phytopathogens causes various biochemycal, physiological, anatomical and morphological changes. In this context, the qualitative analyzes were performed on the biochemical composition of maize grain from hybrids tested under natural and artificial infection on protein, starch and oil content.

Table 3

The influence of the type infection on the starch content

No.	Way of testing	Hybrid	Starch (%)	%	Difference	Signification
1.	Natural infection	Turda 145	71,80	100,0	0,00	Mt.
2.	Artificial infection		71,23	99,2	-0,57	0
3.	Natural infection	Turda 165	72,10	100,0	0,00	Mt.
4.	Artificial infection		71,30	98,9	-0,80	00
5.	Natural infection	Turda Mold 188	71,97	100,0	0,00	Mt.
6.	Artificial infection		71,40	99,2	-0,57	0
7.	Natural infection	Turda 200	70,90	100,0	0,00	Mt.
8.	Artificial infection		70,50	99,4	-0,40	-
9.	Natural infection	Turda 201	71,90	100,0	0,00	Mt.
10.	Artificial infection		71,33	99,2	-0,57	0
11.	Natural infection	Turda Star	72,37	100,0	0,00	Mt.
12.	Artificial infection		70,77	97,8	-1,60	000
13.	Natural infection	Turda Favorit	72,30	100,0	0,00	Mt.
14.	Artificial infection		70,83	98,0	-1,47	000
15.	Natural infection	Turda SU 182	71,33	100,0	0,00	Mt.
16.	Artificial infection		70,33	98,6	-1,00	00
LDS (p 5%)		0,56				
LDS (p 1%)		0,78				
LDs (p 0.1%)		1,07				

Changes of starch content in grain from plants naturally and artificially infected, presented in table 3, show that the hybrids taken in to study react differently to *Fusarium* infections. Thus, if a high level of infection (artificial infection) is a decrease of starch content compared to natural infection.

The hybrids Turda Star and Turda Favorit have the lower rates of starch, the

differences from uninoculated control were very significantly negative. Turda 200 hybrid showed a slight decrease in starch content (0.40 per cent) after artificial infection, no difference statistically assured.

Table 4

The influence of infection mode on the protein content

No.	Way of testing	Hybrid	Protein %	%	Differece	Signif.
1.	Natural infection	Turda 145	9,27	100,0	0,00	Mt.
2.	Artificial infection		10,10	109,0	0,83	**
3.	Natural infection	Turda 165	9,40	100,0	0,00	Mt.
4.	Artificial infection		10,07	107,1	0,67	*
5.	Natural infection	Turda Mold 188	9,27	100,0	0,00	Mt.
6.	Artificial infection		9,97	107,6	0,70	**
7.	Natural infection	Turda 200	10,40	100,0	0,00	Mt.
8.	Artificial infection		10,97	105,4	0,57	*
9.	Natural infection	Turda 201	9,50	100,0	0,00	Mt.
10.	Artificial infection		10,20	107,4	0,70	**
11.	Natural infection	Turda Star	9,10	100,0	0,00	Mt.
12.	Artificial infection		10,93	120,1	1,83	***
13.	Natural infection	Turda Favorit	9,30	100,0	0,00	Mt.
14.	Artificial infection		11,00	118,3	1,70	***
15.	Natural infection	Turda SU 182	10,07	100,0	0,00	Mt.
16.	Artificial infection		11,20	111,3	1,13	***
LDS (p 5%)		0,50				
LDS (p 1%)		0,69				
LDS (p 0.1%)		0,95				

Regarding the protein content, from the data presented in table 4, we can say that artificial infections increased percentage of protein in all hybrids studied. At Turda Favorit Turda Star and Turda SU 182 hybrids, increased protein content was high, differences from the control is very significant positive. In other hybrids, increases protein content were significant and distinct differences from the uninoculated control.

Tabel 5

The influence of infection mode on the oil content

No.	Way of testing	Hybrid	Oil %	%	Difference	Signification
1.	Natural infection	Turda 145	4,37	100,0	0,00	Mt.
2.	Artificial infection		4,07	93,1	-0,30	00
3.	Natural infection	Turda 165	4,07	100,0	0,00	Mt.
4.	Artificial infection		4,03	99,2	-0,03	-
5.	Natural infection	Turda Mold 188	4,17	100,0	0,00	Mt.
6.	Artificial infection		3,93	94,4	-0,23	0
7.	Natural infection	Turda 200	4,27	100,0	0,00	Mt.
8.	Artificial infection		3,97	93,0	-0,30	00
9.	Natural infection	Turda 201	4,10	100,0	0,00	Mt.
10.	Artificial infection		3,87	94,3	-0,23	0
11.	Natural infection	Turda Star	4,00	100,0	0,00	Mt.
12.	Artificial infection		3,70	92,5	-0,30	00
13.	Natural infection	Turda Favorit	3,97	100,0	0,00	Mt.
14.	Artificial infection		3,67	92,4	-0,30	00
15.	Natural infection	Turda SU 182	4,10	100,0	0,00	Mt.
16.	Artificial infection		3,87	94,3	-0,23	0
LDS (p 5%)		0,17				
LDS (p 1%)		0,23				
LDS (p 0.1%)		0,32				

Oil content changes after artificial infection. From the eight hybrids analyzed, on seven of them the oil percentage decreased to the uninoculated control, differences were significant and distinctive negative significant (table 5).

CONCLUSIONS

- The evolution of temperature and rainfall in the three trials years have appreciably influenced *Fusarium* spp. attack;
- The percentage of diseased grains was influenced by climatic conditions and testing mode therefore in year 2010 was recorded the highest percent of diseased grains, both in artificial and natural infection conditions;
- Among the hybrids studied, hybrid Turda Star was the most sensitive to artificial infection with *Fusarium* spp, recording the highest percentage of diseased grains in all three trials years;
- Due to weather conditions in the years 2009 - 2011 under artificial infection the production of the hybrids was lower than under natural infection condition;
- The highest yields were obtained in 2011, both under natural and artificial conditions of infection;
- In 2010 was obtained the lowest production under artificial infection these aspect beeing related with the highest percentage of diseased grains from the same year;
- The artificial infection causes changes in biochemical composition of the grain. In all hybrids analyzed starch and oil content decreased, the differences recorded were very significantly negative to control in some hybrids;
- The percentage of protein increases after artificial injection, in the case of all the hybrids studied, the differences to control beeing significant, distinctly significant and very significant positive;

BIBLIOGRAPHY

1. BAICU T., SĂVESCU A. 1986, Sisteme de combatere integrată a bolilor şi dăunătorilor pe culturi, Editura Ceres, Bucureşti, 263 pag.
2. BĂRBULESCU A., C POPOV, M.C. MATEIAŞ, 2002, Bolile şi dăunătorii culturilor de câmp, Editura Ceres, Bucureşti.
3. BOBEŞ IOAN, 1983, Atlas de fitopatologie şi protecţia agroecosistemelor, Editura Ceres, Bucureşti, 696 pag.
4. CEAPOIU N., FLOARE NEGULESCU - Genetica şi ameliorarea rezistenţei la boli a plantelor, - Editura A.R.S.R. Bucureşti 1983.
5. FLORIAN V., 2001, Fitopatologie generală, Ed. Poliam, Cluj-Napoca.
6. NAGY ELENA, HAŞ V., HAŞ I., SUCIU A., FLORIAN V., Effect of ear infection on the maize yield and mycotoxin content, 2010, 11'th European *Fusarium* Seminar *Fusarium* – Mycotoxins,Taxonomy, Phathogenicity and Host Resistance, 20-23 september, Radzikow, Poland, p 287
7. POPESCU G., 1993, Fitopatologie Editura Tehnică, Bucureşti, 524 pag.
8. PUIA CARMEN, 2006, Fitopatologie horticolă, Editura Risoprint, Cluj - Napoca