THE USAGE OF NPK COATED BY POLYMERS ON THE COTTON CROP
*GOSSYPIUM HIRSUTUM L.* FOR BIOMASS PRODUCTION ON THE AERIAL PART

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Abstract. This work has the objective to assess the agronomic efficiency of the nitrogen, phosphate and potassium fertilizations by fertilizers lined up with polymers at the growing cotton. We installed three experiments where the treatments were distributed in factor arrangement 3x2+1, with four replications. The first factor was constituted by three doses of the fertilizer (80, 160 and 240 kg ha⁻¹ of Nitrogen; 50, 100 and 200 kg ha⁻¹ of P₂O₅; 50, 100 and 200 kg ha⁻¹ of K₂O); the second factor were made by two sources of fertilizers (conventional and lined up with polymers); and the additional treatment (control without fertilizer). The production of fresh dry mass of the aerial part of the cotton plant was evaluated 60 days after the emergence. The growth of biomass fresh was superior when using Kimcoat-N (fertilizer lined up with polymers). Phosphate and potassium fertilizations coated polymers were statistically higher in dry mass production. Among the doses studied, there was statistical difference for phosphorus in the production of dry and fresh mass of the Cotton crop.

Keywords: Coated; efficiency; *Gossypium hirsutum* L.

INTRODUCTION
In Brazil, the increased consumption of fertilizers shows an annual average change of 5.3% from 1987 to 2002 (VEGRO; FERREIRA, 2004) and 3.21% from 2002 to 2012 (ANDA, 2012), this increased of consumption together with an efficient application of mineral fertilizers are factors that contributes most for the increase on the agriculture yield.

The efficiency of the fertilization relies basically on the doses and sources of the used fertilizers, the cation exchange capacity and the physical characteristics of the soil (SGARBI et al., 1999). Scivittaro e Pillon (2007) mention that in order to increase the efficiency of fertilization, its fundamental to associate it with soil management, like increasing the native vegetal covering, crop rotation and terracing.

The leaching is the form of losing nitrogen, when it occurs, the nitrate is carried to deep layers on the ground, possibly reaching the groundwater, causing contamination (VILAS BOAS et al., 1999). Another form relevant of losing N is by gaseous compounds, occurring in various situations, which can lead to a low degree of efficiency of the nitrogen fertilizers, notably when they are superficially applied (LOPES; GUILHERME, 2000).

Indeed, various Brazilian authors have related high losses of N by volatilization of NH₃ when the urea is applied on the surface of the soil: about 20 to 40 % of the N applied in sugar cane (CANTARELLA et al., 1999; VITTI, 2003), 16 to 44 % of the N in citrus (CANTARELLA et al., 2003), 16 to 61 % in pastures (CANTARELLA et al., 2001) or even higher, like the one presented by Lara Cabezas et al. (2000), with losses of 40 to 78% of the N applied in the soil surface.

The phosphorus (P) has a great power of adsorption in the soil, making it hard for the plant to absorb it. It occurs mainly by the strong connection with iron and aluminum. The reversibility of the non-labile phosphorus to labile, is very low (NOVAIS; MELLO, 2007). Thus, part of the P adsorbed can become available, however at a very low and slow rate, thereby can be considered a loss (ALCARDE et al., 1998).

An alternative technique of fertilizations is to use fertilizers with protection layers and that have gradual release (SHAVIV, 1999). The inhibitors fertilizers or stabilization fertilizers are products that reduce the nutrient losses by retarding the conversion of original forms of the fertilizer in forms easily lost (BLAYLOCK, 2007). The protection time varies from days to weeks and the effect will manifest if there are real conditions for the losses. For the organic synthetic fertilizers that are not coated with polymers, but with slow availability, protect the nutrient by promoting a gradual release, and the availability of the nutrients depending on the biochemical decomposition of the compounds.

The literature indicates losses by leaching of K is about 50-70% (AUOADA et al., 2008). Therefore, only small amount of nutrients is absorbed by the plants in inadequate managements. To meet this lack, is necessary, fragmentation of application, to avoid waste of fertilizer as well as environmental problems, a studied alternative is the utilization of fertilizers with gradual releases being already cited by Shaviv (1999) and Valderrama et al. (2011). Another option for the increase on the efficiency would be the fertilizers called stabilized, being the ones that contain additives to increase the uptime of the nutrient in the soil, such as the urease and nitrification inhibitors (CANTARELLA, 2007).

According to Trenkel (2010), the fertilizers called as the last generation ones are classified as slow and controlled release fertilizers and stabilized fertilizers. Valderrama et al. (2009) said that coated
The usage of NPK... fertilizers or encapsulated can bring a reduction to the production cost and less environmental impact due to the reduction on the leaching, volatilization and fixation losses.

The polymer coated fertilizers, for example, search to reduce the nutrient losses by leaching, volatilization and adsorption, causing dose reduction (VIEIRA; TEIXEIRA, 2004). However, practicing the dose reduction can lead to a drain of the soil nutrients, even with sources of improved efficiency, making necessary it is evaluation along the agricultural years.

It is worth to note that the lack of studies involving the use of polymer coated fertilizers in the Central region of Brazil (cerrado), especially with the cotton crop. In that way, this work aimed to evaluate the biomass production of the aerial part of the cotton plant with the increment of crescent doses of NPK coated up with polymers.

**MATERIAL AND METHODS**

Three experiments were installed between 8/15/2009 to 10/14/2009, in a greenhouse at Rio Verde, GO, with geographical location among the parallels 20º 45’ 53’’ of south latitude and the meridians 51° 55’ 53’’ of west of Greenwich longitude, with a 748 m of height. For both experiments, we utilized soil which physical-chemical characterization presented the following values: pH (in water) = 6.3; Corg = 48.84 g dm$^{-3}$; P(Mehlich I) = 7.83 mg dm$^{-3}$; K = 2.05 mmol c dm$^{-3}$; Ca = 23.0 mmol c dm$^{-3}$; Mg = 15.8 mmol c dm$^{-3}$; Al = 0.0 mmol c dm$^{-3}$; V = 57.16% and medium texture (449 g kg$^{-1}$ of clay, 150 g kg$^{-1}$ of silt and 401 g kg$^{-1}$ of sand).

The three experiments were outlined in a complete randomized blocks design, with 4 replicates, both in 3x2+1 factorial design. Treatments from the experiment 1 were composed by three doses of nitrogen (80, 160 and 240 kg ha$^{-1}$), two sources of nitrogen fertilizers (urea and Kimcoat-N) and the control (without N-fertilizer). The Kimcoat-N fertilizer differs from urea by having three layers polymer-coated granules. The treatments from experiment 2 were composed by three doses of P$_2$O$_5$ (50, 100 and 200 kg ha$^{-1}$), two sources of phosphate fertilizers (triple-superphosphate and Kimcoat-P) and the control (without P-fertilizer). The Kimcoat-P differs from the triple-superphosphate by having three layers polymer-coated granules. The treatments from experiment 3, were three doses of K$_2$O (50, 100 and 200 kg ha$^{-1}$), two sources of potassium fertilizers (potassium chloride and Kimcoat-K) and the control (without K-fertilizer). The Kimcoat-K differs from the potassium chloride by having three layers polymer-coated granules.

Each experimental unit were formed by a vessel with a 7.0 kg capacity of soil. Delta Penta variety was sown in 8/15/2009 along with the following treatments application. Additionally has been applied the equivalent to 100 kg ha$^{-1}$ of P$_2$O$_5$ through triple-superphosphate and 100 kg ha$^{-1}$ of K$_2$O through potassium chloride on the N evaluation (experiment 1); 160 kg ha$^{-1}$ of N through urea and 100 kg ha$^{-1}$ of K$_2$O through potassium chloride on the P evaluation (experiment 2); and 160 kg ha$^{-1}$ of N through urea and 100 kg ha$^{-1}$ of P$_2$O$_5$ through triple-superphosphate on the K evaluation (experiment 3).

On to 60 days after emerge, a biomass gathering was made from the aerial part of the plants, after the gathering, the plants were weighed in a precision scale. To quantify the production of the dry biomass from the aerial part, the plants were packed in a kiln with forced-ventilation with a 65ºC temperature for 72 hours, after this period, a weigh was realized to estimate the dry mass.

The data were submitted to an analysis of variance with a 5% level of probability. For the variables with a significant effect on the doses were realized...
the regression analysis, whereas the comparison among the fertilizers followed the Tukey’s test at 5% probability level.

RESULTS AND DISCUSSION

Concerning the nitrogen (N) experiment, a significant difference was spotted related to the productivity of dry mass of the aerial part comparing the nitrogen fertilization with the control (without N-fertilizer), proving the need of the nitrogen fertilization in the cotton crop (Table 1). For the fresh mass, the Kimcoat-N was higher to urea, however this difference was not observed in the dry mass, this difference can be explained due to the polymer-coating reduce the nitrification of ammonium, remaining in the ammonium form, this which has preference the absorption, stressing that the transport of N, by mass flow (BARBER, 1995), is completely dependent of water.

Table 1. Production of fresh mass (g pl⁻¹) and dry mass (g pl⁻¹) comparing the different types of nitrogen fertilizer and control

<table>
<thead>
<tr>
<th>Nitrogen Fertilizer</th>
<th>Dry Biomass</th>
<th>Fresh Biomass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kimcoat-N</td>
<td>6.84 a*</td>
<td>22.71 a</td>
</tr>
<tr>
<td>Urea</td>
<td>6.21 a</td>
<td>16.76 b</td>
</tr>
<tr>
<td>Control</td>
<td>3.44 b</td>
<td>10.48 c</td>
</tr>
<tr>
<td>CV (%)</td>
<td>24.82</td>
<td>28.85</td>
</tr>
</tbody>
</table>

*Means followed by the same letter in the column do not differ significantly by Tukey test at 5% of probability.

As for the fresh mass variable, a significant difference was spotted among the studied sources, where the Kimcoat-N obtained a higher productivity than the urea (Table 2). This difference can be explained by the fact that the controlled-release fertilizer reduces damage to the roots by high concentration of fertilizers and amounts to a homogeneous distribution of the soil nutrients, favoring the supply and the physiological demand of the plant (ROSSA, 2008).

Table 2. Productivity of fresh mass (g pl⁻¹) and dry mass (g pl⁻¹) submitted to the interaction between fertilizers and doses of Nitrogen

<table>
<thead>
<tr>
<th>Fertilizer</th>
<th>80</th>
<th>160</th>
<th>240</th>
<th>80</th>
<th>160</th>
<th>240</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dose of N (kg ha⁻¹)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kimcoat-N</td>
<td>6.75 aA*</td>
<td>6.90 aA</td>
<td>6.88 aA</td>
<td>23.70 aA</td>
<td>20.28 aA</td>
<td>24.15 aA</td>
</tr>
<tr>
<td>Urea</td>
<td>6.21 aA</td>
<td>6.26 aA</td>
<td>6.16 aA</td>
<td>15.73 bA</td>
<td>16.27 aA</td>
<td>18.28 bA</td>
</tr>
<tr>
<td>CV (%)</td>
<td>24.82</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>28.85</td>
</tr>
</tbody>
</table>

*Means followed by the same letter, lowercase on column and capitalized on the line, do not differ significantly by Tukey test at 5% probability.

A significant interaction was not spotted among the studied sources and doses of N in the production of fresh mass, confirming the results of Valderrama et al. (2011), where has been no significant interaction among the foliar nitrogen content, height of plants, diameter of the second internode, height of first cob and the number of plants of corn by hectare.

For the studied doses of N no statistic difference has been seen, evidencing that the lower dose is enough to keep the production,
not making necessary doses above 80 kg ha\(^{-1}\) of N, leading to lower costs with nitrogen fertilizers than the other studied doses (160 kg ha\(^{-1}\) and 240 kg ha\(^{-1}\) of N). Valderrama et al. (2009) noted that the sources and doses (conventional and polymer-coated) of N showed no difference in 100 grains of beans mass.

The coated fertilizer provided an increased the index of fresh weight when compared to the conventional fertilizer for the 80 kg ha\(^{-1}\) and 240 kg ha\(^{-1}\) of N (Table 2). That result is due to the fact that the coating increases the efficiency of the fertilizer by reducing leaching and volatilization of N. According to Lopes and Guilherme (2000), the most significant ways of losing fertilizers are by leaching and volatilization of N, however the polymer-coated fertilizers seek to reduce such losses.

As to the experiment where sources and doses of phosphate were tested, a significant difference in the production of dry mass was spotted, however that difference could not be seen for the fresh mass. For the dry mass productivity, the Kimcoat-P was superior to the triple-superphosphate (Table 3). For the studied doses of P, the use of 50 and 100 kg ha\(^{-1}\) of P\(_2\)O\(_5\) did not differed statistically, likewise the doses of 50 and 200 kg ha\(^{-1}\) of P\(_2\)O\(_5\) were similar in productivity (Table 4).

**Table 3.** Production of fresh mass (g pl\(^{-1}\)) and dry mass (g pl\(^{-1}\)) comparing the different types of Phosphate fertilizer and control

<table>
<thead>
<tr>
<th>Phosphate Fertilizer</th>
<th>Dry Biomass</th>
<th>Fresh Biomass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kimcoat-P</td>
<td>8.20 a*</td>
<td>22.87 a</td>
</tr>
<tr>
<td>Triple Superphosphate</td>
<td>6.10 b</td>
<td>20.86 a</td>
</tr>
<tr>
<td>Control</td>
<td>5.22 b</td>
<td>20.20 a</td>
</tr>
<tr>
<td>CV (%)</td>
<td>27.97</td>
<td>18.34</td>
</tr>
</tbody>
</table>

*Means followed by the same letter in the column do not differ significantly by Tukey test at 5% of probability.

There was a statistically significant interaction among the sources and doses of phosphate in the productivity of dry mass. When comparing the polymer fertilizer, the 50 kg ha\(^{-1}\) dose of P\(_2\)O\(_5\) showed no difference from the others, however the 200 kg ha\(^{-1}\) of P\(_2\)O\(_5\) presented a lesser productivity of dry mass than the 100 kg ha\(^{-1}\) dose of P\(_2\)O\(_5\).
Table 4. Productivity of fresh mass (g pl⁻¹) and dry mass (g pl⁻¹) submitted to the interaction between fertilizers and doses of phosphorus

<table>
<thead>
<tr>
<th>Fertilizer</th>
<th>Dry Mass 50</th>
<th>Dry Mass 100</th>
<th>Dry Mass 200</th>
<th>Dry Mass 500</th>
<th>Fresh Mass 50</th>
<th>Fresh Mass 100</th>
<th>Fresh Mass 200</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kimcoat-P</td>
<td>8.31 aAB</td>
<td>11.10 aA</td>
<td>5.42 aB</td>
<td>22.47 aB</td>
<td>28.13 aA</td>
<td>18.00 bB</td>
<td></td>
</tr>
<tr>
<td>Triple Superphosphate</td>
<td>5.52 bA</td>
<td>6.27 bA</td>
<td>6.73 aA</td>
<td>20.76 aA</td>
<td>19.28 bA</td>
<td>22.54 aA</td>
<td></td>
</tr>
<tr>
<td>CV (%)</td>
<td>27.97</td>
<td></td>
<td>18.34</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Means followed by the same letter, lowercase on column and capitalized on the line, do not differ significantly by Tukey test at 5% probability.

On the triple-superphosphate, a difference between the doses was not observed for the productivity of dry and fresh mass. There was no statistically difference for the productivity of dry mass among the highest dose (200 kg ha⁻¹ of P₂O₅) between the studied sources, for the 50 and 100 kg ha⁻¹ of P₂O₅ the Kimcoat-P demonstrated a higher productivity of dry mass then the triple-superphosphate (Table 4).

There was a significant interaction in the production of fresh mass among the doses of phosphate fertilizers. The triple-superphosphate showed no difference between the doses, however the Kimcoat-P provided a higher efficiency of fresh mass in the 100 kg ha⁻¹ of P₂O₅ dose, while the other doses showed no statistical difference. For the 100 kg ha⁻¹ dose, the Kimcoat-P provided the highest productivity, however for the 200 kg ha⁻¹ of P₂O₅ dose, the triple-superphosphate presented a higher productivity (Table 4). This can be explained by the fact that the Kimcoat-P is protected by the polymer-coated which entails less adsorption losses to the soil. It is noteworthy that the experiment was carried out in soil of a tropical region, that presents nutrient deficit, and higher rate of absorption, limiting the productivity of the cultures (RAIJ, 1991). According to Shaviv (2001), one of the advantages of the polymer-coated fertilizers is the lower losses by the immobilization process, being the use of P, higher for the 100 kg ha⁻¹ of P₂O₅ with Kimcoat-P. Another question to be considered is that may have occurred an overdose of P₂O₅ during the use of 200 kg ha⁻¹ of P₂O₅ trough Kimcoat-P. Thereby, with a high dose of P, the soil might have absorbed a higher amount, since the Kimcoat-P liberation is controlled, Valderrama et al. (2010) quote that the increase of the polymer coated fertilizers provides a higher productivity for the hybrid corn Bt 30F53H, at the 120 kg ha⁻¹ of P₂O₅ dose, providing the highest grains production.

Among the studied doses of P, there was a significant difference for the productivity of fresh and dry mass only for the coated fertilizers (Picture 1), being performed the regression that showed respectively the r of 0.9167 and 0.9785 , the dose that demonstrated the highest productivity was shown to be the 109 kg ha⁻¹ of P₂O₅, presenting a productivity of 25.8176 g pl⁻¹ of fresh mass and the highest productivity dose was shown to be the 91.6 kg ha⁻¹ of P₂O₅, presenting a productivity of 10.73 g pl⁻¹ of dry mass.
The usage of NPK...

Figure 1. Productivity curves of dry mass ($\gamma=-0.0005P^2+0.1091P+4.9392 \quad r=0.9785$) and fresh mass ($\gamma=-0.0008P^2+0.1466P+19.343 \quad r=0.9167$) of cotton, comparing doses of P fertilizer (P<0.05).

As to the potassium (K) experiment, there was a significant difference for the potassium fertilizers compared to the control (without K-fertilizer) (Table 5). Among the production factor that contributes to high incomes, the potassium fertilizers assume an important role, since, after the N, K is the most required element in quantity for the plants (SIMONETE et al., 2002).

Table 5. Production of fresh mass (g pl$^{-1}$) and dry mass (g pl$^{-1}$) comparing the different types of potassium fertilizer and control

<table>
<thead>
<tr>
<th>Potassic Fertilizer</th>
<th>Dry Biomass</th>
<th>Fresh Biomass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kimcoat-K</td>
<td>7.77 a*</td>
<td>19.04 a</td>
</tr>
<tr>
<td>Potassium Chloride</td>
<td>5.72 b</td>
<td>16.00 a</td>
</tr>
<tr>
<td>Control</td>
<td>4.04 c</td>
<td>11.48 b</td>
</tr>
<tr>
<td>CV (%)</td>
<td>26.57</td>
<td>24.48</td>
</tr>
</tbody>
</table>

Means followed by the same letter in the column do not differ significantly by Tukey test at 5% of probability.

There was no significant difference spotted on the productivity of fresh mass when comparing the doses of K. Valderrama et al. (2011) quote that the increase of the K doses has not affected the height of the plants and the diameter of the culm and the height of the first cob, however, a higher productivity was expected since K is the activator of more than 60 enzymes of the plant, being important for the expansion of the cell volume and ions transportation to the cells (Prado, 2008). Regarding the tested sources, the Kimcoat-K fertilizer conferred a higher productivity of dry mass then KCl (Table 6). Rossa (2008) quotes that the controlled-release fertilizers attribute less damage to the environment by softening the losses by leaching, besides having other advantages about conventional fertilizers, like the elimination of the damage caused on
the roots by the high concentration of salts and a more homogeneous distribution of the nutrients in the soil, favoring the synchronization between the supply and physiologic request of the plant.

**Table 6.** Productivity of fresh mass (g pl⁻¹) and dry mass (g pl⁻¹) submitted to the interaction between fertilizers and doses of Nitrogen, Phosphorus and Potassium

<table>
<thead>
<tr>
<th>Fertilizer</th>
<th>Dry Mass</th>
<th>Fresh Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dose of K₂O (kg ha⁻¹)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>Kimcoat-K</td>
<td>6.82 aA*</td>
<td>8.26 aA</td>
</tr>
<tr>
<td>Potassium Chloride</td>
<td>5.72 aA</td>
<td>4.97 bA</td>
</tr>
<tr>
<td>CV (%)</td>
<td>26.57</td>
<td></td>
</tr>
</tbody>
</table>

Means followed by the same letter, lowercase on column and capitalized on the line, do not differ significantly by Tukey test at 5% probability.

There was no interaction in the productivity of dry mass among the potassium doses and sources. However for the 100 kg ha⁻¹ of K₂O the Kimcoat-K provided the highest productivity of dry mass than the KCl (Table 6), which was not observed in other doses, due to the high content of K in the soil of the experiment. Souza and Lobato (2004) quote that for a soil with an adequate content of K is necessary less than 100 kg ha⁻¹ of K₂O for growing cotton, and that doses higher than 60 kg ha⁻¹ of K₂O, must be split, applying half in coverage. That way the lesser dose did not differed for being inferior to 60 kg ha⁻¹ of K₂O, and the higher dose (200 kg ha⁻¹ of K₂O), was superior than the necessary. For the 100 kg ha⁻¹ of K₂O the Kimcoat-K was superior to the KCl, due to its controlled liberation, supplying the physiological demand of K for cotton without making necessary the split fertilizing of this nutrient.

For all the proceeded analysis, there was a statistical difference among the control and the fertilizers. Guareschi et al. (2011) observed a response between the application of P and K in the production of fresh mass and the productivity of soybean, and that the lack of fertilization impaired the growth of the soybean.

**CONCLUSIONS**

The supply of potash and phosphate by fertilizers-coated provide higher increase in dry matter production compared to conventional fertilizers.

In the conditions studied, increasing doses of phosphorus resulted to an increase in the production until the dosage of 91.62 kg ha⁻¹ of P₂O₅. The cotton crop does not respond to high doses of nitrogen and potassium in seeding.

The coated fertilizers have been presented as promising. However, more detailed studies are needed for evaluating its real effectiveness.

**REFERENCES**


