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IMPROVING NITROGEN FERTILIZER ABSORPTION AND ITS EFFECT ON QUALITY AND SEED YIELD OF CORN (*Zea mays L.*)

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ABSTRACT

Improving nitrogen uptake by pyraclostrobin application in maize under green house and field conditions were investigated. There were three series experiments conducted in dry season, 2011 and 2012. The research was conducted using nested design and three replications. Nested design was applied in order to get information as careful as possible about the role of treatment, especially the main factor. The first experiment was carried out in the field while the second and third were in the green house.The experiments had two factors, pyraclostrobin application and nitrogen fertilizer. Vegetative growth, flowering and earing age, chlorophyll content, yield, amylose and protein content were evaluated. Application of pyraclostrobin, significantly increased nitrogen fertilizer efficiency. Amylose content and fresh yield were different on nitrogen and pyraclostrobin application. Application of pyraclostrobin 400 ml/ha significantly increased amylose 10.85-18.5%.Both amylose and protein content were increased by nitrogen fertilizer application. Vegetative growth and chlorophyll content were affected by nitrogen and pyraclostrobin significantly.

Keywords: corn, N efficiency, pyraclostrobin, amylose, yield.

INTRODUCTION

Corn (*Zea mays* L.) is an important cereal crop in Indonesia and has a priority in low and middle land, especially in Java. It is grown in rainy season, at non rice land, and is used as a grain as well as fodder crop. Increased production per unit area is the primary objective of corn research program. In Indonesia, many different types of corn evolved with the help of indigenous people who were the first corn breeders. The grain yield is the most important and complex trait as it is quantitatively inherited.

Breeding high-yielding and nutrient-efficient cultivars is one strategy to simultaneously resolve the problems of food security, resource shortage, and environmental pollution. However, the potential increased yield and reduction in fertilizer input achievable by using high-yielding and nutrient-efficient cultivars is unclear (Fan Jun *et al*., 2013). The production and utilization potential of corn in recent years is not only attracting the attention of research scientist but also evolving major national and international thrust with a view to providing solution to various problems of maize which include low seed yield (Kim, 1994).

Corn or maize is a C4 plant (Crafts-Brandner and Salvucci, 2002). During photosynthesis, plants use energy from the sun to form sugar from carbon dioxide and water. As temperatures rise, however, photosynthesis becomes increasingly inefficient in most plants and their productivity is drastically diminished. However, corn as a C4 plants has developed an alternate means of photosynthesis that allows them to maintain efficiency, even during hot weather. According to several researchers, despite the low numbers of C4 species, they carry out a quarter of the photosynthesis on arable land.

Study of quality and quantity of corn seed is an important effort to improve the yield in future. The seed is the main yield of corn. The main content of seed is a starch. The starch consist of amylose and amylopectin. The amylose and amylopectin content of starch,are 20-30% and 70-80%, respectively. Amylose is the important component of starch responsible for the hardness of the seed. Amylose content may be increased by pyraclostrobin application, so corn seed nutrition will be increased.

Pyraclostrobin is a member of the strobilurin group of fungicides. The strobilurin fungicides act through inhibition of mitochondrial respiration by blocking electron transfer within the respiratory chain, which in turn causes important cellular biochemical processes to be severely disrupted, and results in cessation of fungal growth. There were some cases about pyraclostrobin application on plant. The ultimate goal of pyraclostrobin application was improve the yield or nutrition, make the flowering age be shorten, tolerance to both abiotic or biotic factors.

Research has shown that pyraclostrobin was important in stimulating nitric oxide, a key messenger in plants (Conrath *et al*., 2004). Increased nitrate uptake and assimilation following the application of a strobilurin fungicide would justify additional fertilizer at the time of application. Identifying fertilizer sources that synergistically increase yield with a fungicide treatment would provide opportunities to manage disease, reduce application costs, and provide additional fertilizer when crop demand was greatest.

Furthermore, several researches have shown that *pyraclostrobin* was important in stimulating nitric oxide, a key messenger in plants, increased nitrate uptake and assimilation (Conrath *et al*., 2004). Application of a strobilurin fungicide such as *pyraclostrobin* would justify additional fertilizer at the time of application. Identifying fertilizer sources that synergistically increase yield with a fungicide treatment would provide opportunities to manage disease, reduce application costs, and provide additional fertilizer when crop demand is in maximum condition.

Nitrogen deficiency is a worldwide problem in crop production (Fan Jun *et al*., 2013). Nitrogen fertilizer is needed by corn at the vegetative growth phase. However, some fertilizer will not be absorbed by the plant, because the environment, may not be suitable with plant growth condition. Low nitrogen (N) and stress during critical stages of crop growth are the major abiotic challenges (Macharia *et al*., 2010). *Pyraclostrobin* application may be improve absorption and application of nitrogen fertilizer on corn. There was unique chemical substance keep the plant will always be health and vigorous.

Several researches on corn have shown variability in N response. Brown *et al*. (1993) reported that economically optimal N rates among 77 sites in Illinois ranged from zero to more than 200 lb N per acre. Results from other studies show similar variability in time and space. Even with such variability, results over environments have been combined and used to develop N fertilizer rate guideline in Illinois based on anticipated corn yield (Hoeft and Peck, 2002). This guideline suggests providing 1.2 lb of N (or a different factor based on the relative prices of corn and N) for each bushel of expected yield for corn following corn, with credits given when corn follows a legume or when manure has been applied to the field.

It is well known that yields, and thus actual N requirement, cannot be predicted with accuracy, however the use of this guideline has proven to be satisfactory in most years and on most fields. As N costs have increased in recent years, hence, it has become clear that using proven yield as a predictor of N rate tends to result in using more N than can be economically justified. This has led to the use of recent data to formulate N rate guidelines, with adjustments based on N and corn prices (Nafziger *et al*., 2004).

The ultimate objectives of this research are to evaluate the role of pyraclostrobin on nitrogen absorption and seed quantity and quality of corn

MATERIALS AND METHODS

This research was conducted at University of Brawijaya Research Station Malang Indonesia. The Research Station was situated at an altitude of 303 m above sea level. Three series of experiments were conducted in dry season, from June-November 2011 (two experiments) and May-October 2012. The research materials were corn seed P21 variety, nitrogen fertilizer and pyraclostrobin. The experiments were conducted using nested design and three replications.

The first and second experiments were respectively carried out in the field and green house. There were two experimental factors in the experiments. The first pyraclostrobin, consisted of without pyraclostrobin (P0) and pryraclostrobin 400 ml/ha (P1). The second factor was nitrogen fertilizer and consisted of without N (N0), 30 kg N/ha (N1), 60 kg N/ha (N2), 90 kg N/ha (N3) and 120 kh N/ha (N4).The third experiment was carried out in a green house. The replication was nested on pyraclostrobin factor, and there was interaction of sum of square and variance between both pyraclostrobin and nitrogen fertilizer factors.

Maize cultivation was using the standard manual of the plant. The application of fertilizer was basedon the treatment nitrogen dosages. Pyraclostrobin application by was foliar spray conducted once on 30 days after planting, while nitrogen fertilizer was applied on 30 days and 44 days after planting each with half of the treatment's dosage. The data collection focused on the plant height, number of leave, kernel period, kernel weight, 100 seeds weight, protein and amylose content of seed and chlorophyll content, respectively. Quantitative data were analyzed using analysis of variance with nested design. The difference among treatments was analyzed by least significant different test. After harvest, amylose and protein analysis was conducted at Central Laboratory of life Science, University of Brawijaya. Data were arranged and were analyzed by analysis of variance on nested design.

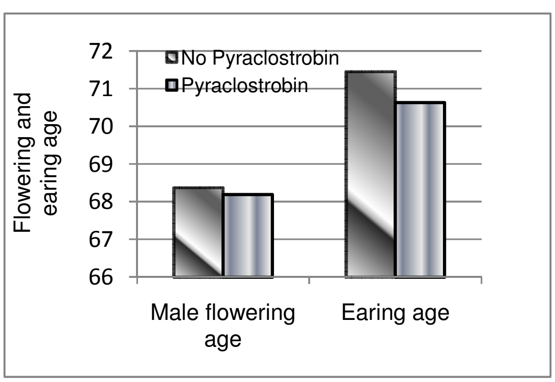
RESULTS AND DISCUSSIONS

The absorption of nitrogen by plants plays an important role in their growth. Consequently, nitrogen fertilization has been a powerful tool for increasing the yield of cultivated plants (Gallais and Hirel, 2004). The efficiency of nitrogen fertilizer to vegetative growth (plant length and leave number) was not dependent on pyraclostrobin application. The pyraclostrobin treated grew and absorbed nitrogen weren't different from without pyraclostrobin. Surprisingly, the last of vegetative growth was affected by pyraclostrobin application dependently.

The plant was sprayed with pyraclostrobin on the surface of the leaves. Pyraclostrobin enhanced plant height or leave number after application. Plant height and leave number were increased. It induced vegetative growth of plant several weeks after application. Theoretically, early and middle growth of corn were affected by nitrogen. Nitrogen enhanced increasing and developing of cells number. Vegetative growth was affected by dosages of nitrogen fertilizer. The higher dosages of nitrogen fertilizer, the higher the plant and more leave number. The role of nitrogen was enhancer vegetative growth of plant. The plant height and leave number will be added if vegetative growth be enhanced.

There was different phenomenon on both of flowering and earing age. They had same response with all the treatments. There was not significant different earlier or delayed flowering as a response of treatments. Flowering and earing age of corn were not affected by pyraclostrobin and nitrogen application (Figure 1). Just for flowering and earing age, absorbing nitrogen did not more efficient if pyraclostrobin applied it. Actually, it was not new one, because nitrogen just absorbed by corn to growing the early of vegetative growth. At that time, pyraclostrobin did not apply yet. The absence difference of early vegetative growth, caused flowering and earing age wasn't different.

The leaf chlorophyll content was affected by pyraclostrobin application, mainly on lately phase after application (Figure 2). The chlorophyll was affected by nitrogen because nitrogen is an important component of chlorophyll substance for arrange green color of leaves. But the effect of nitrogen on chlorophyll was significant at the last vegetative phase of growth



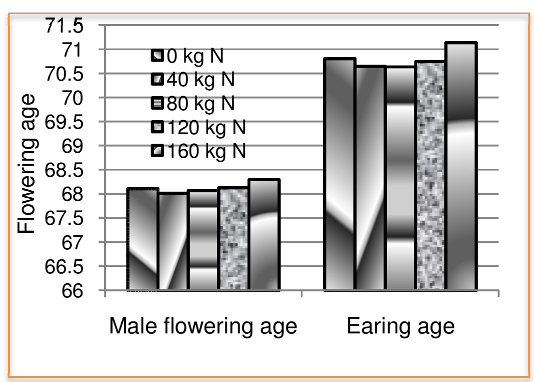


Figure 1. Flowering and earing age on pyraclostrobin application (a) and nitrogen fertilizer (b)

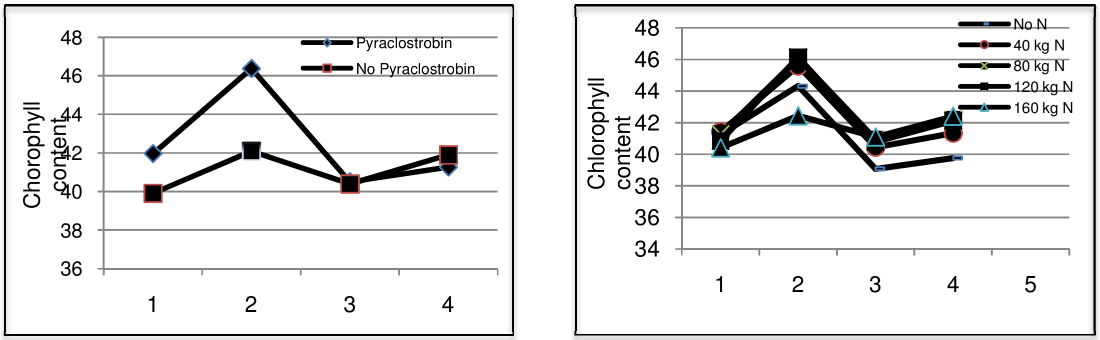


Figure 2. Chlorophyll content after the application of pyraclostrobin (a) and nitrogen fertilizer (b).

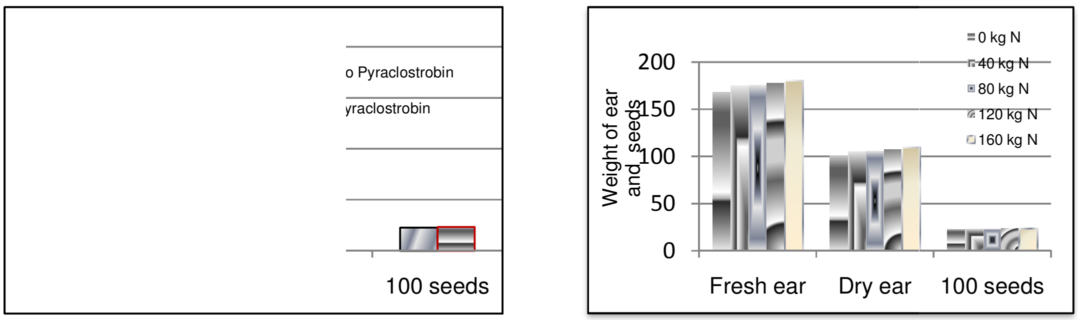


Figure 3. Ear and seed weight on pyraclostrobin application (a) and nitrogen fertilizer (b)

The yield of ear or kernels on different nitrogen were not affected by pyraclostrobin. Ear weight was affected by nitrogen. Plant fertilized by nitrogen will produce more yield (Figure 3).

Figure 4 was information to understand the role of pyraclostrobin on efficiency of nitrogen fertilizer on weight of ear and seed. On fresh ear weight, indication of interaction between both pyraclostrobin and nitrogen just indicated on highest dosage. This phenomenon described linear model y = 0.0109x + 8.5784 (R^2 = 0.7434). It's mean, nitrogen absorption supported by pyraclostrobin to get fresh ear. Increased nitrate uptake and assimilation following an application of a strobilurin fungicide would justify additional nitrogen fertilizer at the time of application to corn (Nelson *et al*., 2012). But similar response was not observed on the dry weight. The linear model was y = 0.0054x + 5.3434 (R^2 = 0.3242). It is shown in Figure 4 on twin straight lines.

Figure 5 shows that amylose content will decrease while protein content will increase, if the experiment hold at green house on dosage up to 120 kg/ha. Dosage 50 kg N/ha was suitable to grow corn in green house, so got the high amylose content. The observation was different in case of the field experiment where both amylose and protein contents increased on 120 kg/ha nitrogen application. This observation signifies that a dosage of 120 kg N/ha was suitable to get high amylose and protein content. Increasing level of nitrogen will usually result in the increase of protein content in the seed (Morshed *et al*., 2008).

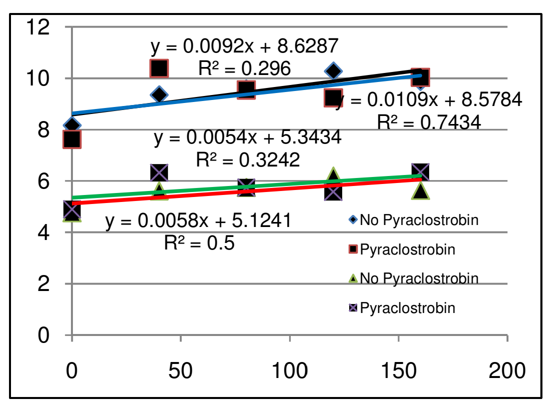


Figure 4. Fresh weight (above) and dry weight (below) (ton) of ear in response to pyraclostrobin application

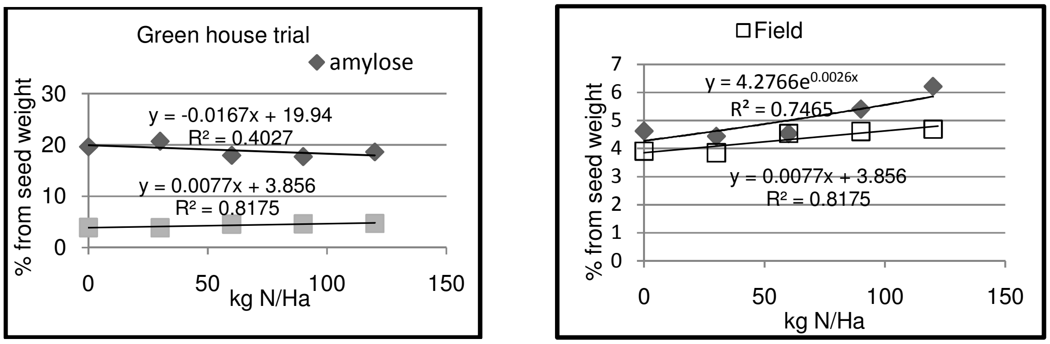


Figure 5. Response of seed amylose and protein content to nitrogen in Green house and field experiment

Application of nitrogen fertilizer may increase kernel hardness through increased protein content. The interrelationship between protein bodies and starch granules, an increase in protein may reduce starch extraction. Regardless of small significance on vegetative and generative phase, it was found that amylose contents significantly increased with the application of pyraclostrobin in plant grown in the green house. At the green house, pyraclostrobin application at 400 ml/ha was capable of increasing grain amylose content from 17.33% to 20.53% or increase to 18.5% higher. Pyraclostrobin had the important role to increase the efficiency of nitrogen uptake. (Figure 6). The unique chemistry of its active ingredient enables more efficient nitrogen uptake and more robust plant growth. Ultimately, this means healthier plants and higher yield potential.

Figure 6, all the treatment with pyraclostrobin shows significant effect on the synthesis of amylose, even with the minimum nitrogen treatment. It is clear that on the small dosage pyraclostrobin has a positive impact on plant quality (Jabs and Slusarenko, 2000) mainly under level and reduce reactive oxygen in leaf tissues by more than 50%. The significant increase of amylose could also be a mechanism of stress tolerance developed by the plant with the help of pyraclostrobin.

There were similar observations in the second green house experiment, but the increase in amylose was less than in the previous experiment. Amylose content was significantly increased by 10.85% on pyraclostrobin application, thus pyraclostrobin enhanced starch formation. Protein content was significantly increased on nitrogen fertilizer application. It was clear because N is an important component of protein structure.

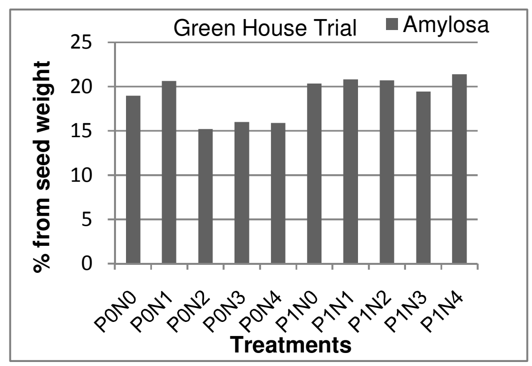


Figure 6. Effect Pyraclostrobin and Nitrogen to seed's amylose content

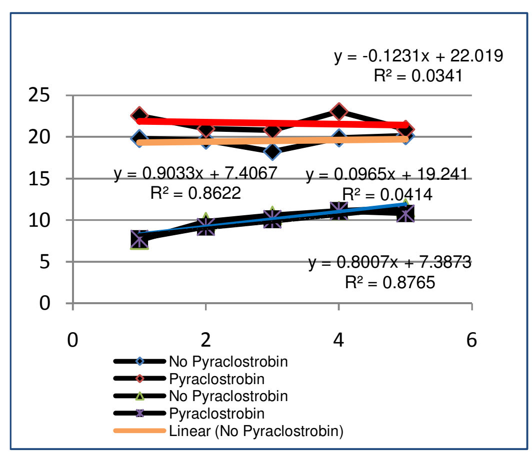


Figure 7. Response of seed amylose (above) and protein (below) content to pyraclostrobin and Nitrogen

Figure 7 shows response of seed amylose and protein content to pyraclostrobin and nitrogen. The above twin straight lines indicate the slope of nitrogen dosage with and without pyraclostrobin applied. The unique chemistry of the compound enables more efficient nitrogen uptake and more robust plant growth. Both indicate the nitrogen uptake efficiency with pyraclostrobin application. The below twin straight lines indicate the raising protein content with and without pyraclostrobin. These straight lines, supported by high determination coefficient, determine linear effect of nitrogen on protein content.

CONCLUSIONS

Application of pyraclostrobin, significantly increased nitrogen fertilizer efficiency. Application of pyraclostrobin 400 ml/ha significantly increase grain amylose 10.85-18.5%. Both amylose and protein content were increased by nitrogen fertilizer application. Vegetative growth and chlorophyll content were affected by pyraclostrobin.

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