English Version

Physilogical effetc of the fungicide Pyraclostrobin and seed treatment in the corn crop

Adenilsom dos Santos Lima[1], Marcus, Taiã Nogara Reffatti[2], Michel Caldas Juncos[3], Talita Burbulhan[4], Lais Martikoski[5]

Abstract

The activities of field research have showed that some fungicides, notably those which belong to the group of the strobirulins, present effects which go beyond the disease control, named physiological effects. However, the results have varied, and in some cases there is including the risk of reduction of the production, which shows the importance of the development of new researches in this field. The research was developed in the South Center region of the state of Paraná – Brazil, aiming to evaluate the effect of the treatment with seeds with the fungicide Pyraclostrobin + Thiophanate-methyl, of the crop management with fungicide Pyraclostrobin in different combinations and their effects over the development of the leaf area, production of vegetative dry matter and grain productivity in the corn crop. The crop was implanted in field in January 2009 with density of 60000 plants ha^{-1}, in completely randomized design. The dosages of 100 ml ha^{-1} of (Pyraclostrobin + Thiophanate-methyl) and of 300 to 600 mL ha^{-1} of Pyraclostrobin and other combinations were compared among themselves and with control without application of these products. It was verified that the application of Treatment of seeds with (Pyraclostrobin + Thiophanate-methyl) in the dose of 100 mL ha-1 + Comet (Pyraclostrobin) in the dose of 0,3 L ha-1 sprayed 12 DAE is the combination which presented best results for the characteristics ILA, DM and productivity evaluated in the experiment.

Key words: leaf area, additive effect, production, *Zea mays*.

Introduction

Corn (*Zea mays*) is produced in almost all the Brazilian territory, with the most different production systems. According to CONAB (2009), Brazil produces annually 50.2 million tones of corn in an area of 14.1 million hectares obtaining a productivity of 3.5 tones per hectare, For Trentin (2007) this yield is still very inferior to the potential of the crop and of the most technified plantations, considering that this average productivity is linked to the lack of appropriated management also added to the unfavorable climate conditions in certain regions of the country which do not favor the crop performance, limiting the productivity.

The crop management has been exhaustively studied and researched, and the application of fungicide is an activity increasingly applied in crops. The results of the researches performed by Embrapa Milho e Sorgo in other research institutions demonstrate that the use of fungicides is been a viable and efficient strategy of management in the corn crop. However, some factors must be observed so that the relation cost/benefit is positive, i.e., that the benefit of control of the diseases with use of the fungicides is superior to the cost of its use (COSTA et al., 1999).

In the last years, the research about the properties of the strobirulins became more intense and according to Venancio et al. (2004) it was evidenced some direct influences in physiological process of plants which were non infected or threatened by pathogens, characteristic which was named additive effects or positive physiological effect.

Oliveira (2005) describe that the named physiological effects act in several ways: in the cellular respiration, in the mitochondria, in the cythocrome Bc1, interfering transitorily in the transport of electrons and, as consequence, there is a better use of CO2, reducing expenses of energy, resulting in

1 Engº Agric. Dr. Prof. Departamento Agromomia - UNICENTRO. Av. Simeão Camargo Varela de Sá, n.3 Campus CEDETEG. Universidade Estadual do Centro Oeste Paraná. Email: aslima@unicentro.br

2 Acadêmico Departamento de Agronomia Universidade Estadual do Centro Oeste Paraná. UNICENTRO

3 Acadêmico Departamento de Agronomia Universidade Estadual do Centro Oeste Paraná. UNICENTRO

4 Acadêmico Departamento de Agronomia Universidade Estadual do Centro Oeste Paraná. UNICENTRO

5 Acadêmico Departamento de Agronomia Universidade Estadual do Centro Oeste Paraná. UNICENTRO

increase of the net photosynthesis, increase of the activity of the nitrate reductase, green effect due to the large content of chlorophyll and reduction of the stress associated with the reduction of the synthesis of ethylene, enabling thus larger length of leaf area and effects over the culture yield.

It has been showed that some fungicides, especially those which belong to the group of the strobirulins, present effects which go beyond the disease control, named physiological effects. According to Costa et al. (2009), among these effects, there is the higher resistance to several types of stress as draught and nutritional, increase of the photosynthetic capacity, reduction of leaf respiration and greater efficiency in the use of water. However, these effects are still not very clear for the corn crop.

The evolution of the chemical products for the use in agriculture is increasingly expressive, being the chemical group of the strobirulins one of the most important and remarkable recent discoveries (AZEVEDO, 2003). Among the analogical substances which belong to this group it is noteworthy Azoxystrobin, Kresoxim-methyl, Trifloxystrobin, Metominostrobin and Pyraclostrobin.

The physiological activity of the plant is associated with the main sources which produce carbohydrate inside the plants, changing the speed and intensity of the leaf senescence, and the standard of accumulation of dry matter (UHART and ANDRADE, 1995).The quantification of the leaf areas provides important information, as evaluation of the grain yield and effect of management practices (SILVA, 2001). Bryson et al. (2000) verified that strobilurins affect the vegetative development and the leaf area of agricultural crops.

Juliatti et al. (2007) verified that in the corn crop the use of pyraclostrobin + epoxiconazol provided improvement in the grain quality, which is considered one of the additional benefits of the fungicide.

In researches with winter cereals, Koehle et al. (2003) concluded that the application of strobilurin in the wheat plant increases the assimilation of nitrate, considering that this application Will have better effect when effected in the phase in which the crop needs a higher demand of N. Considering that most part of the N found in grains is assimilated before the anthesis and that carbohydrates are produced after this phase, it can be concluded that the length on the green leaf area from that has a direct relation with the production. For Jabs (2004), the earlier the strobilurin is applied, the better will be the physiological response, responding positively under conditions of stress.

The aim of the work was to evaluate the effect of the treatment of seeds with fungicide Pyraclostrobin + Methyl Tiophanate of the crop management with fungicide Pyraclostrobin in different combinations of these products over the development of the leaf area, production of vegetative dry matter and productivity of grains of the corn crop.

Material and methods

The work was developed in the experimental area of the Department of Agronomy – campus CEDETEG – of the Universidade Estadual do Centro-Oeste (UNICENTRO – State University of Mid West). It is located in 25° 23' 36" S and 51° 27' 19" W, with altitude of approximately 1025 m, and climate Cfb – Humid Subtropical Mesothermic climate – according to the classification of Köeppen.

The soil of the place is classified as Latossolo Bruno Distroférico[1] (EMBRAPA, 2006). The chemical characteristics of the local soil are presented in Table 1.

Before the planting, it was performed the soil correction with 0,9 Mg ha^{-1} of limestone distributed in the soil surface for seeding in no-tillage system. The crop (Hybrid Attack®) was seeded in January 06 2009 with density 60000 plants ha^{-1} and spacing 80 cm between plant lines. The base fertilization consisted in application of 500 kg ha^{-1} of fertilizer NPK of the formula 5-20-20. Eleven days after emergence (DAE) it was performed the application of 250 kg ha^{-1} of urea in cover.

It was used the completely randomized design (CRD) with five treatments and five replications, with the total of 25 experimental units. The evaluated treatments were: T1 – Control with base fertilization and urea in cover (similar to the other treatments); T2 – Comet (Pyraclostrobin): Dose of 0.3 L ha^{-1} at

1 According to the Brazilian Soil classification

Table 1. Chemical characteristics of the soil of the experimental area. Guarapuava – PR, 2011.

P Mehlich mg dm^3	M.O mg dm^3	pH $CaCl_2$	K cmol dm^{-3}	Ca cmol dm^{-3}	Mg cmol dm^{-3}	H+Al	Al	SB	CTC	V%	Micronutrients (mg dm^{-3})		
											Cu	Mn	Zn
1.86	41.1	5.2	0.36	3.7	2.1	4.91	0.02	6.38	11.28	56.2	1.3	41.2	0.9

the 12 DAE; T3 – treatment of seeds with Acronis (Pyraclostrobin + Methyl Tiophanate): dose of 0.1 L ha^{-1}; T4 – treatment of seeds with Acronis (Pyraclostrobin + Methyl Tiophanate): dose of 0.1 L ha^{-1} + Comet (Pyraclostrobin): Dose of 0.3 L ha^{-1} at the 12 DAE; T5 – treatment of seeds with Acronis (Pyraclostrobin + Methyl Tiophanate): dose of 0.1 L ha^{-1} + Comet (Pyraclostrobin): Dose of 0.6 L ha^{-1} at the 12 DAE. The application of the treatments with fungicide with spray volume of 120 L ha^{-1} was performed 12 DAE, one day after the application of urea in cover, using sack sprayer with 4 points of sprayer pressurized by CO_2 gas.

The combination Pyraclostrobin + Methyl Tiophanate is registered as fungicide for treatment of soybean seeds, and Pyraclostrobin is fungicide of the chemical group of the strobirulins indicated for different crops. In this study, it was evaluated concerning the additive effect (positive physiological effect) over the corn crop, not directly as fungicide effect.

During the cycle of crop development it was performed sprayer with insecticides for the control of plagues as *Spodoptera frugiperda*, *Diatraea saccharalis*, *Helicoverpa zea*, among others, which are common in the region and cause damages in plants, damaging their development and production in case they are not controlled.

The plots were constituted by 5 plant rows with 10 m of length, being considered as useful area for evaluation the 3 center rows, not considering 2 m in each one of the extremities.

The leaf area of the crop was determined from 15 DAE in intervals of 15 days, with mediation in five plants of each plot, which was chosen randomly in the beginning of the experiment. The determinations were performed trough the measure of the length (L) and width (W) of the leaf and the leaf area calculated trough the equation (La = L x W x 0.75), according to Stikler (1961). It was considered the leaf area (LAI) photosynthetically active, not considering the senescence area of the leave. The index of leaf area (LAI) was calculated by the division of the leaf area by the soil area available for the plant.

In the end of the experiment it was performed the evaluation of the production collecting at the 139 DAE the ears of the plants of the useful area of the plot, which were trilled, and after the determination of the humidity, the grains were weighted and it was calculated the productivity considering the correction of humidity for 13%, according to which was practiced in units of beneficiation and storage of grains of the region.

The dry matter (DM) of the plant shoot (except ear) was determined in the harvest, in which it was evaluated the five plants of each plot considered before in the determination of the LAI. It was removed the ears with straw, and plants were cut at the level of the soil, minced, packed in paper packages, identified, weighted for the determination of the fresh weigh and placed to dry in ventilated oven, in temperature of 65 °C until it reaches constant weight, being later weighted for the determination of the dry matter.

The data obtained were submitted to analysis of variance and the averages compared by the Tukey test ($p>0.05$) using the software SAS 9.2®.

Results and discussion

The statistic evaluation of the results had differences of LAI active of the crop in relation to the treatments. In Figure 1, it can be observed that the curve of development of the LAI of plants in the treatment T1 presented tendency to be maintained below the curves of the other treatments, with higher acceleration of the leaf senescence from the beginning of the stage of reproductive development, later at the 70 DAE, which shows that treatments with Pyraclostrobin and Methyl Tiophanate and the tested combinations have additive effects over the vegetative development of the crop.

The results also showed that the plants of the treatment T3 presented curve of development of the

active LAI approximately similar to T1, considering that in the conditions of the treatments T2, T4 and T5 the superior positioning of these curves enables to verify that the plants presented better development of the LAI, maintaining higher active leaf area, mainly in the reproductive period until the maximum senescence in the end of the cycle.

In Table 2 it can be observed that with the cycle of crop development the effect of the treatments was becoming more expressive and causing significant statistic differences. The best results were presented by plants of the treatment T4, which presented best average of LAI from 30 DAE, in most cases differing from the other treatments.

The results verified in the average comparison of the Table 2 confirmed the tendencies verified in Figure 1, because it can be verified that the LAI of the plants of the treatment T1 was statistically inferior to the others, presenting in part of the more initial and intermediate stages of the cycle some similarities with the averages verified in the treatment T3. The average of plants of the treatment T5 were superior in the initial vegetative stages and the ones of the T4 in the reproductive stages, with some statistical similarities between T4 and T5 and less markedly with plants of the T2.

These results evidence the additive effect of the treatments in the plant development, however, these effects are more pronounced in relation to the application of Pyraclostrobin trough leaves in the beginning of the vegetative development that only the use of Pyraclostrobin + Methyl Tiophanate as seed treatment, although in both cases the results are more expressive in comparison with the control.

The results are in accordance with Koehle et al. (2003) who describe that the application of strobilurins in moments of high demand of N by the crop, as in the vegetative development, tends to result in higher benefit in relation to the additive effects, when compared to other moments. In this case, the application in the treatment of seeds is less favorable than in the beginning of the vegetative development, as performed in treatments T2, T4 and T5 with application of Pyraclostrobin trough leaves.

This consideration consist in the fact that the plants of the treatment T3 receive only treatment of seeds and, in this case, the development of the ILA was in general inferior to the treatments in which it was applied Pyraclostrobin. In relation to the effects of Pyraclostrobin, it can be verified that the dosage of 0.3 L ha^{-1} was more appropriated than the application of 0.6 L ha^{-1}, showing that possibly there

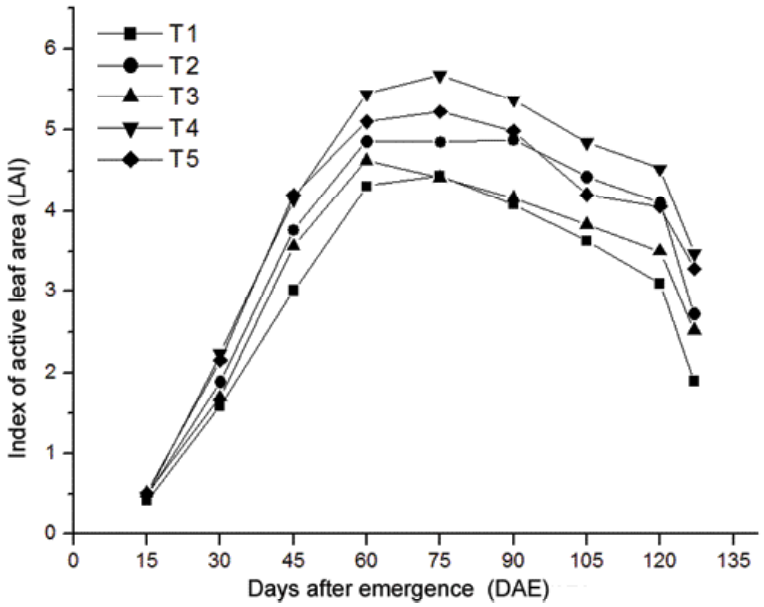

Figure 1. Variation of the index of active leaf area (LAI) of the corn crop over the crop cycle according to treatments of application of fungicides.

is a limit from which there is saturation of the active principle, reducing thus its activity and the effects on the vegetative development of the crop.

In Figure 2 it is presented graphically the values of dry matter of the plant shoot. Treatment T4 resulted in plants with higher production of DM and the other treatments did not differ from each other. This result may be associated with the pronounced effects of this treatment over the vegetative development of the crop, also verified for the ILA, according to Table 2.

The differences verified for the LAI considering treatments T1, T2, T3 and T5 were not significant for the production of DM. In this case, it is pertinent the supposition that the additive effects in the vegetative development of corn caused by Pyraclostrobin are more pronounced in the leaf tissues than in stems. In this case, it is possible that the differences verified in the leaf area do not lead to proportional differences of production of dry matter, which may be defined statistically, because a great difference in quantity of area of leaf tissue may cause a small difference of DM, since they are parameters determined with different units.

The fact of evaluate the active leaf area, not considering the senescence, may contribute to the results, since the effect of the Pyraclostrobin may also be associated with maintaining a higher active ILA and in this case all the differences of ILA are not necessarily proportional due to a larger production of leaf tissue. Still in relation to Figure 2, it must be emphasized the evident tendency of similarity of the behavior of the maximum values of DM and ILA for the different treatments, although the fact was not statistically supported.

The results of culture productivity in the experiment are presented in Figure 2. The values range between approximately 9500 and 11250 ha^{-1}. This range of productivity is superior to the historical average of the crops of the region of Guarapuava, which according to SEAB/DERAL (2007) is 7500 kg ha^{-1}.

For the factor productivity, treatment T4 again presented the highest average, however, the

Table 1. Chemical characteristics of the soil of the experimental area. Guarapuava – PR, 2011.

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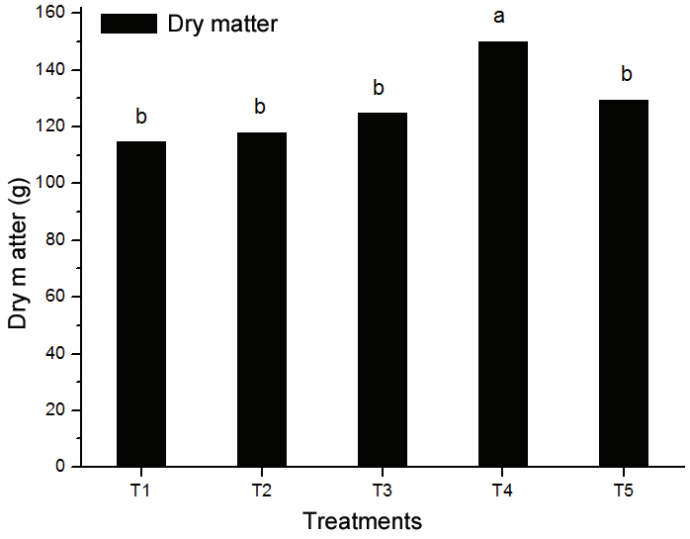

Figure 2. Dry matter of corn plant shoot (except ear) in the end of the crop cycle (Tukey: p>0,05).

statistical differences occurred only in relation to the treatments T1 and T3. This result is in accordance with the evidences emphasized in relation to LAI, that the effects of the active principles which are being discussed are more pronounced in relation to Pyraclostrobin applied trough leaves in the beginning of the vegetative development, than Pyraclostrobin + Methyl Tiophanate inserted as seed treatment.

These effects which are produced over the LAI affect directly the productivity, and it is expected that in the managements which cause better results of LAI it is also verified higher productivity.

The results are in accordance with Bryson et al. (2000) who verified that the strobirulin caused increase of the leaf retention of the plant and increase in productivity of grains in the wheat crop. Rava (2002) report that the use of strobilurin caused increase of productivity up to 97% in the bean crop.

MANFRON et al., (2003) emphasize that the LAI normally increases until a maximum limit, in which it remains for some time, decreasing next, due to the senescence of old leaves. These authors add that as well as photosynthesis depends on the leaf area, the crop yield will the higher the fastest the plant reaches the maximum index of leaf area and the longer the leaf area remains active. In this case, when observing the Figure 1, it can be observed that there is an important relation of the factors LAI and production.

It is evidenced once more that the dosage of 0.6 L ha^{-1} of Pyraclostrobin has lower additive effect over the crop than the dose of 0.3 L ha^{-1}, because there is a point of saturation between these dosages from which the corn crop responses in a less pronounced way to the presence of these active principle. Grossmann and Retzlaff (1997) commented about the possibility of these type of effect, verifying some behaviors of negative effect in the wheat crop in the presence of high concentration of strobilurin.

Corn seeds are generally commercialized when they are already treated, thus, in a general way, the producer does not consider this activity as mandatory part of the crop management, and it is, in many cases, performed with different products and aims.

In this reality, the differences of productivity evidenced in Figure 2, which goes from approximately 9500 to 11250 kg ha^{-1} evidence that the use of products which are based in Pyraclostrobin must be an alternative to be considered in the planning of the crop management, and in new researches

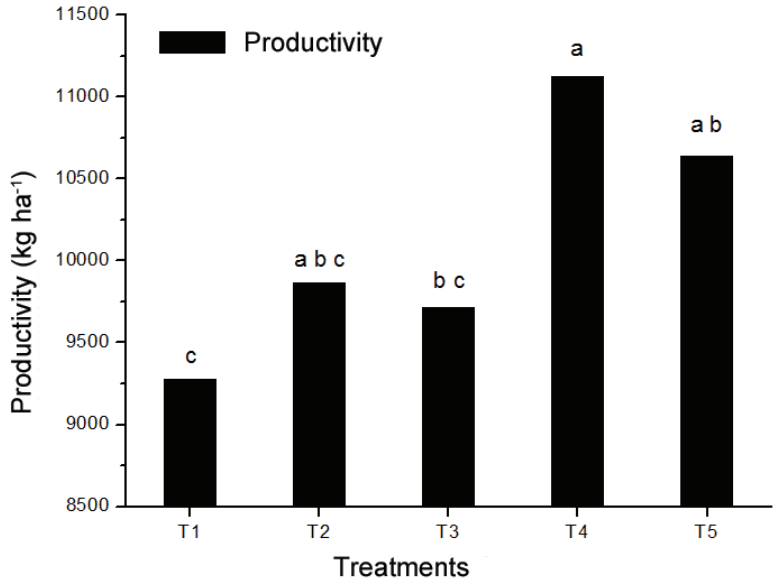

Figure 3. Productivity of the corn crop (humidity corrected to 13%) according to the application of fungicide (Tukey: p>0.05).

aiming to characterize more clearly the technical and economical viability of the use of this product in the cycle of production of corn, aiming to obtain the positive physiological effect. These results are in accordance with Juliatti (2007), who verified positive physiological effect in the production of grain by the use of strobilurins in the corn crop.

In this sense, Costa et al. (2009) consider that the studies of the physiological effects of fungicides were well developed in the soybean crop. In the corn crop, tough, these effects have not been so evident, being detect, in some situations, lower productivity in areas sprayed with fungicide when compared to areas where it was not sprayed. For the authors, the first factor to be considered in the decision-making about the application of fungicides in corn is the specific characteristics of the cultivar.

Conclusions

The application of fungicide Pyraclostrobin in spraying in the beginning of the development cycle of the vegetative canopy presents benefic result for the corn crop, causing higher development of the vegetative canopy and increase in grain productivity.

The application of seed treatment with (Pyraclostrobin + Methyl Tiophanate) in the dose of 0.1 L ha^{-1} + Comet (Pyraclostrobin) in the dose of 0.3 L ha^{-1} sprayed 12 DAE is the combination which present best results for the characteristics ILA, DM and productivity evaluated in the experiment.

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