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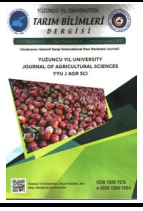

Araştırma Makalesi

Effects of Different PGPR Formulations, Chemical Fertilizers and Their Combinations on Some Plant Growth Characteristics of Poinsettia **

Fazilet PARLAKOVA KARAGÖZ*, Atilla DURSUN

[1] Atatürk University, Agriculture Faculty, Department of Horticulture, Erzurum, Turkey
*Corresponding author e-mail: f.parlakova@atauni.edu.tr

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Abstract: This study was carried out to determine effects of different PGPR formulations, chemical fertilizers and their combinations on some plant growth characteristics of poinsettia under climate-controlled research greenhouse between July 2015 and July 2017. In the study, rooted cuttings of poinsettia (*Euphorbia pulcherrima* Willd. ex Klotzsch cv. Christmas Feelings) were used as plant material. The applications were created as formulation 1, formulation 2, formulation 3, formulation 4, the full amount of commonly used chemical fertilizer (100% CF), by combining the reduced amount of chemical fertilizer by 50% with each bacterial formulation and control. Plant height, main stem diameter, number of bract, length and diameter of root, fresh and dry weight of plant were evaluated in the experiment. According to CF and control applications, BIV+CF application was increased in the number of bract leaves between 14.76% and 29.32%; and it was also increased in plant height between 2.87% and 5.27%, respectively. The highest plant fresh weight (16.93 g) was obtained from BII and CF applications. The highest average fresh (4.69 g) and dry (1.57 g) plant weight were determined in BII application. It has been determined that bacterial formulations BIV+CF, BIII+CF, BIV and BII, which have positive effects on some plant growth and quality characteristics of poinsettia, can be used in poinsettia production stage. Thus, bacterial formulations may allow reducing the using chemical fertilizer in its cultivation.

Farklı PGPR Formülasyonları, Kimyasal Gübre ve Kombinasyonlarının Atatürk Çiçeğinin Bazı Gelişim Parametreleri Üzerine Etkileri

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Anahtar kelimeler
Brakte,
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Saksılı süs bitkisi, Rizobakteri formulasyonu

Öz: Bu çalışma, farklı PGPR formülasyonları, kimyasal gübre ve kombinasyonlarının Atatürk Çiçeği'nin bazı gelişim parametreleri üzerine etkilerini belirlemek amacıyla Temmuz 2015-Temmuz 2016 tarihleri arasında iklim kontrollü araştırma serasında gerçekleştirilmiştir. Atatürk Çiçeği (*Euphorbia pulcherrima* Willd. ex Klotzsch cv. Christmas Feelings) köklü çelikleri bitki materyali olarak kullanılmıştır. Formülasyon 1, formülasyon 2, formülasyon 3, formülasyon 4, yaygın olarak kullanılan kimyasal gübre miktarının tamamı (%100 KG) ve her bir formülasyon ile kimyasal gübrenin %50 azaltılmış miktarının kombinasyonları ve kontrol olarak uygulamalar oluşturulmuştur. Denemede bitki boyu, ana gövde çapı, kök sayısı, kök uzunluğu ve çapı, bitkinin taze ve kuru ağırlığı değerlendirilmiştir. KG ve kontrol uygulamalarına göre, BIV+KG uygulaması brakte yaprak sayısını % 14,76 ile % 29,32 arasında arttırmıştır ve ayrıca bitki boyunu da %2,87 ile % 5,27 arasında arttırmıştır. En yüksek bitki yaş ağırlığı (16,93 g) BII ve KG uygulamalarından elde edilmiştir. En yüksek ortalama bitki yaş (4,69 g) ve kuru ağırlığı (1,57 g) BII uygulamasında belirlenmiştir. Atatürk Çiçeğinin bazı bitki

gelişimi ve kalite özellikleri üzerinde olumlu etkileri olan BIV+KG, BIII+ KG, BIV ve BII bakteri formülasyonlarının Atatürk Çiçeği yetiştirme aşamasında kullanılabileceği belirlenmiştir. Böylece, bakteriyel formülasyonlar Atatürk Çiçeği yetiştiriciliğinde kimyasal gübre kullanımının azaltılmasına yol açabilecektir.

**Çalışma Fazilet PARLAKOVA KARAGÖZ'ün doktora tezinin bir bölümünden üretilmiştir.

1. Introduction

Poinsettia (*Euphorbia pulcherrima* Willd. ex Klotzsch) is one of the most important indoor plants grown for showy flowers and a member of the *Euphorbiaceae* family (Steinmann and Porter, 2002; Zulueta-Rodriguez et al., 2014). It is known that poinsettia is highly sensitive to day length and temperature (Larson et al., 1978). The short-day conditions warn blooming along with the color change of the top leaves (bracts) of this plant (Anonymous, 2013). It is important to produce plants with the intensive green leaf and bract coloring for consumer demand in poinsettia cultivation. It is defined that red pigment on poinsettia's bracts is anthocyanin (Lawrence et al., 1941).

Anthocyanin presence is determined by the lack of or intensity of red color in brackets (Lawrence et al., 1941; Bennett et al., 2008). It is known that control of plant nutrition and photoperiod is the most important factor to obtain intense color. In cultivation of potted poinsettia, it needs to be cultivated with materials having high nutrient content for production of quality flowers. For this reason, weekly fertilizing and / or adjustments involving other chemical applications are required (Siemonsma, 2007). Day after day, there is growing interest in the ideas of reducing the use of chemicals in agricultural areas in order to protect plant health and reduce production costs. For this reason, the use of bacteria in the root rhizosphere of plants in the field of horticultural and in ornamental plant cultivation (although not too much) has recently become important. There are few studies on the use of plant growth promoting rhizobacteria in cultivation of ornamental plants (van Peer et al., 1991; Padmadevi et al., 2004; Selvaraj et al., 2008; Karishma et al., 2013; Parlakova, 2014; Arab et al., 2015; Parlakova Karagöz and Dursun, 2019). In this context, the number of researches on the use of PGPR (Zulueta-Rodriguez et al., 2014) in poinsettia is very limited in worldwide.

This study was carried out to determine effects of different PGPR formulations, chemical fertilizers and their combinations on some plant growth characteristics of poinsettia.

2. Materials and Methods

The research was conducted in climate controlled research greenhouse between July 2015 and July 2017. In the study, rooted cuttings of poinsettia (*Euphorbia pulcherrima* Willd.ex Klotzsch cv. Christmas Feelings) were used as plant material. The cultivation medium was prepared by mixing peat in ratio of 2: 1 (diameter: 3,10 mm) and ponza (diameter: 10-30 mm) as volume (Cantin, 2016, Anonymous, 2018). Plants were planted in 3.5 l plastic pots. The applications were created as formulation 1 (*Paenibacillus polymyxa* TV-12E + *Pseudomonas putida* TV-42A + *Pantoea agglomerans* RK-79), formulation 2 (*Bacillus megaterium* TV-91C + *Pantoea agglomerans* RK-92 + *Bacillus subtilis* TV-17C), formulation 3 (*Bacillus megaterium* TV-91C + *Pantoea agglomerans* RK-92 + *Kluyvera cryocrescens* TV-113C), formulation 4 (*Bacillus megaterium* TV-91C + *Pantoea agglomerans* RK-79 + *Bacillus megaterium* TV-6D) (Tablo 1), the full amount of commonly used chemical fertilizer (100% CF) and by combining the reduced amount of chemical fertilizer by 50% with each bacterial formulation.

Table 1. Bacterial isolates used in the study and some biochemical properties (Kotan et al., 2009; Kotan et al., 2010)

Isolate No	MIS Diagnosis Result	SIM	Location	Host	Nitrogen	Phosphate
RK-79	*Pantoea agglomerans*	0.762	Erzurum	Apple	+	+
TV-12E	*Paenibacillus polymyxa*	0,551	Van	Poaceae	S+	+
TV-17C	*Bacillus subtilis*	0,677	Van	Raspberry	S	W+
TV-6D	*Bacillus megaterium*	0,750	Van	Poaceae	+	+
TV-42A	*Pseudomonas putida*	0,113	Van	Poaceae	W+	W+
TV-91C	*Bacillus megaterium*	0,474	Van	Poaceae	+	W+
TV-113C	*Kluyvera cryocrescens*	0,688	Van	Garlic	+	+
RK-92	*Pantoea agglomerans*	0.889	Erzurum	Pear	+	S

(SIM: Similarity index, S: Strong +, W: Weak +; +: Positive, -: Negative).

Bacterial formulations were inoculated in the rooted cuttings of the poinsettia by dipping method and they were planted in pots filled with appropriate growing medium. The study was designed as 3 replicates in factorial design with 1 (variety) x10 (application) in randomized parcel trial design.

After planting of rooted cuttings in pots, two different types of fertilizer in a form that can be completely dissolved in water were applied to the pot groups to be applied chemical fertilizer at the determined different doses. These are comprised from "White 15-0-19 + 9CaO + 2MgO + TE, NPK ratio 4: 0: 5" and "Blue 18-11-18 + 2.5MgO, NPK ratio 3: 2: 3". These two different chemical fertilizers were given in specified amounts with the irrigation water consecutively (Kofranek et al. 1963; Faust et al. 2001; Anonymous 2018). The recommended dose (150 grams / 100 liters) of these fertilizers for pots, flower beds and all covered seedlings was used in this study.

After 110-120 days from bacterial inoculation, in measurements of some plant growth parameters were made on 10 samples from each application. These parameters are plant height, main stem diameter, number of bract, length and diameter of root, fresh and dry weight of plant.

2.1. Statistical analysis

All data in the present study have been evaluated by analysis of variance, which was performed using the SPSS version 20.0 statistical software package (SPSS Inc., Chicago, IL, USA) and the means were separated by Duncan's multiple range tests. 5% has been set to be the maximum acceptable limit and to be considered a significant result.

3. Results and Discussion

Effects of different PGPR formulations, chemical fertilizers and their combinations on some plant growth characteristics of poinsettia were given in Table 2. As a result of this study conducted in both years; the effect of applications on plant height was found to be significant at $p<0.001$ level. In 1st year while the highest value was obtained in the BIII+CF application with 42.82 cm compared to the control, and significant increases were also achieved in BIV+CF and CF applications. In 2nd year, the highest plant height was determined in BIV, BIV+CF and control applications. According to the evaluation of the general average of the two years, the effect of applications ($p<0.01$) on plant height was found statistically significant. The highest plant height was obtained from BIV+CF application. Díaz (1998) reported that bacterial strains have positive effects on the growth and development of plants.

In addition, Ashrafuzzaman et al. (2009) and Nandakumar et al. (2001) demonstrated that PGPR applications were increased in plant height of rice; Gholami et al. (2009) and Shaharoona et al. (2006) reported that PGPR were increased in plant height of maize. These literature findings showed parallelism with the findings of our study evaluated of using potential of PGPR in poinsettia cultivation.

In the first year of the study, applications on the main stem diameter were statistically significant at $p<0.01$ level. Compared to the control, the highest value was obtained from BIV application with a main stem diameter of 8.05 mm. The increasing was significantly obtained from BI application (Table 2). De Silva et al. (2000) observed that applications with *P. fluorescens* Pf5 and *B. pumilus* on blueberries were increased in main stem diameter. PGPR applications were increased in the main stem diameter of canola plants (Asghar et al., 2004). The obtaining from the BIV application of the highest main stem diameter in our study is supported the previous findings.

When the general averages of the data for the two years of the study are examined; while the maximum number of bract leaf (9.96 number plant^{-1}) was determined in BIV+CF application, least number of bract leaf was obtained in control (7.04 number plant^{-1}) (Table 2). Thapa (2017) determined that the number of bract leaf varied between 7.86 and 8.40 number / plant for the cultivar 'Christmas Day' of *Euphorbia pulcherrima* according to the applications. PGPRs inoculated on seedling of *Cistus lanceolate* increased in number of leaf (Solano et al., 2007). *Pseudomonas putida* has been effective on increasing in the number of leaves of poinsettia plant (Zulueta-Rodriguez et al., 2014).

In terms of mean diameter of root, the effect of the applications was significant ($p<0.05$) in 2nd year and general averages of the two years. The highest mean diameter of root was determined in BIV+CF (2.79 mm) application in general averages of the two years (Table 2). Baset et al. (2010) indicated that a remarkable increase in root growth of banana plantlets was recorded due to the PGPR inoculation. These results can be explained as the effect of plant nutrition.

While the effect of the applications on the fresh weight of plant was statistically significant ($p<0.001$), the highest fresh weight of plant was obtained from BII and CF applications. Ge et al. (2016) reported that *Bacillus methylotrophicus* strain NKG-1 increased in the fresh weights of tomato seedlings by 27.4%. Jaleel et al. (2007) demonstrated that *Pseudomonas fluorescens* has positive effects on fresh weight of Madagascar

periwinkle (*Catharanthus roseus*). Our study results related to the fresh weight of plant increase are in harmony with of the results of researches studied by Jaleel et al. (2007), Martinetti et al. (2007) and Ge et al. (2016).

Table 2. The effects of treatments on some plant growth characteristics of poinsettia

Treatments	**Plant height (cm)**			**Main stem diameter (mm)**		
	1st year	2nd year	Overall mean	1st year	2nd year	Overall mean
Control	37.26 d***	22.58 a***	29.92 bc**	7.29 cd**	5.59 ns	6.44 ns
CF	41.30 ab	20.25 bc	30.78 ab	7.17 d	5.78	6.47
BI	36.61 d	21.64 ab	29.13 c	7.81 ab	5.44	6.63
BI+CF	38.11 cd	20.31 bc	29.21 c	7.15 d	5.60	6.37
BII	39.58 bc	20.90 abc	30.24 bc	7.59 abcd	5.49	6.54
BII+CF	40.86 ab	20.86 abc	30.86 ab	7.78 abc	5.82	6.80
BIII	38.76 cd	19.52 c	29.14 c	7.53 bcd	5.59	6.56
BIII+CF	42.82 a	16.99 d	29.90 bc	7.75 abc	5.36	6.55
BIV	38.12 cd	22.55 a	30.33 abc	8.05 a	5.93	6.99
BIV+CF	41.15 ab	22.23 a	31.69 a	7.53 bcd	5.81	6.67
Mean	39.46	20.78	30.12	7.57	5.64	6.60
Treatments	**Number of bract (number plant^{-1})**			**Mean length of root (cm)**		
	1st year	2nd year	Overall mean	1st year	2nd year	Overall mean
Control	6.63 e***	7.45 d**	7.04 e***	32.86 ns	29.27 a**	31,06 a**
CF	8.43 cd	8.55 abc	8.49 bcd	31.29	22.52 bc	26.91 ab
BI	9.04 bc	9.08 ab	9.06 b	33.41	22.86 abc	28.13 ab
BI+CF	9.78 ab	8.19 bcd	8.98 b	31.34	24.92 ab	28.13 ab
BII	6.37 e	9.33 a	7.85 d	36.27	24.08 ab	30.18 a
BII+CF	8.72 cd	8.77 ab	8.74 bc	31.46	22.14 bc	26.80 ab
BIII	7.97 d	7.73 cd	7.85 d	31.59	18.34 bc	24.96bc
BIII+CF	6.80 e	7.42 d	7.11 e	32.40	22.28 bc	27.34 ab
BIV	8.47 cd	8.10 bcd	8.28 cd	30.84	29.46 a	30.15 a
BIV+CF	10.64 a	9.28 a	9.96 a	28.37	16.97 c	22.67 c
Mean	8.28	8.39	8.34	31.98	23.28	27.63
Treatments	**Mean diemeter of root (mm)**			**Fresh weight of plant (g)**		
	1st year	2nd year	Overall mean	1st year	2nd year	Overall mean
Control	2.64 ns	1.98 cd*	2.31 bc*	14.38 bc**	17.13 b***	15.75ab***
CF	2.47	2.25 abc	2.36 abc	15.87 ab	17.75 ab	16.81 a
BI	2.78	2.20 abcd	2.49 ab	10.93 d	19.29 ab	15.11ab
BI+CF	2.70	2.46 abc	2.58 ab	12.43 cd	16.44 bc	14.44bc
BII	2.84	2.25 abc	2.54 ab	13.41 bcd	20.45 a	16.93 a
BII+CF	2.83	2.07 abcd	2.45 abc	12.73 cd	17.34 b	15.04 ab
BIII	2.34	1.74 d	2.04 c	13.50 bcd	11.92 d	12.71 c
BIII+CF	2.96	1.99 bcd	2.48 ab	17.23 a	14.04 cd	15.64 ab
BIV	2.96	2.48 ab	2.72 ab	12.37 cd	20.26 a	16.31 ab
BIV+CF	3.09	2.49 a	2.79 a	14.08 bc	18.34 ab	16.21 ab
Mean	2.76	2.19	2.48	13.69	17.30	15.49
Treatments	**Dry weight of plant (g)**					
	1st year	2nd year	Overall mean			
Control	2.37 ab*	1.80 ns	2.08 ns			
CF	2.86 a	1.42	2.14			
BI	2.06 b	1.59	1.83			
BI+CF	2.12 b	1.50	1.81			
BII	2.36 ab	1.67	2.02			
BII+CF	2.24 ab	1.45	1.85			
BIII	2.66 ab	1.05	1.85			
BIII+CF	2.83 a	1.67	2.25			
BIV	2.23 ab	1.77	2.00			
BIV+CF	2.67 ab	1.54	2.11			
Mean	2.44	1.55	1.99			

* $p<0.05$; ** $p<0.01$; ** $p<0.001$; ns: not significant. The numbers in one column having the same letter are not significantly different.

Figure 1. General appearances from the poinsettia plant belonging to the application

In the first year of the study, applications on the dry weight of plant were statistically significant at $p<0.05$ level. The highest dry weight of plant was determined in BIII+CF (2.83 g) and CF (2.86 g) applications. In terms of dry weight of plant, the effect of the applications was not significant ($p>0.05$) according to in 2nd year and general averages of the data for the two years of the study (Table 2). Our study results related to the dry weight of plant increase are in harmony with of the results of researches studied by Kokalis–Burelle et al. (2002) (for tomato and pepper seedling), Jaleel et al. (2007) (for Madagascar periwinkle), Martinetti et al. (2007) and Thapa (2017) (for poinsettia).

4. Conclusion

In conclusion, it has been concluded that PGPRs used in this study have positive effects on plant development of Christmas Feelings cultivar of poinsettia and provide important contributions in terms of quality parameters. It has been determined that bacterial formulations BIV+CF, BIII+CF, BIV and BII, which have positive effects on plant growth and development characteristics of poinsettia, can be used as biological fertilizer in poinsettia production. It has been estimated that the use of PGPR as a biological fertilizer could reduce the cost of care in production of a high quality potted poinsettia plants.

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