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CHRYSANTHEMUM AND GAILLARDIA AS STUNTED WINTER ANNUALS
II. BLANKETFLOWER (*GAILLARDIA PULCHELLA* FOUG.)

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ABSTRACT: Blanketflower (*Gaillardia pulchella* Foug.) is a tall herbaceous annual (more than 1 m long), usually subjects to slanting if it was grow alone in pot. So, the present investigation was carried out at Orman Botanical Garden, Giza, Egypt during the seasons of 2012/2013 and 2013/2014 in order to reduce its tall and branched stem by spraying the foliage with the aqueous solution of either paclobutrazol (PP-333) at 0, 50 and 100 ppm or cycocel (CCC) at 0, 1000 and 2000 ppm concentrations, two times with 3 weeks interval, and to study the effect of these treatments on flowering and chemical composition of 75-days-old seedlings of such winter annual when grown in 15-cm-diameter plastic pots filled with about 1.5kg of an equal mixture of sand and clay (1:1, v/v).

The obtained results indicated that both PP-333 and CCC at various concentrations significantly decreased all vegetative and root growth criteria, with few exceptions compared to control in the two seasons. The low level of PP-333 caused about 20% reduction in height and branching of treated plants giving plants near at its size to those of control ones. On the contrary, the high level of CCC (2000 ppm) excessively decreased these parameters to more than 65% compared to control treatment, and that was accompanied with reducing root length to less than 10 cm in both seasons. However, the most appropriate size wherefrom height, branching and number of leaves was gained from applying either PP-333 at 100 ppm or CCC at 1000 ppm, with the preference 100 ppm PP-333 treatment which resulted the most suitable plant size in harmony with the pot size.

The flowering was delayed due to all the used treatments, but delaying by CCC treatments was more than that by PP-333 ones (about 7-9 days against only 4-5 days, respectively). All other flowering characters were significantly decreased by the different levels of growth retardants used in this work in most cases of both seasons, except for the two rates of PP-333 which were raised inflorescence diameter and number of ray florets/inflorescence, with the superiority of PP-333 at 100 ppm treatment, as it gave the widest inflorescence with the utmost high number of ray florets per inflorescence at all. This treatment also resulted the shortest stalk length which was useful in restricting flower head nutation phenomenon in this plant. Paclobutrazol at any rate markedly increased chlorophyll a and b, carotenoids, total soluble sugars, total indoles and total phenols content in the leaves, whereas CCC treatments decreased content of these constituents with the exception of total phenols content that was greatly increased.

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From the previous results, it is recommended to spray the foliage of 75-days-old seedlings of *Gaillardia pulchella* winter annual plant with PP-333 at 100 ppm level, twice with 3 weeks interval for production of petit, dwarfed, flowering-pot-plant from commercial point of view.

Key words: *Gaillardia pulchella*, Blanket flower, vegetative growth, flowering, dwarfing, flowering-pot-winter annual, PP-333, CCC.

INTRODUCTION

Gaillardia pulchella Foug, Blanketflower (Fam. Asteraceae "Compositae") is an annual 3 ft. or more; lower leaves oblanceolate to spatulate, to 5-6 inch long, toothed or pinnately lobed, sessile or short-petioled, upper leaves oblong or oblanceolate, usually entire, sessile; heads 2 inch across, long peduncled, involucral bracts green with short papery base; disc flowers yellow or with red tips, the lobes long-acuminate, ray flowers red, tipped with yellow or entirely yellow or red. Gaillardias grow best in light, open, well-drained soils and full sunlight. They are favorites for cut flowers and propagated by seeds (Bailey, 1976).

Until now, a huge number of consumers and amateurs are fond of dwarfed ornamentals to use them for beautifying their balconies, terraces and petit gardens. So, trials are still continuous to produce new and unique specimens suitable for these purposes. Among of these trials, that of Hugar and Nalawadi (1999) who reported that CCC at 750 ppm reduced height of *Gaillardia pulchella* cv. Picta plants, but produced a higher flowers yield than the control due to increasing flowers number/plant and the weight of 10 flowers.

On the other ornamentals, Dasoju *et al.* (1998) remarked that leaves of potted sunflower plants treated with PP-333 at 16 or 32 mg/pot were smaller and greener than those of control. Barett *et al.* (2003) revealed that uniconazole application as a spray to the surface of media prior to planting at the level of 200 ml/m^2 decreased plant height and flower number of *Petunia hybrida* and *Catharanthus roseus* plants. On *Rudbeckia hirta*, Shahin *et al.* (2006) observed that spraying the foliage with CCC at 2000 ppm rate gave the best dwarfing effect on shoot and root growth. The flowering was delayed and flower heads number/plant, flower head diameter, flowering stalk length and period of flowering were decreased. Furthermore, total indoles content in the leaves was cumulatively decreased with increasing CCC level, while total phenols content was increased. Pigments content (chlorophyll a, b and carotenoids) in the leaves, as well as total carbohydrates, N and K content in the leaves and roots were linearly decreased with rising CCC rate, while P content showed a slight increment. Similarly, were those results indicated by Criley (2000) on rhododendron, Li (2013) on *Achillea* "Coronation Gold" and *Coreopsis verticillata* "Moonbeam", Baloch *et al.* (2013) on snapdragon cv. Coronette, petunia cv. Dreams and annual verbena cv. Obsession and Pethybridge *et al.* (2014) on pyrethrum.

This study, however aims to produce a high quality and medium-sized flowering pot plants of gaillardia for decoration of sunny terraces, verandah and any other open field.

MATERIALS AND METHODS

A pot experiment was carried out at Orman Botanical Garden, Giza, Egypt during the two consecutive seasons of 2012/2013 and 2013/2014 to study the response of Blanketflower to foliar spraying with pacloburazol and cycocel at the different concentrations, and to detect the most suitable treatment for production of a miniature and picturesque specimen from such plant in an appropriate size.

Therefore, seeds of *Gaillardia pulchella* Foug. (obtained from Orman Botanical Garden, Giza, Egypt) were sown in nursery

bed on mid of September for the two seasons. After 75 days from sowing (on December, 1st), the produced seedlings with 8-10 leaves were transplanted into 15-cm-diameter plastic pots (one seedling/pot) filled with about 1.5 kg of sand + clay mixture at equal parts by volume (1:1, v/v). Some physical and chemical properties of the used sand and clay soils in both seasons are shown in Table (a).

The pots were arranged in the open field under the full sun in a complete randomized design (Das and Giri, 1986) for the two seasons, with 3 replicates, as each replicate contained 5 plants. All plants were fertilized with 2 g/pot of kristalon fertilizer (19:19:19 + micronutrients, manufactured by DSM Agrospecialists, Holland), twice, as the first batch drenched in the pot mixture 3 weeks after transplanting, while the second one was added 3 weeks after the first. Three weeks later (on January, 31st), the plants received the following treatments as a foliar spray till the solution was run-off, 2 times with 3 weeks interval:

1- No treatment, as the foliage was sprayed with a tap water, referred to as control.
2- Paclobutrazol (PP-333) at the concentrations of 50 and 100 ppm as an aqueous solution.
3- Cycocel (CCC) at the concentrations of 1000 and 2000 ppm, also as an aqueous solution.

During the course of this study, all agricultural practices needed for such plantation were carried out. At the end of each season (on March, 30th), data were recorded as follows: plant height (cm), stem diameter at the base (cm), branch number/plant, leaf number/plant, leaf length (cm), root length (cm) as well as fresh and dry weights of top growth and roots (g). Furthermore, number of days from transplanting to the first inflorescence opening (day), number of inflorescences/plant, inflorescence stalk length (cm), inflorescence diameter (cm), number of petals (ray florets)/inflorescence and fresh and dry weights of inflorescence (g). In fresh leaf samples taken from the middle parts of the plants after the second spray by 10 days in the only 2nd season, photosynthetic pigments (chlorophyll a, b and carotenoids, mg/g F.W.) were determined according to the method of Moran (1982), total soluble sugars content as g/100 g F.W. (Dubois *et al.*, 1966), total indoles (A.O.A.C., 1980) and total phenols (William *et al.*, 1965) as ppm were also measured.

Data were then tabulated and subjected to analysis of variance using SAS Institute Program (1994) and Duncan's Multiple Range Test (Duncan, 1955) was employed to test the significancy among the means of various treatments.

RESULTS AND DISCUSSION

Effect of paclobutrazol and cycocel treatments on:

1-Vegetative and root growth parameters:

Data presented in Tables (1 and 2) show that both PP-333 and CCC at the various levels significantly decreased all vegetative and root growth measurements, with few exceptions relative to control in the two seasons. The low level of PP-333 (50 ppm) only caused about 20% reduction in height and branching giving plants near at its size to those of control ones, whereas the high level of CCC (2000 ppm) greatly reduced these parameters to more than 65% reduction, and that was coupled with reducing root length to less than 10 cm in both seasons. So, the produced plants were more compressed. On the other side, PP-333 at 100 ppm and CCC at 1000 ppm gave the most appropriate size wherefrom height, branching and number of leaves, with the preference of the former treatment (100 ppm PP-333) which gave the most suitable plant size going with the pot size (Photo, 1). It was noticed that control plants were falling because of their longer stems, more leaves and heavier weight, but the opposite was the right regarding the dwarfed plants which were less tall, branching and weight.

Table a. Physical and chemical analysis of the used soils in the two seasons.

Soil type	Particle size distribution (%)				S.P.	E.C. (dS/m)	pH	Cations (meq/L)				Anions (meq/L)		
	Coarse sand	Fine sand	Silt	Clay				Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^{-}	Cl^{-}	SO_4^{--}
Clay	7.46	16.75	34.53	40.89	41.76	2.18	8.33	16.93	9.33	20.44	0.37	3.82	1.46	41.79
Sand	18.72	71.28	4.76	5.34	21.83	1.58	8.20	2.65	2.48	21.87	0.78	3.85	13.00	10.93

Table 1. Effect of paclobutrazol and cycocel concentrations on some vegetative and root growth traits of *Gaillardia pulchella* Foug. plants during 2012/2013 and 2013/2014 seasons.

Growth retardants concentration	Plant height (cm)	Stem diameter (cm)	Branch No. per plant	Leaf No. per plant	Leaf length (cm)	Root length (cm)
First season: 2012/13						
Control	99.78a	0.93a	8.00a	136.00a	19.07a	28.73b
PP-333 at 50 ppm	79.86b	0.86b	6.53b	108.00b	15.10b	32.00a
PP-333 at 100 ppm	60.72c	0.80b	5.00c	76.38c	13.36c	27.50b
CCC at 1000 ppm	43.50d	0.63c	4.00d	44.00d	12.10cd	18.00c
CCC at 2000 ppm	34.10e	0.51d	3.00e	35.00e	10.33d	9.33d
Second season: 2013/14						
Control	102.33a	0.95a	9.00a	138.33a	20.40a	32.00a
PP-333 at 50 ppm	85.60b	0.87b	7.33b	102.76b	16.31b	28.67b
PP-333 at 100 ppm	65.18c	0.86b	5.00c	80.90c	15.25c	28.76b
CCC at 1000 ppm	42.10d	0.70c	3.33d	42.00d	12.60cd	19.33c
CCC at 2000 ppm	33.62e	0.50d	2.56d	36.10e	9.78d	8.39d

*** Means within a column having the same letters are not significantly different according to Duncan's Multiple Range Test at 5% confidence level.**

Table 2. Effect of paclobutrazol and cycocel concentrations on top growth and root fresh and dry weights of *Gaillardia pulchella* Foug. plants during 2012/2013 and 2013/2014 seasons.

Growth retardants concentration	Fresh weight (g)		Dry weight (g)	
	Top growth	Roots	Top growth	Roots
First season: 2012/13				
Control	144.38a	3.18a	18.54a	1.25a
PP-333 at 50 ppm	113.47b	2.56b	13.87b	1.01b
PP-333 at 100 ppm	46.72d	2.49b	7.18c	0.98b
CCC at 1000 ppm	61.90c	1.36c	7.00c	0.58c
CCC at 2000 ppm	40.58e	1.05c	6.10d	0.42c
Second season: 2013/14				
Control	147.65a	3.55a	18.98a	1.40a
PP-333 at 50 ppm	108.96b	3.10ab	12.33b	1.23b
PP-333 at 100 ppm	47.84d	3.20ab	7.42c	1.30a
CCC at 1000 ppm	59.73c	1.51b	8.16c	0.61c
CCC at 2000 ppm	41.36e	1.18c	6.24d	0.50d

*** Means within a column having the same letters are not significantly different according to Duncan's Multiple Range Test at 5% confidence level.**

Photo 1. Effect of PP-333 at 100 ppm (left) compared to control (right).

The previous results can be discussed as done before in case of vegetative and root growth parameters of *Chrysanthemum carinatum* (Part, I). Similarly, were those findings of Hugar and Nalawadi (1999) on *Gaillardia pullchella*, Shahin *et al.* (2006) on *Rudbeckia hirta* and Li (2013) on *Achillea* "Coronation Gold" and *Coreopsis verticillata* "Moonbeam".

2- Flowering parameters:

It is obvious from data presented in Table (3) that flowering was significantly delayed as a result of spraying with either PP-333 or CCC at the different concentrations in both seasons. However, CCC treatments caused delaying more than PP-333 ones (about 7-9 days against only 4-5 days, respectively). All other flowering traits were markedly decreased by the various levels of both chemicals used, except for the two levels of PP-333 which were raised inflorescence diameter (cm) and number of ray florets/inflorescence, with the prevalence of PP-333 at 100 ppm treatment that gave the widest inflorescence with the highest number of ray florets/inflorescence at all in the two seasons. Moreover, such treatment resulted the shortest stalk length (15 cm in both seasons) compared with control and all other retarding treatments. That, of course was benefit in preventing head nutation phenomenon, to some extent in this plant.

These gains may be explained as previously mentioned when the authors discussed these characters in *Chrysanthemum carinatum* plant at part (I). Equal observations were also attained by Barett *et al.* (2003) on *Petunia hybrida* and *Catharanthus roseus* and El-Sayed *et al.* (2010) who found that PP-333 at 50, 100, 150 and 200 ppm significantly delayed flowering of jasmine plant in a gradual manner. Number of flowers per plant was markedly decreased with increasing the rate of paclobutrazol, while flower diameter was not affected by either concentration, except for 200 ppm one which significantly reduced this trait to the minimum value.

3- Chemical composition:

As shown in Table (4), it is clear that PP-333 at either low (50 ppm) or high (100 ppm) level pronouncedly increased content of the different photosynthetic pigments (chlorophyll a, b and carotenoids) in the leaves (mg/g F.W.). The higher level gave the higher content. The opposite was the right concerning CCC treatments, which linearly reduced content of these pigments.

A similar response occurred as well in respect of total soluble sugars content (g/100 g F.W.) in the leaves of plants sprayed with these two retardants. Both concentrations of PP-333 induced a marked increment in total indoles and phenols contents, but the rate of increment in total indoles was less than 50% relative to total phenols, while increment rate of total indoles in control leaves was about 100% compared to phenols. So, control plants flowered early. On the other hand, CCC treatments slightly diminished total indoles content, meanwhile caused the mostly highest increase in total phenols content which reached more than 8-fold and 11-fold for 1000 and 2000 ppm, respectively, so the plants greatly delayed in flowering.

Table 3. Effect of paclobutrazol and cycocel concentrations on flowering traits of *Gaillardia pulchella* Foug. plants during 2012/2013 and 2013/2014 seasons.

Growth retardants concentration	No. days to flowering (day)	No. inflorescence per plant	Inflorescence stalk length (cm)	Inflorescence diameter (cm)	No. ray florets per inflorescence	Inflorescence F.W. (g)	Inflorescence D.W. (g)
First season: 2012/13							
Control	128.00d	8.00a	20.50a	5.00b	28.00b	1.47b	0.42b
PP-333 at 50 ppm	132.50c	6.00b	18.71b	5.50ab	28.00b	1.58ba	0.50ba
PP-333 at 100 ppm	133.46c	5.00c	15.00c	6.21a	34.00a	1.83a	0.61a
CCC at 1000 ppm	135.00b	4.00d	18.58b	5.33b	25.46c	1.34bc	0.35bc
CCC at 2000 ppm	137.68a	3.00e	18.00b	4.50c	22.10d	1.16c	0.30c
Second season: 2013/14							
Control	126.33d	8.00a	22.30a	4.67bc	26.33bc	1.62b	0.38b
PP-333 at 50 ppm	129.85c	7.00b	20.51b	5.36ba	28.00b	1.70ba	0.41b
PP-333 at 100 ppm	131.00c	5.00c	15.00d	5.98a	31.76a	1.96a	0.56a
CCC at 1000 ppm	133.30b	3.00d	20.27b	5.00b	23.00c	1.31c	0.30c
CCC at 2000 ppm	137.00a	3.00d	17.50c	4.50c	21.33d	1.09d	0.27c

*** Means within a column having the same letters are not significantly different according to Duncan's Multiple Range Test at 5% confidence level.**

Table 4. Effect of paclobutrazol and cycocel concentrations on some chemical constituents in the leaves of *Gaillardia pulchella* Foug. plants during 2013/2014 season.

Growth retardants concentration	Photosynthetic pigments (mg/g F.W.)			Total soluble sugars (g/100g F.W.)	Total indoles (ppm)	Total phenols (ppm)
	Chl. a	Chl. b	Carotenoids			
Control	0.859	0.590	0.436	1.130	0.084	0.042
PP-333 at 50 ppm	0.901	0.682	0.577	1.339	0.103	0.058
PP-333 at 100 ppm	1.033	0.713	0.605	1.446	0.106	0.067
CCC at 1000 ppm	0.729	0.501	0.410	0.891	0.075	0.619
CCC at 2000 ppm	0.672	0.482	0.413	0.814	0.062	0.734

These results are in accordance with those revealed by Shahin *et al.* (2006) on *Rudbeckia hirta*, Baloch *et al.* (2013) on snapdragon cv. Coronette, petunia cv. Dreams and annual verbena cv. Obsession and Pethybridge *et al.* (2014) on pyrethrum.

From the aforementioned results, it is concluded that paclobutrazol foliar spray at 100 ppm concentration, twice with 3 weeks interval is one of the proper way, according to this trial conditions to obtain a stunted flowering pot plant from the tall and branched *Gaillardia pullchella* annual plants suitable for decoration of limited and sunny places.

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المرجريت وعنبر كشمير كحوليات شتوية مقزمة

٢- عنبر كشمير (*Gaillardia pulchella* Foug.) Blanketflower

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يعتبر نبات عنبر كشمير (*Gaillardia pulchella* Foug.) من الحوليات الشتوية التي تتعرض للميل أو الانحناء نحو الأرض، خاصة عند زراعتها بمفردها في أصيص. لذلك، أجريت هذه الدراسة بحديقة الأورمان النباتية، الجيزة، مصر خلال موسمي ٢٠١٢/٢٠١٣ ، ٢٠١٣/٢٠١٤ لتقصير الساق الطويلة عديدة الأفرع لهذا النبات، وذلك عن طريق رش المجموع الورقي بالمحلول المائي للباكلوبيوترازول (PP-333) بتركيزات: صفر، ٥٠، ١٠٠ جزء في المليون أو

السيكوسيل (CCC) بتركيزات: صفر، ١٠٠٠ ، ٢٠٠٠ جزء في المليون، مرتين و بفاصل ثلاثة أسابيع فيما بينهما. وكذلك لدراسة تأثير هذه المعاملات على الإزهار والتركيب الكيميائي لشتلات عمر ٧٥ يوم من هذا النبات الحولي الشتوي عند زراعتها في أصص بلاستيك قطرها ١٥سم مملوءة بحوالي ١,٥ كجم من مخلوط متساوي من الرمل و الطين (١:١ بالحجم).

أوضحت النتائج المتحصل عليها أن الرش بالتركيزات المختلفة من الباكلوبيوترازول والسيكوسيل أحدثت انخفاضاً معنوياً في جميع قياسات النمو الخضري و الجذري، مع بعض الإستثناءات البسيطة عند مقارنتها بالكنترول في كلا الموسمين. أحدث التركيز المنخفض من الباكلوبيوترازول (٥٠ جزء في المليون) انخفاضاً بنسبة ٢٠% فقط في إرتفاع و عدد أفرع النباتات المعاملة معطياً نباتات قريبة إلى حدٍ ما في حجمها من نباتات المقارنة، بينما أدى التركيز المرتفع من السيكوسيل (٢٠٠٠ جزء في المليون) إلى خفض متوسطات هذه القياسات بشكل زائد بلغ أكثر من ٦٥% مقارنة بالكنترول، وكان ذلك مصحوباً بخفض متوسط طول الجذر لأقل من ١٠سم بكلا الموسمين. على الجانب الآخر، فقد أعطت معاملتا الباكلوبيوترازول بتركيز ١٠٠ جزء في المليون و السيكوسيل بتركيز ١٠٠٠ جزء في المليون أكثر حجم نباتي ملائم من حيث الإرتفاع وعدد الأفرع والأوراق، وإن كانت معاملة الرش بالباكلوبيوترازول بمعدل ١٠٠ جزء في المليون أعطت نباتات ذات حجم أفضل وأكثر ملائمة لحجم الأصص المنزرعة بها مقارنة بالسيكوسيل (١٠٠٠ جزء في المليون). ولقد أدت جميع المعاملات المطبقة بهذه الدراسة إلى تأخير الإزهار، إلا أن معدل التأخير الذي أحدثته معاملات السيكوسيل كان أكبر من الذي أحدثته معاملات الباكلوبيوترازول (حوالي ٧-٩ ايام مقابل ٤-٥ أيام فقط، على الترتيب). أيضاً إنخفضت معنوياً جميع قياسات الإزهار الأخرى متأثرة بالمعاملات المختلفة لهذه الدراسة في معظم الحالات بكلا الموسمين، باستثناء تركيزي الباكلوبيوترازول و اللذان أحدثا زيادة في قطر النورة و عدد الزهيرات الشعاعية/نورة، مع تفوق التركيز المرتفع (١٠٠ جزء في المليون) والذي أعطى أعرض النورات وأكثرها إمتلاءاً بالزهيرات الشعاعية على الإطلاق. أعطت هذه المعاملة أيضاً أقصر طول للحامل النوري، وكان ذلك مفيداً في منع حدوث إنحناء للرأس الزهرية في هذا النبات. أوضحت النتائج أيضاً أن التركيزات المختلفة للباكلوبيوترازول أحدثت زيادة ملحوظة في محتوى الأوراق من كلوروفيللي أ، ب، الكاروتينويدات، السكريات الكلية الذائبة، الأندولات الكلية والفينولات الكلية، بينما أحدثت التركيزات المختلفة للسيكوسيل إنخفاضاً في محتوى هذه المكونات بالأوراق، باستثناء محتوى الفينولات الكلية الذي زاد بشكل واضح.

من هذه النتائج، يمكن النصح برش أوراق الشتلات عمر ٧٥ يوم لنبات عنبر كشمير الحولي الطويل بالباكلوبيوترازول بتركيز ١٠٠ جزء في المليون، مرتين وبفاصل ثلاثة أسابيع فيما بينهما لإنتاج نباتات أصص مزهرة، صغيرة، مقزمة تصلح للتسويق التجاري.