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Physiological and agronomic traits of cabbage plants hybrid Fuyutoyo® sprayed with plant growth regulators

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ABSTRACT

In this study we aimed to evaluate the effect of using the mixture of plant growth regulators auxin, gibberellin and cytokinin in the physiological behavior and productive components of cabbage plants hybrid Fuyutoyo®. The experimental design was completely randomized, with four replications, evaluating five doses of the mixture of plant growth regulators, in the form of the commercial product *Stimulate*® (0, 50, 100, 150 and 200 mL p.c./100 L H_2O). The spray applications of plant growth regulators started when the plants presented 7-8 expanded leaves, carried out fortnightly, totaling five applications along the cycle. The authors evaluated gas exchange measures; fresh mass, diameter and firmness of "heads"; and number of leaves. The study concluded that applications of 200 mL of the mixture of plant growth regulators p.c/100 L H2O promoted higher photosynthetic yield (21.40 μmol $CO_2/m^2/s$), and fresh mass (3.46 kg), vertical and horizontal diameter (13.23 and 16.61 cm), number of leaves (30.95) and firmness of the "head" (54.48 N). The authors recommend, in order to choose the best dose, to analyze to which market segment the product will be directed.

Keywords: *Brassica oleracea* var. *capitata*, plant growth regulators, gas exchange.

RESUMO

Características fisiológicas e agronômicas do híbrido de repolho Fuyutoyo® pulverizado com reguladores vegetais

O trabalho teve como objetivo avaliar o efeito da utilização da mistura de reguladores vegetais, auxina, giberelina e citocinina no comportamento fisiológico e componentes produtivos de plantas de repolho híbrido Fuyutoyo®. Utilizou-se o delineamento experimental de blocos ao acaso, com quatro repetições, avaliando-se cinco doses da mistura de reguladores vegetais, na forma do produto comercial *Stimulate*® (0, 50, 100, 150 e 200 mL p.c./100 L H_2O). As aplicações de reguladores vegetais iniciaram quando as plantas apresentavam 7 a 8 folhas expandidas, realizadas quinzenalmente, totalizando-se ao longo do ciclo, cinco aplicações. Avaliaram-se as medidas de trocas gasosas; massa fresca, diâmetro e firmeza das cabeças; e número de folhas. Conclui-se que aplicações de 200 mL da mistura de reguladores vegetais p.c./100 L H_2O, promoveram maior rendimento fotossintético (21,40 μmol $CO_2/m^2/s$), massa fresca (3,46 kg), diâmetro vertical e horizontal (13,23 e 16,61 cm), número de folhas (30,95) e firmeza da "cabeça" (54,48 N). Recomenda-se para escolha da melhor dose, avaliar a que segmento do mercado será direcionado o produto.

Palavras-chave: *Brassica oleracea* var. *capitata*, reguladores vegetais, trocas gasosas.

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Especially grown by small producers, cabbage (*Brassica oleracea* var. *capitata*) is an herbaceous, biennial vegetable; this crop has a great economic and social importance in Brazil (Silva *et al*., 2012, 2014). Cabbage can be eaten raw, canned or dehydrated, being characterized by showing great diversity of nutritive properties, such as vitamin C, iron salts, β-carotene and mineral salts (Ferreira *et al*., 2002; Luz *et al*., 2002).

Hormone balance in plants directly reflects the productivity, defining the crop phenotypic expression depending on the resource availability in the cultivation environment (Fioreze & Rodrigues, 2014). The authors observed a possibility to improve the productive traits of plants through exogenous application of plant growth regulators (Reghin *et al*., 2000; Bertolin *et al*., 2010; Palangana *et al*., 2012).

Plant growth regulators or bioregulators are substances which produce effects similar to plant hormones when they are applied to plants. In agriculture, regulators are able to promote plant development and productivity (Reghin *et al*., 2000; Bertolin *et al*., 2010; Palangana *et al*., 2012), and also stimulate stake rooting (Fischer *et al*., 2008), promote dormancy breaking in fruits and favor budding (Segantini *et al*., 2011), accelerate or delay the ripening of fruits (Jadoski *et al*., 2011) and control plant development, helping cultural management and harvesting, among other purposes (Fioreze & Rodrigues, 2014).

Stimulate® is a commercial bioregulator composed of a mixture of cytokinin, auxin and gibberellin {kinetin (90 mg/L), IBA (50 mg/L) and GA_3 (50 mg/L)} (Palangana *et al*., 2012). Among the main physiological effects of plant growth regulators present in the formula of *Stimulate,* cytokinin promotes cell division and differentiation, stimulating lateral buddings and greater leaf expansion (Reghin *et al*., 2000), auxin stimulates elongation and cellular differentiation of phloem and xylem, also favoring formation and development of floral organs (Davies, 2004), and gibberellin favors germination and growth by lengthening (Botelho *et al.*, 2001).

The agronomic efficiency of these plant growth regulators was confirmed by Bertolin *et al.* (2010), when applying this product to soybeans, these authors verified an increase in number of pods and, consequently, an increase in final productivity. In arracacha (Peruvian carrot), Reghin *et al.* (2000) testing different doses of this mixture of plant growth regulator verified a significant increase in number and length of roots, according to the increase of plant regulator concentration, up to the dose of 7.5 mL/L. In sweet pepper, Palangana *et al.* (2012), when testing different doses of this mixture, an increase of productivity, in grafted and ungrafted plants, was verified. Miguel *et al.* (2009) also observed an increase in production in sugar cane and Repke *et al.* (2009) in lettuce.

Several studies proved the agronomic efficiency of this mixture of plant growth regulators. However, no information on the effect of this application with cytokinin, auxin and gibberellin in physiological behavior and in productive traits of cabbage is available.

Considering the above-mentioned information, this study was performed to evaluate the effect of using plant growth regulators, cytokinin, auxin and gibberellin in physiological behavior and productive components of cabbage plants hybrid Fuyutoyo®, grown in a greenhouse.

MATERIAL AND METHODS

The experiment was carried out in a greenhouse, in Setor de Olericultura do Departamento de Agronomia da Universidade Estadual do Centro-Oeste, in Guarapuava, Paraná State, Brazil (25°38'S, 51°48'W, altitude 1100 m). The local climate is cfb type, according to Köppen classification (humid subtropical mesothermal), temperate, without defined dry season, with hot summer and moderate winter (Wrege *et al.*, 2011).

The authors used the cabbage hybrid Fuyutoyo, characterized by producing large heads of semi-flattened shape, showing good resistance to transport. The experimental design used in the experiment was of randomized blocks with four replications; each plot consisting of five plants. The treatments consisted of five doses of the mixture of plant growth regulators, using the commercial product *Stimulate*, containing 90 mg/L of kinetin, 50 mg/L of indolylbutyric acid (IBA) and 50 mg/L of GA_3: T1= 0 [control (H_2O)]; T2= 50; T3= 100; T4= 150; and T5= 200 mL p.c./100 L H_2O. In all spray applications, 0.05% of vegetable oil was added to syrup, according to the recommendation of the manufacturer.

The sowing of hybrid Fuyutoyo was carried out into polystyrene trays with 200 cells, containing commercial substrates (Mecplant) and grown in floating hydroponic system. In order to guarantee enough quantity of seedlings to the experiment, the seedlings were sown in the proportion of two seeds per cell, with subsequent thinning of the seedlings, 4-5 days after emergency, leaving one seedling per cell.

The seedling transplanting was carried out in May, 2014, when the plants showed 4-5 true leaves (25 days after emergency), into 10 L capacity pots, containing sieved soil and cattle manure at a ratio of 3:1. The compost containing sieved soil and cattle manure was corrected previously, according to the need pointed out by the soil chemical analysis, through application of calcitic limestone in order to raise the base saturation to 80% and keep 4:1 ratio between Ca and Mg. In order to carry out basic planting fertilization, the authors used 12 g of NPK in the formula 04-20-20 and 0.4 g of borax per pot. Drip irrigation was performed, according to the plant need, using micro-drippers.

In order to reduce weed infestation and to keep humidity, the authors covered the surface of the pots with 3 cm of decomposed wood. For phytosanitary control, the authors applied preventive sprayings, according to the manufacturer´s recommendations, using tiametoxam (Actara®) and copper oxychloride + mancozeb (Cuprozeb).

For the foliar spraying, which was carried out in the morning, the authors used costal sprayer, with constant pressure valve (Jacto), pressure of 2 kgf/cm^2, conical nozzle X2 (2/110), velocity of 1.05/ms, using a syrup volume of 240 L/ha. The authors used plastic curtains, at the moment of application of the doses, to avoid any product drift onto neighboring plots. The spray applications, which were carried out fortnightly, began when the plants showed 7-8 expanded leaves, totalizing five applications along the crop cycle.

The authors evaluated the water vapor exchange, through portable photosynthesis system (IRGA, Infrared Gas Analyzer, Li-cor, LI6400XT), with 1000 μmol photons/m^2/s, 400 μmol/mol of CO_2 and $\Delta CO_2 + \Delta H_20$ less than 1%, determining photosynthetic yield or liquid assimilation (*A*, μmol CO_2/m^2/s), internal CO_2 concentration (*Ci*, μmol/mol), stomatal conductance (*Gs*, mol CO_2/m^2/s) and transpiration rate (*E*, mmol H_2O/m^2/s). Evaluations were carried out using fully expanded leaves, external expansion, obtaining the measurements close to noon, five days after the third spray application. The efficiency of water use (*EUA*, mmol/H_2O) was estimated through ratio between CO_2 assimilation rate and transpiration rate (*A*/*E*).

Harvesting was carried out 84 days after transplanting, evaluating in laboratory, three center plants of each plot when the fresh mass of the "head" (MC) (kg/plant), determined by weighing the "head" on a digital scale. Diameter of "head" [vertical (DV) and horizontal (DH)] (cm), determined using a digital caliper both in vertical and horizontal directions. Number of commercial leaves (NF/plant), determined by the removal and counting of the "head" leaves. Firmness (N), determined using a digital penetrometer (Instrutherm DD-200) and a 8 mm diameter tip, compression exerted on two points of the central region of the head, with results expressed in Newton (N).

The data obtained were tested for normality and subsequently submitted to analysis of variance and regression, considering probability level of $p \leq 0,05$ by the F test, using computer program ASSISTAT version7.7, 2014 (Silva, 2014).

RESULTS AND DISCUSSION

The authors observed significant linear relationships ($p<0.05$) for doses of the mixture of plant growth regulators on the photosynthetic yield (*A*), intercellular CO_2 concentration (*Ci*), fresh mass of the "head" (MC), diameter of the "head" [vertical (DV) and horizontal (DH)], number of commercial leaves (NF) and firmness (N). For these traits, except for *Ci*, according to the increase of doses of the plant growth regulators, the authors observed an increasing linear adjustment of equation with determination coefficient ($R^2 \geq 0.67$). *Ci* was the only one which presented decreasing linearity, $R^2= 0.88$.

Photosynthetic yield (*A*), presented significant linear behavior, showing linear adjustment of the equation to the linear model, for the maximum dose evaluated, 200 mL, the highest *A*, showing 26 µmol $CO_2/m^2/s$. On the other hand, the control treatment showed the lowest *A*, 21.40 µmol CO/ m^2/s (Figure 1a).

Spray applications with cytokinin, auxin and gibberellin on cabbage promoted photosynthetic yield higher than the control treatment, 0.34; 1.49; 0.81; 4.81 µmol $CO_2/m^2/s$, respectively, for treatments 50; 100; 150; and 200 mL p.c./100 L H_2O (Figure 1a).

According to Fioreze & Rodrigues (2014), foliar sprays with plant growth regulators can promote changes in stomatal development, related to their quantity and size and can even collaborate to stomatal opening and closing, resulting in changes in gas exchange. These same authors verified in wheat, that the flag leaf transpiration rate increased significantly with foliar sprays using the mixture of plant growth regulators.

Intercellular CO_2 concentration (*Ci*) decreased linearly according to the increase of doses of plant growth regulators (Figure 1). Thus, the control treatment (zero dose), showed the highest *Ci*, 135.90 mol $CO_2/m^2/s$. On the other hand, dose at 200 mL p.c./100 L H_2O showed the lowest *Ci*, 112.90 µmol $CO_2/m^2/s$.

According to Machado *et al*. (2005), *Ci* consists of the null balance between the CO_2 entering and leaving the substomatal chamber and higher internal CO_2 concentration can contribute to obtaining high photosynthetic rates.

However, in this work higher photosynthetic yield (*A*) was inversely related to internal CO_2 concentration (*Ci*). The authors assume that lower CO_2 concentration in substomatal chamber of cabbage plants is related to a greater use of CO_2 by ribulose-1.5-bisphosphate carboxylase oxygenase (Rubisco) in the Calvin cycle, for the synthesis of P-trioses. Lower *Ci* in plants tends to stimulate the stomatal opening, allowing greater input of CO_2 to the stomatal spaces and, which, consequently, promotes higher photosynthetic yield, as the authors observed for the treatment with 200 mL p.c./100 L H_2O.

Dalastra *et al.* (2014), evaluating gas exchange indexes of melon cultivars conducted with one and two fruits, verified results similar to the ones found in this work for cultivar Sancho, 'Piel del Sapo', occurring simultaneously increase of *A* and reduction of *Ci*, when the plants were evaluated 56 days after transplanting.

Significant increasing linear adjustment, according to the one verified for photosynthetic yield (*A*), fresh mass of the "head" (MC), vertical diameter (DV) and horizontal diameter (DH) of the "head", number of commercial leaves (NF) and firmness (N) were also observed. The plants sprayed with the 200 mL mixture of plant growth regulators showed fresh mass of the "head" equal to 3.46 kg, values 21.76; 17.22; 7.09; and 5.92%, respectively higher to treatments 0; 50; 100; and 150 p.c./100 L H_2O (Figure 2a).

The authors could conclude that the increase of fresh mass of the "head" for

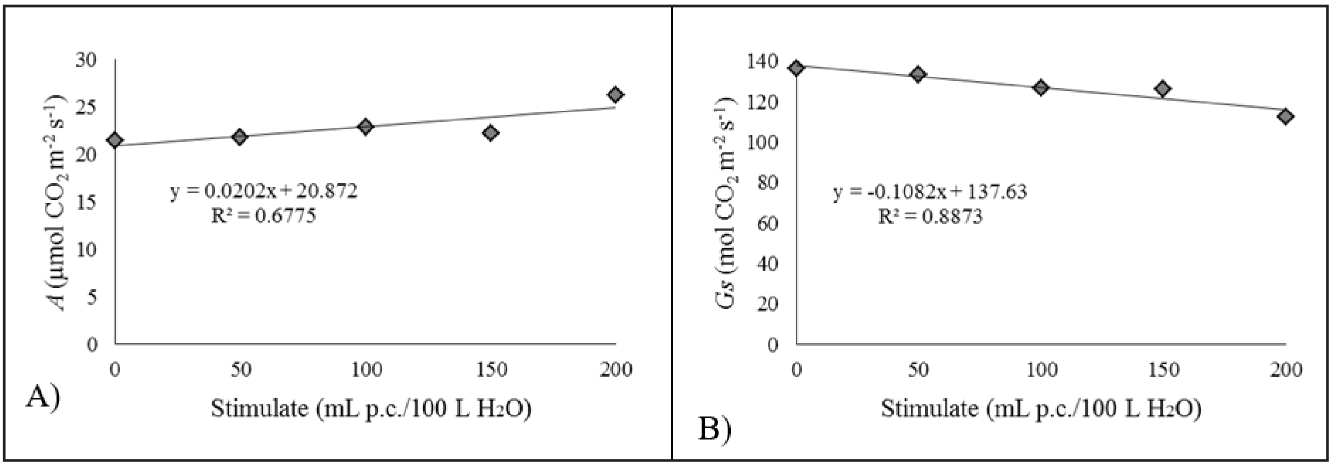

Figure 1. Intercellular CO_2 concentration (*Ci*) (1A) and photosynthetic yield (*A*) (1B) in cabbage plants hybrid Fuyutoyo (*A*) (1B) sprayed with different doses of the bioregulator *Stimulate*. Guarapuava, UNICENTRO, 2014.

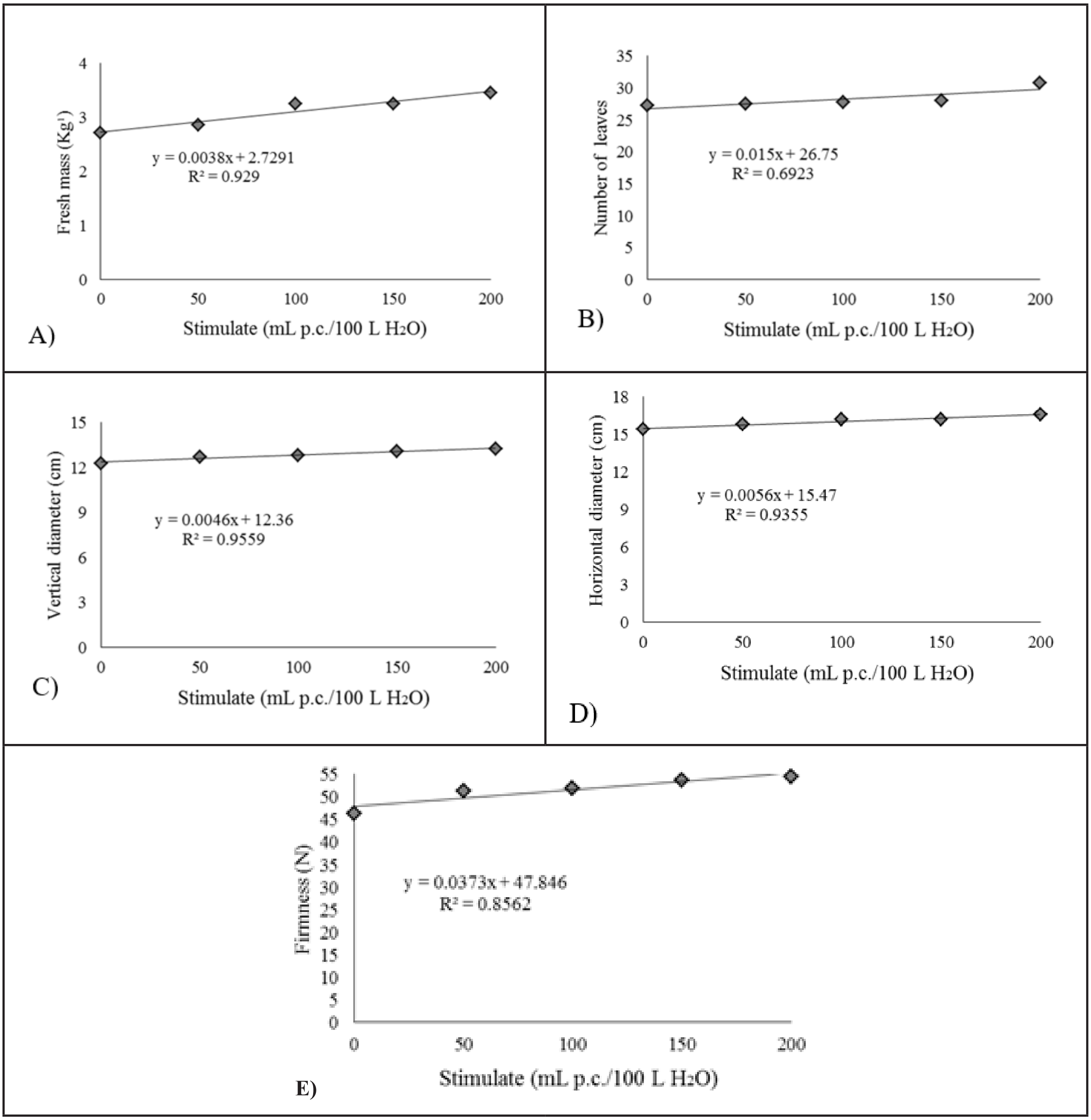

Figure 2. Fresh mass of "head" (MC) (A), number of commercial leaves (NF) (B), vertical diameter (DV) (C) and horizontal diameter (DH) (D) and firmness of the "head" (N) (E) in cabbage plants hybrid Fuyutoyo sprayed with different doses of the bioregulator *Stimulate*. Guarapuava, UNICENTRO, 2014.

a dose of 200 mL was due to a greater number of leaves and an increase in vertical diameter (DV) and horizontal diameter (DH). The treatment with 200 mL of the mixture of plant growth regulators provided values of 3.5; 3.25; 3; and 2.75 leaves, respectively, superior to treatments 0; 50; 100; and 150 p.c./100 L H_2O (Figure 2b). Similar behaviors were also verified for vertical diameter (DV) and horizontal diameter (DH) of the "head" (Figure 2c and 2d).

The authors could conclude that a greater number of leaves for the dose of 200 mL of the commercial product, consequently, provided higher vertical diameter (DV) and horizontal diameter (DH) of the "head". The dose of 200 mL also provided, cabbage "head" production with higher firmness (N), which can be considered the most important trait for cabbage production, with values of 8.13; 3.13; 2.52; and 0.73 N, respectively superior to treatments 0; 50; 100; and 150 mL p.c./100 L H_2O (Figure 2e).

The authors expect that "heads" with higher firmness show greater compactness and, consequently, greater resistance to cracking and transport, besides a longer post-harvest period. These traits meet the requirements of the Brazilian consumer market; these "heads" are called compact "heads" of cabbage (Lédo *et al.*, 2000).

No significant differences were observed for stomatal conductance (*Gs*), transpiration rate (*E*) and efficiency of water use (EUA), with average results of 0.52 mol $CO_2/m^2/s$; 11.08 mmol $H_2O/m^2/s$ and 2.07 mmol/H_2O, respectively.

Even showing no significant differences for stomatal conductance (*Gs*) in relation to doses of *Stimulate*, the average value of 0.52 mol $CO_2/m^2/s$, according to Beecka (2010), shows that for *Brassicas*, at the moment of gas exchange evaluation, the stomatal pores were completely open. This aspect allows the CO_2 input into intracellular spaces, favoring CO_2 liquid assimilation. The increasing of stomatal opening also promotes greater loss of water to the atmosphere, making the plant water potential more negative, which increases water uptake and can facilitate nutrient uptake in the rhizosphere (Machado & Lagôa, 1994).

The authors can consider, in this work, superior results for the productive components, when cabbage plants were sprayed with dose of 200 mL p.c./100 L H_2O, is due to an increase of photosynthetic yield (*A*), promoted by the treatment during plant development phase. This fact shows that the higher the *A* presented by cabbage plants, the greater photoassimilates production which will be directed to growth and development of reproductive organs, providing cabbage "heads" greater number of leaves, diameter and fresh mass.

According to Benincasa (2003), the vegetative development is extremely dependent on photosynthesis, being approximately 90% of the dry mass accumulated by the plants during their growth from photoassimilates, and only 10% from mineral nutrient uptake. The behavior correlated to photosynthetic yield and agronomic potential, for *Brassica*, was also verified by He *et al.* (2015), in *Brassica oleracea* var. *Alboglabra,* evaluating the effects of different combinations of red and blue films.

During photosynthesis, the plant uses solar energy to oxidize water and promote the reduction of carbon dioxide, resulting in release of oxygen, generating the production of carbon compounds, in particular sugars (trioses-P) which in the plant stimulate cellular metabolic pathways, being used as form of energy for the vital maintenance processes (Pereira, 1989; Taiz & Zeiger, 2013). Therefore, cabbage plants with higher photosynthetic yield (*A*) tend, consequently, to have higher production of carbon compounds, favoring growth and development.

Similar results to ones verified in this work, with spray application with the mixture of plant growth regulators, was verified by Palangana *et al.* (2012), also for the highest concentrations tested in ungrafted sweet peppers, in which spray applications of 125-150 mL p.c. /100 L H_2O promoted an increase in productivity. Superior results compared to the control treatment, with spray applications using plant growth regulators were also verified by Repke *et al.* (2009), in lettuce variety Verônica and head lettuce variety Lucy Brow, showing significant increases for the plant diameter. Bertolin *et al.* (2010) report that the mixture of cytokinin, auxin and gibberellin provided an increase in number of pods in soybeans and, consequently, an increase in final productivity. Reghin *et al.* (2000), in arracacha (Peruvian carrot), verified that the mixture of plant growth regulators provided an increase in number and length of roots.

An increase in the doses of this mixture of plant growth regulators provided bigger 'heads' and with greater fresh mass and firmness, however, wide enlargement of the "head" diameter may be undesirable. According to Moreira *et al.* (2011), when cabbage is directed to fresh consumption, the consumer market tends to prefer smaller and compact cabbage "heads". On the other hand, when cabbage is directed to industrial processing, no size standard for "heads" is required.

The doses of plant growth regulators when compared to the control treatment provided higher firmness for "heads" of cabbage, one desirable trait according to consumer market requirements. A significant increase in diameter, which is considered one undesirable trait, depending on the consumer market, was also observed. Considering these aspects, the authors recommend the producer when choosing the best dose of mixture of plant growth regulators (*Stimulate*) to take into account not only the agronomic efficiency but also consumer market requirements to which the product will be directed, where the size of the cabbage is important.

In relation to the productive components of the cabbage for fresh consumption, although the authors adjusted the equation to the linear model for the maximum dose of 200 mL p.c./100 L H_2O, aiming to avoid even bigger "heads", further studies in order to evaluate the agronomic efficiency of higher doses, from the ones tested in this work, are not necessary. On the other hand, when cabbage is directed to industrial processing, studies on agronomic efficiency of higher doses are important, considering the possibility of obtaining cabbage "heads" with higher fresh mass (post-harvesting) than the ones verified for the dose of 200 mL.

So far, no works on agronomic efficiency of the mixture of cytokinin, auxin and gibberellin, in the form of commercial product *Stimulate*, in cabbage is available. Thus, the authors could conclude that six spray applications of this mixture of plant growth regulators on cabbage plants hybrid *Fuyutoyo* promoted significant increases in plant photosynthetic potential and fresh mass, diameter, number of leaves and "head" firmness. In order to choose the best dose, the authors recommend to evaluate to which market segment will be directed the final product.

REFERENCES

BEECKA, MO; BOCKB, MD; VANDERMEIRENC, K; TEMMERMANC, L; CEULEMANSA, R. 2010. A comparison of two stomatal conductance models for ozone flux modelling using data from two *Brassica* species. *Environmental Pollution* 158: 251-3260.

BENINCASA, MMP. 2003. *Análise de*

crescimento de plantas: noções básicas. 2. ed. Jaboticabal: Funep. 41p.

BERTOLIN, DC; SÁ, ME; ARF, O; JUNIOR, EF; COLOMBO, AS; CARVALHO, FLBM. 2010. Aumento da produtividade de soja com a aplicação de bioestimulantes. *Bragantia* 69: 339-347.

BOTELHO, BA; PEREZ, SCJG. 2001. Estresse hídrico e reguladores de crescimento na germinação de sementes de canafístula. *Scientia Agrícola* 58: 43-49.

DALASTRA, GM; ECHER, MM; GUIMARÃES, VF; HACHMANN, TL; INAGAKI, AM. 2014. Trocas gasosas e produtividade de três cultivares de meloeiro conduzidas com um e dois frutos por planta. *Bragantia* 73: 365-371.

DAVIES, PJ (ed). 2004. Plant hormones. Biosynthesis, signa ltransduction, action. Dordrecht: *Kluwer Academic Publishers*. 750p.

FERREIRA, WR; RANAL, MA; FILGUEIRA, FAR. 2002. Fertilizantes e espaçamento entre plantas na produtividade da couve da malásia. *Horticultura Brasileira* 20: 635-640.

FIOREZE, SL; RODRIGUES, JD. 2014. Componentes produtivos do trigo afetados pela densidade de semeadura e aplicação de regulador vegetal. *Semina* 35: 39-53.

FISCHER, DLO; FACHINELLO, JC; ANTUNES, LEC; TIMM, CRF; GIACOBBO, CL. 2008. Enraizamento de estacas semilenhosas de mirtilo sob efeito de diferentes concentrações de ácido indolbutírico. *Revista Brasileira de Fruticultura* 30: 557-559.

HE, J: QIN, L; LIU, YM; CHOONG, TW. 2015. Photosynthetic capacities and productivity of indoor hydroponically grown *Brassica alboglabra* Bailey under different light sources. *American Journal of Plant Sciences* 6: 554-563.

JADOSKI, CJ; ONO, EO; RODRIGUES, JD; SANTOS, CM. 2011. Ação de reguladores vegetais, controle ambiental e armazenamento sobre parâmetros de conservação do pimentão em pós-colheita. *Pesquisa Aplicada & Agrotecnologia* 4: 99-110.

LÉDO, FJS; SOUZA, JA; SILVA, MR. 2000. Avaliação de cultivares e híbridos de repolho no Estado do Acre. *Horticultura Brasileira* 18: 138-140.

LUZ, FJF; SABOYA, RCC; PEREIRA, PRVS. 2002. *O cultivo do repolho em Roraima*. Boa Vista: Embrapa Roraima,17p. (Circular técnica, 7).

MACHADO, EC; LAGÔA, AMMA. 1994. Trocas gasosas e condutância estomática em três espécies de gramíneas. *Bragantia* 53: 141-149.

MACHADO, EC; SCHMIDT, PT; MEDINA, CL; RIBEIRO, RV. 2005. Respostas da fotossíntese a fatores ambientais em três espécies de citros. *Pesquisa Agropecuária Brasileira* 40: 1161-1170.

MIGUEL, FB; SILVA, JAA; BÁRBARO, IM; ESPERANCINI, MST; TICELLI, M; COSTA, AGF. 2009. Viabilidade econômica na utilização de um regulador vegetal em cana-planta. *Informações Econômicas* 39: 53-59.

MOREIRA, MA; VIDIGAL, SM; SEDIYAMA, MAN; SANTOS, MR. 2011. Crescimento e produção de repolho em função de doses de nitrogênio. *Horticultura Brasileira* 29: 117-121.

PALANGANA, FC; SILVA, ES; GOTO, R; ONO, EO. 2012. Ação conjunta de citocinina, giberelina e auxina em pimentão enxertado e não enxertado sob cultivo protegido. *Horticultura Brasileira* 30: 751-755.

PEREIRA, AR. 1989. Aspectos fisiológicos da produtividade vegetal. *Revista Brasileira de Fisiologia Vegetal* 1: 139-142.

REGHIN, MY; OTTO, RF; SILVA, JBC. 2000. “Stimulate Mo” e proteção com “Tecido-não-Tecido” no pré enraizamento de mudas de mandioquinha salsa. *Horticultura Brasileira* 18: 53-56.

REPKE, RA; VELOZO, MR; DOMINGUES, MCS; RODRIGUES, JD. 2009. Efeitos da aplicação de reguladores vegetais na cultura da Alface (*Lactuca sativa*) crespa var. Verônica e Americana var. Lucy Brow. *Nucleus* 6: 99-110.

SEGANTINI, DM; LEONEL, S; RIPARDO, AKS; AURICCHIO, MGR. 2011. Uso de reguladores de crescimento para a superação da dormência e sua influência na brotação, no florescimento e na produção da amoreira-preta. *Revista Brasileira de Fruticultura* 33: 275-280.

SILVA, FAS. *ASSISTAT: Versão 7.7 beta*. DEAG-CTRN-UFCG – Atualizado em 01 de abril de 2014. Disponível em <http://www.assistat.com/>. Acessado em 20 de maio de 2014.

SILVA, KS; SANTOS, ECM; BENETT, CGS; LARANJEIRA, LT; EBERHARDT NETO, E; COSTA, E. 2012. Produtividade e desenvolvimento de cultivares de repolho em função de doses de boro. *Horticultura Brasileira* 30: 520-525.

SILVA, LM; BASÍLIO, SA; SILVA JÚNIOR, RL; NASCIMENTO, MV; BENETT, CGS; BENETT, KSS. 2014. Aplicação de ácido bórico sobre as características produtivas do repolho em diferentes épocas. *Revista de Agricultura Neotropical* 1: 26-34.

TAIZ, L; ZEIGER, E. 2013. *Fisiologia vegetal*. 5ºed. Porto Alegre: Artmed. 918p.

WREGE, MS; STEINMETZ, S; REISSER JUNIOR, C; ALMEIDA, IR. 2011. *Atlas climático da Região Sul do Brasil: Estados do Paraná, Santa Catarina e Rio Grande do Sul*. 1. Pelotas: Embrapa Clima Temperado; Colombo: Embrapa Florestas, 336p.