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The propagation of forage kochia cutting in different IBA concentrations and at holding times

Farklı İBA konsantrasyonları ve bekletme sürelerinde bozkır otu çeliklerinin çoğaltılması

Nur KOÇ KOYUN[1], Ramazan ACAR[1]
[1]Selçuk University, Faculty of Agriculture, Department of Field Crops, Konya, Turkey

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Sorumlu yazar / *Corresponding author*
Nur KOÇ KOYUN
e-mail: nurkoc@selcuk.edu.tr

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Abstract
Forage kochia, a subshrub forage plant, grows naturally in the pastures of dry areas in Turkey. Their seeds grow slowly in nature, and being short duration of seed viability could be caused by limitations on the cultivation of forage kochia in Turkey. Forage kochia seedlings can be produced serially quickly with cutting propagation as vegetation propagation method. Therefore, forage kochia cuttings were exposed to 12 different IBA concentrations (250, 500, 1000, 1500, 2000, 2500, 3000, 4000, 5000, 6000, 10000, and 15000 mg kg^{-1}) at four holding times (5, 30, 180, and 900 s) in this research carried out Completely Randomized Design in the greenhouse. We investigated the percentage of rooting, the number of the root, shoot and root length, shoot and root weight, dry root weight, and leave yellowing of these cutting. The best developments in the percentage of rooting (100%), number of roots (> 7), shoot length (> 20 cm), root length (>10 cm), root weight (>0.60 g), dry root weight (>0.1 g) and leave yellowing (score >1.60) were obtained from 500 mg kg^{-1} IBA at 900 s, 5000 mg kg^{-1} IBA at 180 s, and 10000 mg kg^{-1} IBA at 5 s interactions. As a result, we advised 500 mg kg^{-1} IBA at 900 s, 5000 mg kg^{-1} IBA at 180 s and 10000 mg kg^{-1} IBA at 5 s for the quick and economically cutting propagation of forage kochia.

Özet
Yarı çalı bir yem bitkisi olan bozkır otu, Türkiye'nin kurak alanlarındaki meralarda doğal olara yetişmektedir. Bozkır otunun doğada tohum ile büyümesi çok yavaş ve tohum canlılığı süresinin kıs olması ülkemizde bozkır otu tarımında kısıtlamaya neden olmaktadır. Vejetatif çoğaltma yöntemi olara çelikle çoğaltma ile bozkır otu fidesi daha kısa sürede seri bir şekilde üretilebilir. Bu sebeple, Tesadü Parselleri Deneme Desenine göre serada yürütülen bu çalışmada 4 adet sürede (5, 30, 180 ve 900 s) v 12 farklı IBA konsantrasyonlarına (250, 500, 1000, 1500, 2000, 2500, 3000, 4000, 5000, 6000, 10000 v 15000 mg kg^{-1}) bozkır otu çelikleri maruz bırakıldı. Bu çeliklerin köklenme yüzdesi, kök sayısı, fide ve kö uzunluğu, yaş fide ve kök ağırlığı, kuru kök ağırlığı ve yaprak sararması incelenmiştir. Çeliklerd köklenme yüzdesi (%100), kök sayısı (>7 adet), fide uzunluğu (>20 cm), kök uzunluğu (>10 cm), kö ağırlığı (>0.60 g), kuru kök ağırlığı (>0.1 g) ve yaprak sararması (Skor >1.60) açısından en iyi gelişim 90 saniyede 500 mg kg^{-1} IBA, 180 saniyede 5.000 mg kg^{-1} IBA ve 5 saniyede 10.000 mg kg^{-1} IB konsantrasyonlarından elde edilmiştir. Sonuç olarak bozkır otunun ekonomik ve hızlı bir şekilde çelikl çoğaltılması için 900 saniyede 500 mg kg^{-1} IBA, 180 saniyede 5.000 mg kg^{-1} IBA ve 5 saniyede 10.000 m kg^{-1} IBA konsantrasyonları önerilmektedir.

INTRODUCTION

Forage kochia or prostrate summer-cypress [*Bassia prostrata* (L.) A.J. Scott (Syn. *Kochia prostrata*)], which is a C4 bush plant, is a member of *the Chenopodiaceae* family (Su et al. 2011). It grows in the pastures of dry areas in Turkey and elsewhere in the world's natural ranges (Acar and Özköse 2012, Acar 2013). Rangeland improvement had been carried out by using this plant in meadows which have 70- 110 mm annual precipitation in Jordan, in the dry pasture in the western regions of the USA, and in rangelands with salinity problems in Russia (Blauer et al. 1993, Harrison et al. 2000, Shamsutdinov and Shamsutdinov 2009, Bailey et al. 2010). Furthermore, it uses as firebreaks to the protection of pasture and forestry (Waldron et al. 2013).

Prostrate summer-cypress's hay yield was between 1.075 kg ha^{-1} and 2580 kg ha^{-1} (Acar and Koç 2019). Plant height ranges between 20 and 100 cm, while canopy diameter ranges between 25 and 120 cm. Also, crude protein of forage kochia populations, which grow in dry and salty conditions, varied between 10% and 17%, and these population's ADF content was between 35% and 43%, and the NDF ranged between 38% and 60% (Koç Koyun 2021).

The forage kochia production takes a long time due to their seeds grow slowly in nature, and for this reason, plants to be used in rangeland improvement grow as a seedling in greenhouse conditions. However, being short duration of seed viability could be caused by limitations on the cultivation of forage kochia in Turkey despite its advantages (Stevens et al. 1985, Zadbar et al. 2007).

Forage kochia seedlings can be produced serially quickly with the vegetation propagation method and give chance conservation of genetic source (Baul et al. 2010, Gibson et al. 2021). Although there is inadequate literature related to vegetative propagation of forage kochia, these methods were applied in alfalfa (Özgen et al. 1997), in sainfoin (Özgen et al. 1998), in medicinal plants (Kara et al. 2011), and mostly in horticultural crops (Yıldız et al. 2009, Susaj et al. 2012, Husen et al. 2017, Pourghorban et al. 2019).

IBA (Indole-3-Butyric Acid) in the auxin family commonly uses to provide the most effective rooting in cutting propagation, one of the vegetation propagation methods. IBA degrades slowly by enzyme systems and applies as concentrated (1000 - 8000 mg kg-1) and diluted (10-250 mg kg-1) solutions (Weaver 1972, Yücesan et al. 2018). Additionally, cuttings of different shrub species at holding times into IBA solution show various researches. According to Basal Quick Dip Method and Basal Long Soak Method, cuttings are held into the solution at different times (Kroin 2011). For this reason, this research aims at showing the responses in rooting and growing of forage kochia cuttings held to different IBA concentrations, including diluted and concentrated solutions, at four holding times.

MATERIAL AND METHODS

Material

This research was used as material cuttings obtained from forage kochia grow naturally in Department of Field Crops' research plots at Selçuk University, an early morning hour on 15 March 2018. Woody branch regrown were selected as cutting owing to being the perennial plant. Cutting lengths ranged between 8 cm and 12 cm, and their diameters varied between 2 mm and 4 mm.

Trials were conducted in the Plant Breeding Greenhouse Department of Field Crops of the Faculty of Agriculture at Selçuk University. Cuttings were planted in pots whose dimensions were 7 x 8 cm, and in each pot included a cutting. A mixture of peat and perlite prepared in a ratio of 1:1 is used as a growth medium. Peat had a pH 5.5-6.5; a fertilizer ratio of 0.30 g L^{-1}; an N content of 30-70 mg L^{-1}; a P_2O_5 range of 30-70 mg L^{-1}, and K_2O content of 40-80 mg L^{-1}. The peat had a dissociation degree between H2-H8. Peat had a porosity weight of 96 %, a moisture content between 40 and 50%, and an electrical conductivity between 0.12 and 0.22 dS m^{-1}.

Methods

The cuttings held on 12 different IBA concentrations (250, 500, 1.000, 1.500, 2.000, 2.500, 3.000, 4.000, 5.000, 6.000, 10.000, and 15.000 mg kg^{-1}) in this research carried out with three replications in a Completely Randomized Design. Also, the cuttings held on IBA concentration at five different times [5 s, 30 s, 180 s (3 min), 900 s (15 min), 3600 s (1 h)]. But at 3600 s (1 h) removed as a holding time because of noting rooting in all cuttings at this holding time. Each replication contained three cuttings for two reasons. The first reason was that regrown branches were scarce during the period taking a cutting. The second reason was that samples of the same phenotype were preferred due to varying between forage kochia phenotypes.

Figure 1. Photos are belonging the research (a), seedling in 10.000 mg kg-1 IBA concentration at 5 s holding time (b), seedling in 5.000 mg kg-1 IBA concentration at 180 s holding time (c), seedling in 500 mg kg-1 IBA concentration at 900 s holding time (d).

We investigated the percentage of rooting (%), the number of the root, shoot and root length (cm), shoot and root weight (g), dry root weight (g), and leave yellowing (Scoring) of these cutting in this study took 114 days. It was expressed that the percentage of rooting (%) was the percentage of total cuttings of rooting cuttings, and the number of roots was the number of whole primary roots occurring cuttings. It was determined to shoot and root length via rule and shoot and root weight by weighted in analytical balance. The dry root weight (%) was determined by drying the samples at 65 °C in ventilated incubators until they reach a constant weight (AOAC 2003). Also, yellowing was observed on leaves in the seedling. So, 1 and 2 were used for scoring the absence and presence of yellowing on leaves, respectively.

According to Completely Randomized Design, the data was analyzed by using JMP 7 software packet program (Sall et al. 2017). Duncan's Multiple Range Test was performed to determine the result of variance analysis using MSTAT-C software packet programs for grouping (Freed et al. 1989).

RESULTS

The analysis of variance results is summarized in Table 1. Average values are given in Table 2, 3, 4 and 5. As shown in Table 1, IBA concentrations of whole properties, except the percentage of rooting, shoot, and root length, were significantly different. On the other hand, all values of the holding time were statistically insignificant. Their interaction of dry root weight, shoot, and root length values were significant statistically at a 5% level.

Table 1. The F values of forage kochia cuttings in different IBA concentrations at four holding times

Source of Variation	Degree of Freedom	Percentage of Rooting	Number of Root	Shoot Length	Root Length	Shoot Weight	Root Weight	Dry Root Weight	Leave Yellowing
T	143								
A	3	0.448	1.323	0.977	2.005	1.029	1.741	0.080	0.828
B	11	1.327	2.116*	1.426	1.198	2.929**	3.565**	2.199*	1.846*
A* B	33	1.516	1.496	1.637*	1.662*	1.427	1.358	1.686*	1.520
E	96								

A: Holding Time, B: IBA Concentration, T: Total, E: Error
**p < 0.01; *p < 0.05

Table 2. Average values and groupings belonging the percentage of rooting and number of root

IBA cons. (mg kg^{-1})	Percentage of Rooting (%)					Number of Root				
	Holding Time (secs)				Average	Holding Time (secs)				Average
	5	30	180	900		5	30	180	900	
250	66.67	66.67	66.67	100.00	75.00	3.00	3.33	2,67	4.00	3.25^{a-c}
500	66.67	0.00	0.00	100.00	41.67	1.33	0.00	0,00	8.67	2.50^{a-c}
1000	33.33	33.33	0.00	33.33	25.00	2.67	1.33	0,00	0.33	1.08^{c}
1500	33.33	33.33	100.00	33.33	50.00	2.67	1.00	3,33	0.33	1.83^{bc}
2000	66.67	33.33	66.67	100.00	66.67	2.67	2.33	7,00	3.67	3.92^{ab}
2500	0.00	33.33	100.00	33.33	41.67	0.00	0.33	3,33	0.33	1.00^{c}
3000	0.00	100.00	33.33	33.33	41.67	0.00	4.33	2,00	0.33	1.67^{bc}
4000	33.33	66.67	66.67	0.00	41.67	1.00	3.00	1,67	0.00	1.42^{c}
5000	33.33	66.67	100.00	66.67	66.67	3.33	4.00	8,33	2.67	4.58^{a}
6000	100.00	33.33	66.67	66.67	66.67	1.67	0.67	4,67	3.33	2.58^{a-c}
10000	100.00	66.67	33.33	33.33	58.33	7.00	4.33	3,00	1.00	3.83^{ab}
15000	33.33	33.33	66.67	0.00	33.33	1.00	1.00	3,00	0.00	1.25^{c}
Average	47.22	47.22	58.33	50.00	50.69	2.19	2.14	3,25	2.06	2.41

$LSD_{0.05;\ IBA\ (NUMBER\ OF\ ROOT)}$: 2.061, $^{a, b,}$ ...p <0.05

Table 3. Average values belonging shoot and root length

IBA cons. (mg kg^{-1})	Shoot Length (cm)					Root Length (cm)				
	Holding Time (secs)				Average	Holding Time (secs)				Average
	5	30	180	900		5	30	180	900	
250	15.67	15.33	13.67	22.13	16.70	8.00	7.17	6.50	13.87	8.88
500	10.33	0.00	0.00	33.17	10.88	3.67	0.00	0.00	23.00	6.67
1000	7.00	6.17	0.00	9.67	5.71	3.67	2.33	0.00	6.67	3.17
1500	7.67	8.33	20.73	4.33	10.27	3.00	6.50	12.00	0.33	5.46
2000	12.33	6.97	14.33	21.00	13.66	7.00	2.67	7.63	14.20	7.88
2500	0.00	4.00	19.40	8.17	7.89	0.00	1.50	10.00	5.33	4.21
3000	0.00	20.33	8.00	3.33	7.92	0.00	9.17	4.60	0.50	3.57
4000	7.67	15.33	10.93	0.00	8.48	4.33	9.33	6.27	0.00	4.98
5000	7.67	14.33	28.93	14.50	16.36	4.17	7.00	18.20	8.90	9.57
6000	17.13	6.67	17.63	18.00	14.86	5.83	4.00	10.50	14.00	8.58
10000	21.50	13.17	6.70	10.67	13.01	12.17	8.17	5.00	7.90	8.31
15000	8.33	3.50	16.87	0.00	7.18	6.67	1.83	11.93	0.00	5.11
Average	9.61	9.51	13.10	12.08	11.07	4.90	4.97	7.72	7.89	6.37

The highest percentage of rooting (100%) was obtained at 900 s holding time in diluted and fewer concentrations (i.e., 250, 500, and 2.000 mg kg^{-1} IBA while at 5 s holding time in high concentrates (i.e., 6.000 and 10.000 mg kg^{-1} IBA) had the highest percentage of rooting (100%). Also, 100% rooting was shown at 30 s holding time in 3.000 mg kg^{-1} IBA and at 180 s holding time in 1.500, 2.500, and 5.000 mg kg^{-1} IBA concentrations (Table 2). The maximum values of the number of the root, shoot, and root lengths were obtained at 900 s in 500 mg kg^{-1} IBA concentration (Table 2, 3).

The highest shoot and root length was obtained at 900 s holding time in 500 mg kg^{-1} IBA concentration with 33.17 cm and 23.00 cm, respectively (Fig. 2, 3, 4). However, the maximum shoot and root weight was found at 180 s holding time in 5000 mg kg^{-1} IBA concentration with 1.60 g and 1.08 g, respectively (Table 4). The highest dry root weight was determined at 5 s holding time in 10000 mg kg^{-1} IBA concentration with 0.160 g (Fig. 5). The minimum leave yellowing (score 2.00), which show the development of healthy seeding, was obtained at 900 s holding time in 500 and 1.000 mg kg^{-1} IBA, at 180 s holding time in 5.000 mg kg^{-1} IBA, and at 30 s holding time in 3.000 mg kg^{-1} IBA concentrations (Table 5). After these concentrations, 6000 and 10000 mg kg^{-1} IBA at 5 s holding time had the minimum leave yellowing (score 1.67).

Figure 2. Photos are belonging the development of roots and seedling. (a) seedling in 10.000 mg kg^{-1} IBA concentration at 5 s holding time, (b) seedling in 5.000 mg kg^{-1} IBA concentration at 180 s holding time, (c) seedling in 500 mg kg^{-1} IBA concentration at 900 s holding time.

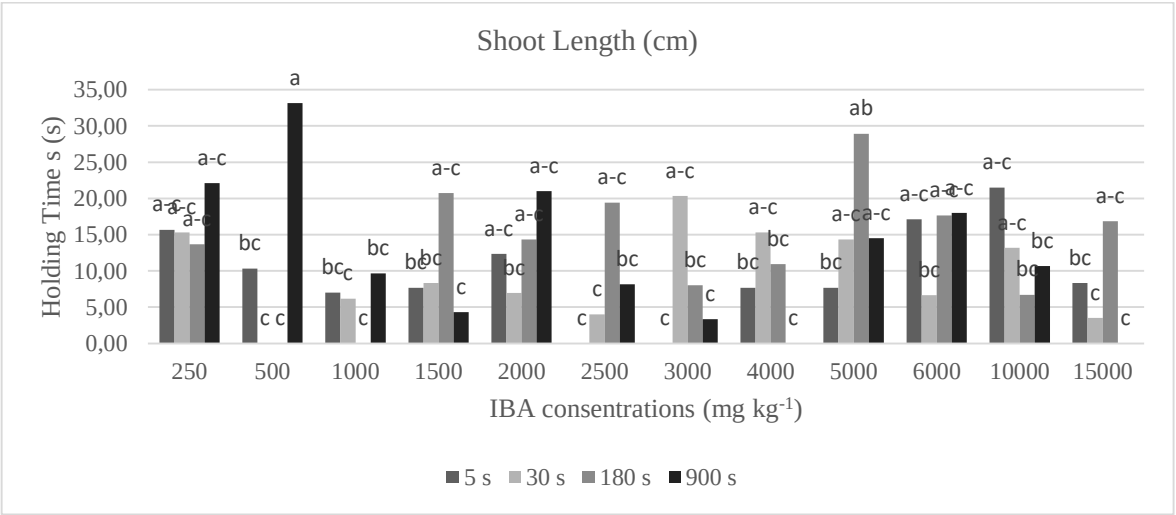

Figure 3. Graphics are belonging interactions average of shoot length ($LSD_{0.05;\ A*B}$ 17.70; $^{a,\ b,}$ ...p <0.05)

As shown in Table 2 and Table 3, 250 mg kg^{-1} IBA concentration had the maximum values in percentage of rooting (75%) and shoot length (16.70 cm). But 5000 mg kg^{-1} IBA concentration had the highest means in the number of root (4.58), root length (9.57 cm), shoot length (1.04 g), root length (0.66 g), dry root weight (0.08 g), and leave yellowing (score 1.33) when considering IBA concentrations means.

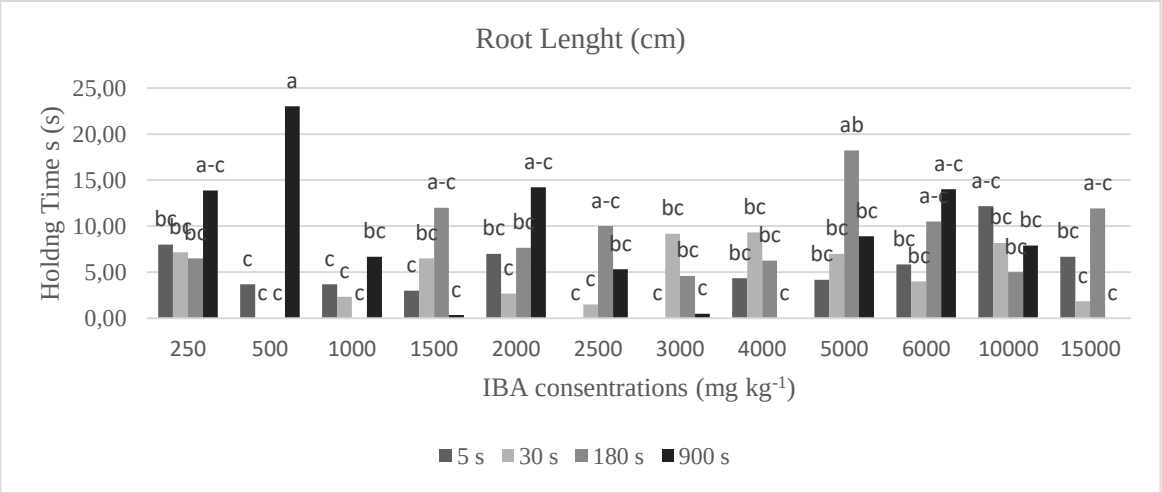

Figure 4. Graphics are belonging interactions average of root length ($LSD_{0.05;\ A*B}$: 11.44; $^{a,\ b,}$ …p <0.05)

Table 4. Average values and groupings belonging shoot and root weight

IBA cons. (mg kg^{-1})	Shoot Weight (g)					Root Weight (g)				
	Holding Time (secs)				Average	Holding Time (secs)				Average
	5	30	180	900		5	30	180	900	
250	0.33	0.71	0.34	0.73	0.53^{A-C}	0.06	0.37	0.11	0.30	0.21^{BC}
500	0.18	0.00	0.00	1.28	0.37^{BC}	0.06	0.00	0.00	0.68	0.19^{BC}
1000	0.46	0.22	0.00	0.08	0.19^{C}	0.20	0.10	0.00	0.03	0.08^{C}
1500	0.64	0.23	0.47	0.09	0.36^{BC}	0.27	0.14	0.15	0.02	0.15^{BC}
2000	0.26	0.61	1.16	1.16	0.80^{AB}	0.11	0.36	0.76	0.71	0.48^{AB}
2500	0.00	0.05	0.86	0.15	0.27^{BC}	0.00	0.01	0.48	0.07	0.14^{BC}
3000	0.00	0.70	0.43	0.05	0.30^{BC}	0.00	0.37	0.20	0.01	0.15^{BC}
4000	0.14	0.41	0.39	0.00	0.24^{BC}	0.03	0.15	0.20	0.00	0.10^{C}
5000	0.38	0.99	1.60	1.19	1.04^{A}	0.23	0.59	1.08	0.74	0.66^{A}
6000	0.65	0.25	1.00	0.53	0.61^{A-C}	0.20	0.08	0.57	0.31	0.29^{BC}
10000	1.21	0.95	0.30	0.20	0.66^{A-C}	0.69	0.50	0.15	0.13	0.37^{A-C}
15000	0.08	0.11	0.47	0.00	0.17^{C}	0.05	0.04	0.30	0.00	0.10^{C}
Average	0.36	0.44	0.59	0.46	0.46	0.16	0.23	0.33	0.25	0.24

$LSD_{0.01;IBA\ (SHOOT\ WEIGHT)}$:0.51; $LSD_{0.01;IBA\ (ROOT\ WEIGHT)}$: 0.31; $^{A,\ B,}$ … p<0.01

The highest root length of forage kochia cuttings was determined at 900 s holding time with 7.89 cm, while maximum dry root weight was obtained at 5 s the holding time with 0.048 g (Table 3, 5). But the highest values in percentage of rooting (58.33%), number of root (3.25), shoot length (13.10 cm), shoot weight (0.59 g), root weight (0.33 g), and leave yellowing (score 1.03) were found at 180 s holding time (Table 2-5) when considering holding times means.

Table 5. Average values and groupings belonging dry root weight and leave yellowing

IBA cons. (mg kg-1)	Dry Root Weight (g)					Leave Yellowing (Score)				
	Holding Time (secs)				Average	Holding Time (secs)				Average
	5	30	180	900		5	30	180	900	
250	0.04	0.08	0.04	0.09	0.06^{a-c}	1.00	1.33	1.00	1.67	1.25^{a}
500	0.03	0.00	0.00	0.14	0.04^{a-c}	0.67	0.00	0.00	2.00	0.67^{ab}
1000	0.05	0.02	0.00	0.01	0.02^{c}	0.33	0.67	0.00	0.67	0.42^{b}
1500	0.06	0.03	0.08	0.01	0.04^{a-c}	0.67	0.67	1.33	0.33	0.75^{ab}
2000	0.03	0.05	0.07	0.11	0.07^{ab}	1.00	0.67	1.33	2.00	1.25^{a}
2500	0.00	0.01	0.08	0.01	0.03^{bc}	0.00	0.67	1.67	0.33	0.67^{ab}
3000	0.00	0.10	0.05	0.01	0.04^{a-c}	0.00	2.00	0.67	0.33	0.75^{ab}
4000	0.02	0.03	0.02	0.00	0.02^{c}	0.67	1.00	1.33	0.00	0.75^{ab}
5000	0.06	0.09	0.10	0.08	0.08^{a}	0.67	1.33	2.00	1.33	1.33^{a}
6000	0.11	0.03	0.06	0.06	0.06^{a-c}	1.67	1.00	1.33	1.00	1.25^{a}
10000	0.16	0.06	0.02	0.03	0.07^{ab}	1.67	1.00	0.67	0.33	0.92^{ab}
15000	0.02	0.01	0.03	0.00	0.02^{c}	0.33	0.33	1.00	0.00	0.42^{b}
Average	0.048	0.042	0.046	0.046	0.046	0.72	0.89	1.03	0.83	0.87

*P Score: 1: Exist, 2: Absent, $^{a, b,}$ …p <0.05; $LSD_{0.05;IBA\ (DRY\ ROOT\ WEIGHT)}$:0.036; $LSD_{0.05;IBA\ (LEAVE\ YELLOWING)}$: 0.587var

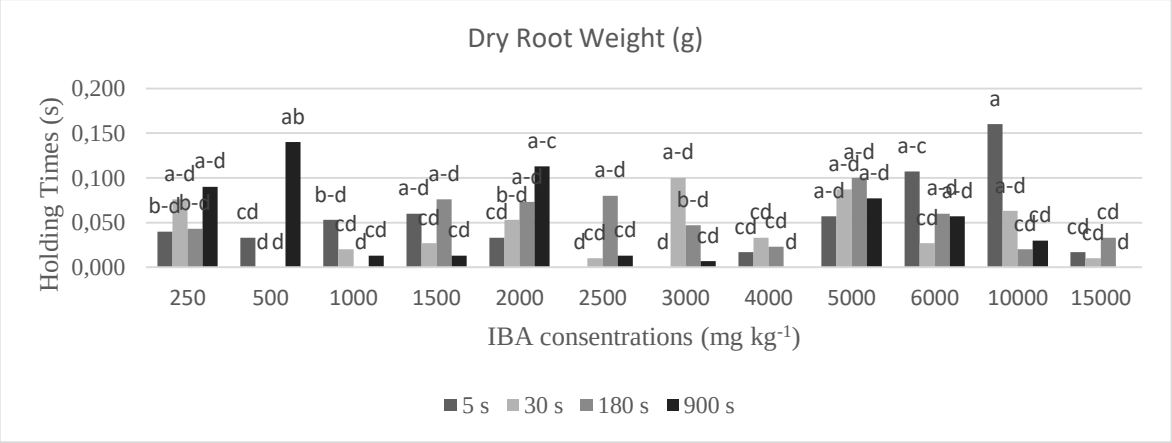

Figure 5. Graphics are belonging interactions average of dry root weight ($LSD_{0.05;A*B}$: 0.084; $^{a, b,}$ …p <0.05)

DISCUSSION AND CONCLUSIONS

This research investigated forage kochia cuttings in different IBA concentrations at four holding times could be stated that 500 mg kg^{-1} IBA at 900 s, 5000 mg kg^{-1} IBA at 180 s and 10000 mg kg^{-1} IBA at 5 s were the best concentrations and holding times for forage kochia cuttings to provide the best growth. There is inadequate literature related to the vegetative propagation of forage kochia, as mentioned earlier. Therefore, Sing and Singh (2017), who studied vegetative propagation of *Bassia latifolia* in the same genus with forage kochia, stated that 1000 mg kg^{-1} IBA concentration was sufficient for successful propagation when using one-year-old branches. Similarly, cuttings of *Kochia americana* (Syn. *Bassia americana*) in the same genus with forage kochia could be propagated without applying IBA in dry greenhouse conditions (Wieland et al. 1971).

Husen et al. (2017) applied different IBA concentrations (Control, 1000, 2000, and 3000 mg L^{-1}) for propagation quickly as clonal of *Morus alba* used as forage and energy plants in Himalaya. In the result was stated that 3000 mg L^{-1} IBA concentration has the maximum percentage of

rooting (86%), number of roots (10.62), and root length (6.74 cm).

Kara et al. (2011) determined that the research was carried out to aim to investigate the effect in five IBA concentrations (control, 1.000, 2.000, 3.000, and 4.000 mg kg^{-1}) at different periods (March, June, and September) on medicinal plants cuttings. The highest values of percentage of rooting (85.4%), number of roots (28.2), and root length (7.1 cm) were obtained in 4.000 mg kg^{-1} IBA concentration in March.

Yücesan et al. (2018) investigated the effect on rooting of two concentrations (1.000 and 5.000 mg kg^{-1}) of IBA and NAA hormones to cutting propagation in *Weigela floribunda* and *Spiraea x vanhuttei* species which use primarily in the landscape. The highest root length was obtained in 1000 mg kg^{-1} IBA with 20.62 cm, while the maximum number of roots was found in 5000 mg kg^{-1} IBA concentration with 12.58 in *W. floribunda*. This research determined that the highest percentage of rooting with 100% was obtained in 5000 mg kg^{-1} IBA concentration in both species. As a result, it was advised to 5000 mg kg^{-1} IBA concentration for strong shoot production.

Pourghorban et al. (2019) investigated the effect on growth parameter of IBA concentrations (0, 1500, 3000, and 4000 mg L^{-1}) in stem cuttings belong to *Rosa hybrida* cv. Dolce Vita. In this research, 3000 mg L^{-1} IBA concentration had the maximum values of percentage of rooting (97%), the number of roots (26.49), root weight (2.01 g), and dry root weight (0.22 g). However, 1500 mg L^{-1} IBA concentration had the highest root length (8.21) and shoot length (11.20 cm). When examined total chlorophyll in the leaves, the highest total chlorophyll was found in 1500 mg L^{-1} IBA concentration. The result has emphasized the importance of root and shoots development in stem cutting, and so, in *R. hybirda,* vegetative propagation was advised to 1500 mg L^{-1} IBA concentration.

The IBA enters the plant's vascular system through open stomata. Then, IBA is translocated by polar transport to the basal end; plants store it for self-regulated root formation (Kroin 2011). In vegetative propagation, such as stenting, it was found interactions between photosynthesis in leaves, root formation, and bud development (van de Pol et al. 1986, van de Pol and Pierik 1995, Pourghorban et al. 2019). For this reason, leave yellowing comes into prominence among other observations to selection cutting propagation of forage kochia. In our research, the best result in terms of percentage of rooting (100%), number of roots (>7), shoot length (>20 cm), root length (>10 cm), root weight (>0.60 g), dry root weight (>0.1 g) and leave yellowing (score >1.60) was obtained in 500 mg kg^{-1} IBA at 900 s, in 5000 mg kg^{-1} IBA at 180 s, in 10000 mg kg^{-1} IBA at 5 s holding time. As a result, we advised 500 mg kg^{-1} IBA at 900 s, 5000 mg kg^{-1} IBA at 180 s, and 10000 mg kg^{-1} IBA at 5 s for the quick and economically cutting propagation of forage kochia.

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