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The accumulation of nitrogen, phosphorus and potassium in cut chrysanthemum (*Dendranthema grandiflorum*) cv. Jospithoven

Acúmulo de nitrogênio, fósforo e potássio em crisântemo de corte (*Dendranthema grandiflorum*) cv. Jospithoven

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Abstract

The objective of this study was to evaluate the accumulation of NPK in cut chrysanthemum, cv. Jospithoven, at different phenologic phases, in the summer. The experiment was carried out in greenhouse environment, in Goiás State, Brazil. The population density was 80 seedlings m^{-2}. The experimental design was completely randomized, with plots split in time, and four replications. The plant portion factor (stem, leaf, inflorescence and whole plant) was applied to plots, and the development phases (45, 60, 75, 90, 105, and 120 days) applied to sub-plots. The plant nutrition was 133 g m^{-2} of thermophosphate Yoorin and 150 g m^{-2} of fertilizer formula 5-25-15, which was added to the circulating nutritive solution of calcium nitrate (20 g m^{-2}), during all the evaluated period, alternated with potassium sulfate (30 g m^{-2}) and potassium nitrate (30 g m^{-2}), each fifteen days. It was concluded that NPK demand by chrysanthemum var. Jospithoven, during the growing cycle, ranges according to the plant age and the organ studied, having been more accentuatedin the leaves and 105 days after sowing.
Key words: Ornamental plant, macronutrients, fertilization

Resumo

O objetivo deste trabalho foi avaliar o acúmulo de NPK nos diferentes estádios fenológicos da cultura de crisântemo, cv. Jospithoven, no período de verão. O experimento foi desenvolvido em condições de ambiente protegido, no município de Santo Antônio de Goiás, GO. A densidade de plantio foi de 80 mudas m^{-2}. O delineamento experimental foi inteiramente casualizado, com parcelas subdivididas no tempo e quatro repetições. O fator aplicado nas parcelas foi representado pelas partes da planta (haste, folha, inflorescência e planta inteira) e aquele aplicado nas sub-parcelas, pelos estádios de seu desenvolvimento (45, 60, 75, 90, 105 e 120 dias de idade). A adubação de plantio foi de 133 g m^{-2} de Yorim, acrescidos de 150 g m^{-2} da formulação química 5-25-15, à qual foi adicionada uma solução nutritiva circulante de nitrato de cálcio (20 g m^{-2}) durante todo o período estudado, alternando-se sulfato de potássio (30 g m^{-2}) e nitrato de potássio (30 g m^{-2}), a cada quinze dias. Concluiu-se que a demanda de NPK pela cultura de crisântemo var. Jospithoven, durante o ciclo de crescimento, varia com a idade e com o órgão estudado, tendo sido mais acentuada nas folhas e aos 105 dias de idade da planta.
Palavras-chave: Planta ornamental, macronutrientes, adubação

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Introduction

Brazil has a great diversity of climate, with large areas under climatic conditions favorable to the chain production of flowers and ornamental plants and strategic marketing (BATISTA et al., 2008). Brazilian floriculture has been characterized as one of the most promisingsegments of the national intensive horticulture. The chrysanthemum (Dendranthema grandiflorum (Ram.) Tzvelev) stands out among the main national products of ornamental horticulture.

Considered easy plant to grow and the cycle of rapid growth, however, demanding in technology as the control of photoperiod to induce flowering. It has high durability of post-harvest as much as the flowers potted plant (BARBOSA, 2003; MAINARDI, BELLE; MAINARDI, 2004).

The plant's growth is affected by mineral nutrients due to a supply of assimilates. Since different vegetative organs work as a source or a drain, the knowledge about supply accumulation in each of these parts, during production cycle, it is important for the understanding and description of the march of accumulation. (TAIZ; ZEIGER, 2004). Therefore, the vegetal tissue can be made in many development stages of the plant, obtaining information about demand periods and different parts of the plant (MALAVOLTA, 1980).

Boodley and Mayer (1966) stated that there's a seasonal variation of amounts of N, P, K, Ca and Mg in chrysanthemum plants. Fernandes (2006) noticed a bigger concentration of K, Ca, and Mg was found in cut chrysanthemum, and N, P and S inflorescence during the winter. On the other hand, during the summer, the biggest foliar concentration found was of K and N; also P, Ca, Mg and S were found in inflorescences.

Stringheta et al. (2004) stated that chrysanthemum presents high demands for N and K during the first six weeks of growth. Gonzalez and Bertsch (1989), in experiments conducted in Costa Rica, verified that those were the nutrients mostly demanded by chrysanthemum and were even found in quantities three times greater than Ca, P and Mg.

Boodley (1975) stated that during the flowering stage, since the floral induction until the opening, the K is the most required nutrient. At the final cultivation stage, there's an increase of the plants demand for P, with a likely beneficial effect from nutrient in the final size of inflorescences.

The difficulty in implementing crop of chrysanthemums is to quantify the doses of fertilizers to be applied as the nutritional needs of the culture. In general, the producers use an unbalanced dose, which interferes with the production potential and the plant longevity (FERNANDES et al., 2008).

Of particular interest to diagnose and determine the mineral composition of plants is the fact that the various bodies respond differently to variations in the concentrations of nutrients in the substrate. The analysis of the whole plant by combining organs showing little or no change in composition to those that respond to marked changes in the levels of nutrients in the substrate often can mask the effect of addition of nutrients (JONES JUNIOR et al., 1991).

This work has as the main objective to study the march of nitrogen accumulation, phospofurum, and potassium in chrysanthemum (*Dendranthema grandiflorum* cv. Josithoven), due to the development stage of the plant, in the summer.

Material and Methodology

The experiment was developed in a protected environment condition, in the period from October to January, herein called summer period, in a commercial property located in the city of Santo Antonio de Goiás, GO. The property is located under the latitude of 16° 29´ 20” S, and longitude 49° 18’ 39” W and 823 m of altitude. The local climate, according to Kappen International System, is classified as tropical rainy (Aw).

The Josithoven cut chrisanthemum's cv presents inflorescence of Capitulum type, in white and pink colors. The speed of reaction to flowering of this co takes eight weeks (inductive period between the beginning of short days and the harvest point).

The experimental design was fully randomized, with plots subdivided in time within four repetitions. The treatments were arranged in a 4 X 6 factorial scheme, in which consisted in parts of the plant considered plots (leaf, stem, inflorescence and whole plant), combined in six phenologigal stages of culture (45, 60, 75, 90, 105 an 120 days after the transplantation) considered subplots.

The whole plant was constituted by leaf samples, stem and chrysanthemum plants inflorescence. The apical cuttings, of 30 days old, enrooted and already treated by hormones (AIB), of 1500 ppm concentration, were transplanted to beds of 1.40m large, 30 m long and 0.15 m high. The spacing between beds was of 0.60 m, therefore the plantation density of 80 seedlings m^{-2}, reaching an amount of 336 seedlings per bed. The fertilization of base was distributed among beds, 133 g m^{-2} of Yoorin (18 % P_2O_5, 18 % Ca, 7 % Mg and 10 % Si) added to 150 g m^{-2} of NPK 05-25-15 formulation. Additional fertilization through micronutrients source was not performed.

The culture fertigation was performed through dripping form fifteen days after plantation, with calcium nitrate (20 g m^{-2}) during all the period studied, alternating every fifteen days, potassium sulfate application (30 g m^{-2}) and potassium nitrate (30 g m^{-2}) until the end of the cycle. Irrigation was done daily through sprinkling, in the first plantation week, and dripping system until the end of the culture cycle. During the first 25 days after transplantation, the seedlings were submitted to treatment of long days, to enhance vegetative growth, with artificial lighting, applied from 10 PM to 2 AM, within fifteen minutes periods of light, followed by fifteen minutes of dark, receiving four hours of night lighting. For this purpose, 60 W lamps, at 1.20 high, spacing 1.37 among themselves were used.

When the plants reached from 25 cm to 30 cm high, the artificial lighting was suspended. Due to longer days in the summer, it was necessary to resort to dark system, to stimulate the blooming, which consisted in the use of black plastic curtains, installed at 1.80 m high. The darkening was done between 5 PM and 7 AM of the following day, reaching 14 hours of dark.

The plants were harvested every fifteen days, according to the different development stages of culture, and they were evaluated according to the quality standard established by the market. The first one occurred forty-five days after the transplantation, with twenty plants per treatment, coming up to six collections at the end of the production cycle. The variant studied was the accumulation of N, P and K, in the leaves, stem, inflorescences, and in the chrysanthemum plant in six phonological stages. The final samples were forwarded to soil and leaf analyses Laboratory of Universidade Federal de Goiás (LASF-EA/UFG).

The plant tissue samples were submitted to washing, wit distilled and deionzed water after the collection and they were separated in leaves, stems, inflorescence and whole plant, being packaged in paper bags and stowed in a greenhouse forced air circulation, under a temperature between 65 °C and 70 °C, for 48 hours, so being weighed afterwards. The amount of each sample was milled in a Willey type mill.

The samples were submitted to nitroperchloric and sulfuric digestion to obtain the extracts and analyses of tissues. The contents of K were determined by photometry of flame emission and the ones of P and N, by spectrophotometry. All the analytical procedures employed used the methodology proposed by Malavolta, Vitti and Oliveira (1997).

The data was submitted to analyses of variance using the SAS program. The test of significance F was used to the level of 1 % and 5 % of probability and the averages were compared by the Turkey's test, also at the level of 5 % of probability.

The type of regression that best represented the accumulation of nutrients due to the culture's phonological stages was determined. It was used as a statistic criterion for the types selected, test F of the variance analyses and the determination's coefficient (R^2).

Results and Discussion

The accumulation of NPK on the aerial part of cv. Josithoven increased until the 105 days of plant's development. The leaves and stems showed decrease after the emission of inflorescence (Table 1). K and N were the most demanded nutrients to be present six times greater than P.

Table 1. Accumulation of nitrogen, potassium in dry matter of the chrysanthemum's plant, cv Jospithoven, according to phonological stages of the culture in the summer.

Stages (Days)	Leaf	Stem	Inflorescence	Aerial part
		N (dag kg^{-1} MS)		
45	1,33 D[1]a[2]	0,35 Bb	0,00 Cb	1,69 Ba
60	2,08 CDa	0,71 Bb	0,00 Cb	2,79 Ba
75	4,37 BCb	2,31 Abc	0,00 Cd	6,69 Ba
90	5,85 Bab	2,69 ABbc	0,00 Cc	8,56 ABa
105	9,46 Ab	5,47 Abc	0,84 Bc	15,70 Aa
120	4,81 BCb	3,57 ABc	3,05 Ac	11,43 Aa
Test F	22,69**	3,42**	75,81**	11,34**
C.V. (%)	26,24	80,95	43,33	46,63
		P (dag kg^{-1} MS)		
45	0,20 Db	0,07 Bc	0,00 Cd	0,27 Da
60	0,32 CDb	0,14 Bc	0,00 Cd	0,46 CDa
75	0,60 BCc	0,57 Bb	0,00 Cb	1,18 BCa
90	0,77 Bb	0,53 Bb	0,00 Cc	1,31 Ba
105	1,23 Ab	1,93 Ab	0,27 Bc	3,42 Aa
120	0,62 Bb	0,60 Bb	0,65 Ab	1,87 Ba
Test F	32,36**	30,29**	59,01**	44,18**
C.V. (%)	20,32	38,08	45,07	28,29
		K (dag kg^{-1} MS)		
45	2,19 Ca	0,64 Db	0,00 Bb	2,83 Da
60	2,97 Cab	1,60 CDbc	0,00 Bc	4,57 CDa
75	8,17 BCb	5,20 BCc	0,00 Bd	13,38 BCa
90	13,72 ABab	6,96 Bbc	0,00 Bc	20,73 Ba
105	16,36 Ab	21,01 Ab	0,59 Bc	37,80 Aa
120	11,75 ABb	6,93 Bc	4,80 Ac	23,48 Ba
Test F	15,26**	70,52**	11,22**	51,35**
C.V. (%)	32,2	24,74	127,81	25,01

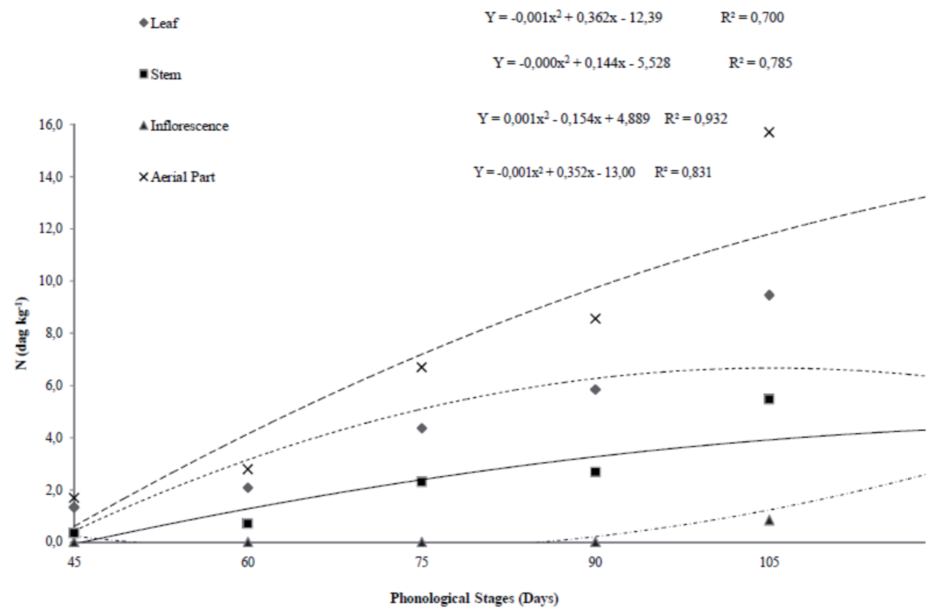
1- Averages followed by the same letter, in the column, don´t statistically differ among themselves, according to the Test of Turkey, in a level of 5 % probability.
2- Averages followed by the same letter, in line (among organs), don't statistically differ among themselves, according to the test of Turkey, in a level of 5 % probability.
(**significant values of 1 % probability).
Source: Elaboration of the authors.

The total accumulation of NPK in the plant, at 120 days, at the aerial part of cultivate presents the following decreasing sequence: K (23.48 dag kg^{-1}) > N (11.43 dag kg^{-1}) > P (1.87 dag kg^{-1}). In terms of concentration of NPK, the whole plant presented the same tendency of organs in it, there being a continuous decrease, with significant differences, at 105 and 120 days of age (Table 1).

The reduction in nutrients concentration of the plant occurred because of the effect of dilution, cause by the increase of dry mass production, which was also observed by Fernandes et al. (2008). In general, through the plant's development, the nutrients absorption decreases, this is known as dilution effect (CAMARGO, 2001). Visible symptoms of nutrients deficiency or excess during cultivation were not observed.

The demand of N varies among the different stages of plant development at cv. Josithoven, they are minimal at initial stages, increasing with elevation of the growth rate and reaching its peak during the period corresponding to the beginning of flowering at 105 days (Figure 1). According to Woodson and Boodley (1983), chrysanthemum presents high requirements of N, mainly, during its vegetative period, as the leaves, stem and rods the regions where it's accumulated and then translocated to the inflorescence development.

Figure 1. March of accumulation of nitrogen in the dry leaves of chrysanthemum cv. Jospithoven, depending on the different growth stages in the summer.



Source: Elaboration of the authors.

The leaves, in all stages observed, showed a greater accumulation of N than the other parts of the plant. There was an application of N during all the period of the plant's development. According to Lunt and Kolfranek (1958), it's necessary to maintain high levels of N during the initial stages of chrysanthemum growth, because the deficiencies of this element after this period can't be corrected, so causing losses to the plant metabolism and, consequently, a reduction of final quality of inflorescences.

N is a mobile nutrient in the phloem and promptly redistributed within the plant. The concentration of

N varied due to the age of the plant and the organ observed. In the leaves and rods a reduction of nutrient concentration at the end of the cycle of 50 % and 35 % occurred, respectively, due to a mobilization for inflorescence growth.

Nitrogen concentration in leaves was higher than in stems during the development cycle of the plant, and that, at 120 days, approximately, 42 % of N was found in leaves, 31 % in rods, and 27 % in inflorescences, which is in accordance with Malavolta (1980), who suggests that production (inflorescence) represents 20 % to 30 % of total nutrient contained in the whole plant.

In cut chrysanthemum leaves, the total accumulation of N found to cv Josithoven was of 4.81 dag kg^{-1} at 120 days, in which is within the parameters presented by Tombolato et al. (1996), which suggests from 4.0 to 6.0 dag kg^{-1} as average content of N in chrysanthemum leaves. This result differs from the ones found by Barbosa et al. (2009), which evaluating the concentration of N in chrysanthemum leaves, cv. Dark Flamengo, Calabria and Blush Hawai, cultivated in hydroponic system, found average values of 3.82 dag kg^{-1} to total N.

In the rods, the accumulation of N grew according to the plant's age, with a greater accumulation at 105 days (5.47 dag kg^{-1}). The average amount accumulated at 120 days was of 3.57 dag kg^{-1}, which is superior to the value observed by Lima and Haag (1989), who found a concentration of N in the rods of 1.25 dag kg^{-1} to a Golden Polaris cv.

Before flower buds appear, the plants of Josithoven's cv had accumulated 54.52% of total N, corresponding to 8.56 dag kg^{-1}. After the inflorescence emission (105 days) the accumulation of N was the greatest observed in the plant (15.70 dag kg^{-1}). The N accumulated in the inflorescence exceeded 0.84 dag kg^{-1} at 105 days, to 3.05 dag kg^{-1} at 120 days. The accumulation of N in the leaves, at the initial stages of cultivation easily move to other growing parts, being mobilized in ripened leaves and moving again to new organs in development with the inflorescences (MARSCHNER, 2005).

It was found that P was the nutrient demanded in smaller quantities by the plant, according to Malavolta (1980), the P is an anionic macronutrient less demanded by cultivations than N. The maximum of P accumulation in the plant happened at 105 days (3.42 dag kg^{-1}), being the accumulation in the plant at the end of the cycle of 1.87 dag kg^{-1} (Table 1). The provision of P happened during transplantation (vegetative phase), therefore, according to Marcolan (2011), the fertilization in small quantities of soil tends to favor the absorption of P at initial stages of the plant's growing when the absorption rate is greater.

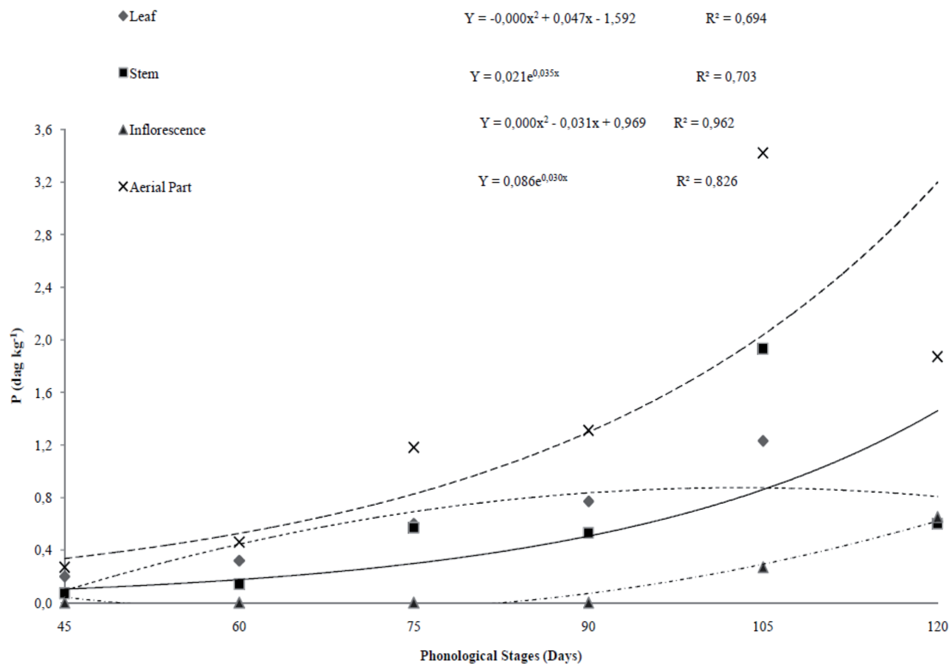
The accumulation of P, such as in leaves as in stems, varied according to the plant's age. The greater accumulation happened at 105 days in the leaves (1.23 dag kg^{-1}) and I stems (1.93 dag kg^{-1}), followed by a reduction of nutrient contents until the end of the cycle, as of 50 % and 31 % respectively, it was a similar behavior noticed in the other nutrients.

The accumulation of P in leaves at 120 days was of 0.62 dag kg^{-1}, which differs from the one observed by Barbosa et al. (2009), who had worked with six cultivate. Of cut chrysanthemum an observed the average value of 0.27 dag kg^{-1}, but it's within Tombolato et al. (1996) parameter, which suggested from 0.25 to 1.0 dag kg^{-1} of P in chrysanthemum leaves.

The accumulated amount of P in stems tended to an increasing accumulation of nutrients and reached maximum values of 0.60 dag kg at the end of the cycle. At Table 1 it can be verified that the stem didn't show similar concentration during the culture cycle. At the end of the cycle, leaves, stems and inflorescence didn´t show significant differences of P accumulation.

There was a sharp increase of P in the inflorescence, from 105 days to 120 days, interval corresponding to the period of intense flowering (Figure 2). At the end of the cycle, an accumulation of the element with a maximum value of 0.65 dag kg^{-1} was observed, this might be understood due to occurrence of translocation of a considerable amount of P in the leaves and stems to reproductive organs, which can be redistributed, as via phloem as via xylem (MENGEL; KIRBY 1987).

Figure 2. March of phosphorus accumulation in the dry leaves of chrysanthemum cv. Jospithoven, depending on the different growth stages in the summer.



Source: Elaboration of the authors.

The values obtained from P in the plant (1.87 dag kg^{-1}) are better than the ones reported by Barbosa et al. (2005), which evaluated the application of different concentrations of NO_3^- and NH_4^+, they found, for the varieties Coral Charm, Fine Time and Puritan, contents of 0.67 dag kg^{-1}, 0.83 dag kg^{-1} and 0.87 dag kg^{-1} of P. They were also better than the ones found by Lima (1987) and Barbosa et al. (1999), which obtained values of 0.24 dag kg^{-1} and 0.28 dag kg^{-1}, respectively. Both had worked with varieties of cut in hydroponics.

The behavior of K followed the plant's growing tendency, gradually increasing through the cultivation cycle, since it's related to important physiological process of plants. Mora Solis et al. (1982) related that the accumulation of nutrients followed dry matter production, which is slow in the beginning and fast from the development and production of flowers.

At the end of the cycle, the parts of the plant showed values of accumulation of P with differences statistically significant (Table 1). The total accumulation of K had its maximum when the inflorescences appeared, according to Faquin (2001), K is important to the development of chrysanthemum in the first six weeks of cultivation, when the plants grow quickly. It's also important when the flowering period approaches, since the formation of the buds until the time of inflorescence color formation.

The fertilization with K was done in plants in the two stages of development, vegetative and reproductive. The maximum accumulation of

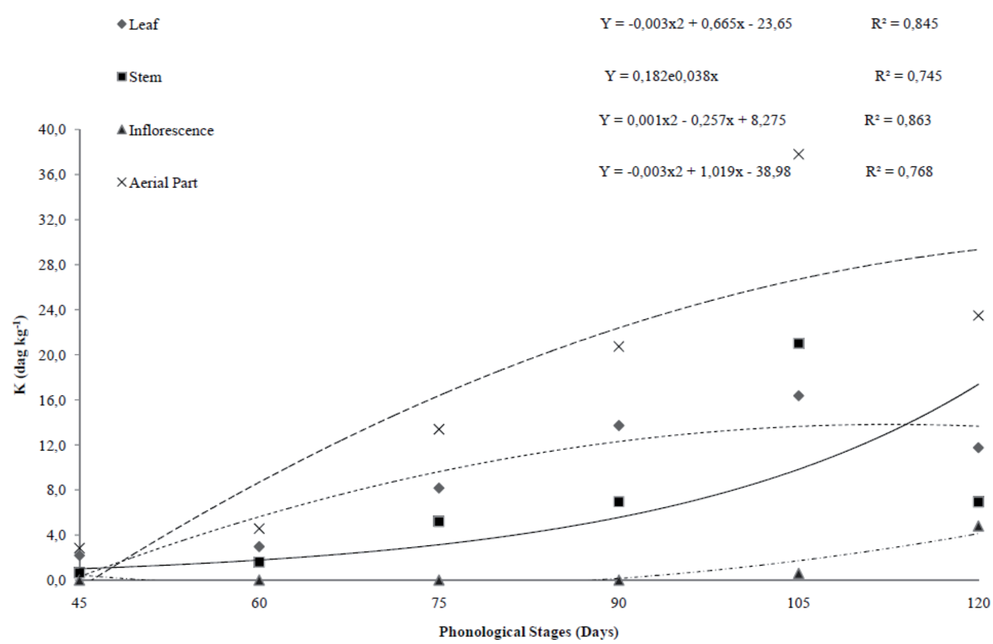
K occurred at 105 days (37.80 dag kg^{-1}), and the accumulation in the plant at the end of the cycle was of 23.48 dag kg^{-1} (Table 1). The accumulation of K, both in the plants and the stems, varied according to the plant's age, which is a similar behavior observed in N and P.

Tombolato et al. (1996) suggests 4.0 and 6.0 dag kg^{-1} K in chrysanthemum leaves. The concentration of K observed was above the suggested range, with values of 11.75 dag kg^{-1} in leaves at the end of the cycle. Barbosa et al. (2009) reports an average concentration of K in leaves of 2.97 dag kg^{-1}. The leaves became responsible for accumulating the K absorbed in excess by the plant; it was the organ that most accumulated this nutrient.

In the stems, the accumulation of K at 120 days was of 6.93 dag kg^{-1}, which is better than the one found by Lima and Haag (1989), it was of 2.24 dag kg^{-1}. Gruszynski (2001) describes that this element is closely linked to the number of stems and consequently to the final number of inflorescences. At 105 days, the accumulation of K in stems was of 21.01 dag kg^{-1}, with pronounced reduction after the total development of inflorescence at the end of the cycle (6.93 dag kg^{-1}).

In inflorescences, the accumulation of K was slow, showing an accentuated increase at the end of production cycle. The maximum accumulated value of K was of 4.8 dag kg^{-1} at the end of the cycle. The absorption curve of cv. Jospithoven showed a peak at 105 days, for all the parts of the plant followed by a reduction of this nutrient until the end of the cycle (Figure 3). Despite the high concentrations of K in the whole cycle, symptoms of toxicity in leaves were not found.

Figure 3. March of potassium accumulation in the dry leaves of chrysanthemum cv. Jospithoven, depending on the different growth stages in the summer.



Source: Elaboration of the authors.

Conclusion

The demand for nutrients follows the plant's growing curve.

The biggest demand for nutrients happened with the inflorescence emission.

The nutrients accumulate in the following order: K > N> P. The accumulation in parts of the plant obeys the following sequence: leaf > stem> inflorescence.

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