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Determination of Imazamox Herbicide Dose in in vivo Selection in Wheat (*Triticum aestivum* L.)

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ABSTRACT

A weed competes with crop plants for light, nutrition, water and air. They cause significant loss to agriculture and also reduce the productive capacity of land. Aim of this study is to evaluate effects of herbicide imazamox (IMI) on germination and seedling growth parameters and determine the optimal herbicide imazamox (IMI) dose which can be used in wheat breeding programs. In this study, 4 IMI doses [0 (control), 40, 50, 60 ppm], 3 buffer solutions (pH = 7.0) [MES hydrate, phosphate buffer and pure water] and 2 different pre-applications (seeds were kept either in herbicide solution for 24 hours or germinated in media containing herbicide) were applied as randomized plots design with two factors and three replications according randomized block in factorial design. Germination rate, average germination time, germination rate index and germination vigor index, root and shoot length and weights were measured. Control application with 24 h kept in water in all tested buffers resulted in increase in average germination time whereas decrease in all other germination parameters. No differences were observed between buffer applications regarding to Control treatment in germination media containing herbicide. When herbicide doses were compared based on average values of buffer applications, average germination time was elevated in respect to increase concentration of herbicide doses, on the other hand, common decrease was observed in other parameters. Effect of herbicide was observed on seedling parameters such as root and shoot length and weight rather than germination parameters. The highest adverse effect on plant growth and development was observed in phosphate buffer with 60 ppm imazomax application.

Buğdayda (*Triticum aestivum* L.) Imazamox (IMI) Herbisit Dozunun in vivo Seleksiyon İçin Belirlenmesi

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ÖZ

Yabancı otlar, kültür bitkileriyle su, mineral maddeler ve alan yönünden rekabete girerek çeşitli oranlarda verim kayıplarına yol açmaktadırlar. Bu çalışma, ekmeklik buğdayın Kırik çeşitinde imazamox (IMI) herbisitinin; çimlenme ve fide ile ilgili etkilerini ve ıslah amaçlı çalışmalarda uygulanabilecek optimum dozu belirlemek amacıyla yapılmıştır. Araştırma tesadüf parsellerinde 4 farklı IMI uygulama konsantrasyonu [0 (kontrol), 40, 50, 60 ppm], 3 farklı tampon solüsyonu (pH=7.0) [MES hydrate, Fosfat Buffer ve Saf su] ve 2 farklı ön uygulama [24 saat herbisit solüsyonunda bekletme ve daha sonra saf su içeren çimlenme kaplarında çimlendirme ve çimlendirme ortamında sürekli bulundurma] faktöriyel deneme desenine göre 4 tekrarlı olarak yürütülmüştür. Araştırma sonunda, çimlenme oranı (ÇO), ortalama çimlenme zamanı (OÇZ), çimlenme hızı indeksi ve çimlenme gücü indeksi (ÇGİ), kök ve sürgün uzunluğu ve ağırlıkları ile ilgili veriler elde edilmiştir. Yapılan incelemeler sonunda tüm çözeltilerdeki kontrol uygulamalarında 24 saat süreyle bekletme işleminde OÇZ zamanında artışa, diğer incelenen özelliklerin tamamında bir azalmaya neden olduğu gözlenmiştir. Çimlenme ortamında herbisitin devamlı olarak bekletildiği uygulama şeklinde yapılan incelemeler sonunda tampon solüsyonların kontrol uygulamaları karşılaştırıldığında aralarında bir fark olmadığı gözlenmiştir. Tampon çözeltilerinin ortalamasına göre herbisit dozları karşılaştırıldığında herbisit dozundaki artışa bağlı olarak OÇZ'de artış, bu özellik dışındaki diğer özelliklerde ise genelde önemli bir azalma kaydedilmiştir. Herbisitin etkisi tohumun çimlenmesinden ziyade bitki gelişimiyle yakından ilgili olan fide özelliklerinde (kök ve sürgün uzunluğu ve ağırlıkları) daha fazla olmuştur. Yapılan incelemeler sonunda en fazla büyüme ve gelişim engellenmesi fosfat tampon çözeltisinde hazırlanmış ve 60 ppm imazomax içeren ortamda meydana gelmiştir.

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1. Introduction

Wheat is one of the first cultivated food products and is the most important staple food. However, weeds are a significant barrier to high wheat productivity and cause 48% more loss of wheat yield (Khan and Haq, 2002). In Turkey, up to 30% reductions in wheat yield have been detected, especially in areas where wheat is planted in winter and where weed control is not done (Anonymous, 2012). Weeds compete with cultivated plants in terms of water, mineral substances and area and cause yield losses at various rates. One of the effective ways used to control weeds is the use of chemicals herbicide.

Winter annual weeds in wheat farming including, *Aegilops cylindrica, Bromus tectorum, Secale cereale, Lolium multiflorum, Avena fatua, Agrostemma githago, Alopecurus myosuroides, Anagallis arvensis, Avena sterilis, Bifora radians, Boreava orientalis, Briza humulis, Capsella bursa pastoris, Cardaria draba, Centaurea spp, Cephalaria syriaca, Hordeum murinum* causes significant losses. These weeds have the same or very similar life cycle as the wheat plant and it is very difficult to combat with classical wheat-fallow or other crop rotation methods. It does not have the power to distinguish the wheat plant from the damaging grass weeds by chemical methods (Ball and Peterson, 2007; Tursun, 2012). The competitiveness of weeds is generally high and especially early germination and development increase crop losses. In addition, the decrease in the quality of the product, the decrease in the seed value, the deterioration of its technological properties, the mixing of weed seeds in the product with the flour, spoiling the color, smell and taste of the flour products, and sometimes causing poisoning are among the other damages. Another negative aspect is that weeds make harvesting difficult, they create shelter, shelter and feeding place for many disease factors and harmful insects (Tursun, 2012).

Today, it is getting harder to discover a new herbicide and it is very difficult to find an herbicide with a new mode of action (Gressel, 2002). Given the difficulty of finding a new herbicide, developing herbicide-resistant cultivars and expanding the use of existing herbicides with a broad spectrum of weed control and environmental profile is a useful strategy. Three strategies are followed in conferring resistance to herbicides: resistance in the area of effect, metabolic detoxification and preventing the herbicide from reaching its area of action (Sherman et al. 1996). By improving one or more of these three mechanisms through genetic modification, a crop can be resistant to herbicide. Imidazolinone herbicides control weeds by inhibiting acetohydroxyacid synthase (Kita et al., 2007), also called acetolactate synthase (ALS), which is a critical enzyme for the biosynthesis of branched-chain amino acids in plants (Lee et al., 2011). These herbicides are used successfully in the control of broad-spectrum grass crops (grassaceae), broad-leaved weeds. In addition, these herbicides are highly effective at low application rates, have low mammalian toxicity, and an environmentally preferable profile. Therefore, imidazolinone herbicides have many ideal properties for use in an herbicide resistant crop.

However, for a system in which all weeds are removed as a result of the use of herbicides and only the wheat plant survives, the appropriate selection method is at the beginning of this process. This research was carried out to determine the effect of imazomax herbicide on wheat germination and seedling and to determine the optimum dose for *in vivo*.

2. Material and Methods

Bread wheat (*Triticum aestivum* L.) Kirik genotype seeds were used as plant material in the study. The seeds were counted and after washing these seeds in tap water, they were mixed in 70% ethyl alcohol (EtOH) for 3 minutes, washed 3 times with sterile distilled water in a sterile cabinet, and surface sterilization by mixing in 20% sodium hypochlorite containing a few drops of Tween 20 (Sigma) for 25 minutes. In this experiment, 4 different IMI concentrations [0 (control), 40, 50, 60 ppm], 3 different buffer solutions (PH=7.0) [MES hydrate, phosphate buffer and purified water] and 2 different pretreatments [Soaking in herbicide solution for 24 hours and then continuous keeping in germination and germination medium in germination containers containing pure water] was carried out in 4 repetitions according to the factorial trial design. The seeds were taken to germinate in the germination cabinet between papers in petri dishes. 14 ml of distilled water was placed in each petri dish. During germination, the temperature was adjusted to 25 ^{o}C and 16 hours of light and 8 hours of dark periods were applied. After the seeds were placed in the germination medium, germination data were obtained by counting every day for 14 days (the ones with a root length of 1 mm and above were considered germinated). The petri dishes were covered to prevent the lossof moisture by evaporation were kept in 16:8 h light: dark photoperiod and germinated at 25±1 °C.

Germination-Related Characters

Germination rate (%) (GR), mean germination time (MGT), germination rate index (GRI), and seedling vigor index (SVI) characters were obtained at the end of the 14th day (Hosseinpour et al., 2021).

Seedling-Related Characters

14 days after the seeds were placed in the germination medium, 10 seedlings were randomly taken from each petri dish, including root length (cm) (RL), shoot length (cm) (SL), root dry weight (g) (RDW), shoot. dry weight (g) (SDW) characters were measured (Hosseinpour et al., 2021).

Statistical Analysis

The effect of the herbicide dose, buffer solution type and herbicide application method were analyzed in a 4×3×2 according randomized block in factorial design. Differences between the means of variation sources in terms of germination and seedling growth characteristics were determined by LSD multiple comparison test at 5% significance level.

3. Results

Germination Characters

When GR, MGT, GRI, and SVI were examined, the main effect of the sources of variation and the effects of the double and triple interactions of these sources of variation differed according to the examined characteristics (Table 1 and Figure 1).

When evaluated according to the method of application on the basis of the averages, the highest GR, GRI and SVI were obtained in the form of herbicide application in the germination medium with 97.86%, 49.47 and 559.21, and the longest MGT was obtained in the form of 24 hours pre-application to the seed with 2.26 days. The lowest GR, GRI and SVI were obtained as 84.25%, 43.61 and 51.97 seed pre-application herbicides, respectively, and the lowest MGT was obtained in the form of herbicide application in the germination medium with 1.65 days (Table 2).

Based on the averages according to the buffer type, the highest GR, MGT, GRI and SVI were found to be 92.21% (pure water), 2.05 days (phosphate buffer), 47.73 (pure water) and 559.40 (pure water), respectively. The lowest GR, MGT, GRI and SVI were determined as 88.79% (Mes Hydrate), 1.89 days (Mes hydrate), 45.61 (phosphate buffer) and 521.44 (Mes hydrate) (Table 2). When evaluated according to the imazamox dose on the basis of the averages, the highest GR, GRI and SVI were obtained in the control (0 ppm) with 93.78%, 48.15 and 1454.86, and the longest MGT was obtained at 60 ppm imazamox dose with 2.04 days. The lowest GR, GRI and SVI were obtained in the control (0 ppm) with 88.06%, 45.20 and 200.77%, respectively, and the lowest MGT was obtained at 0 ppm Imazamox dose with 1.85 days (Table In terms of germination-related characters, the effect of the application method of imazamox herbicide, except for GRI, differed according to the buffer type used. Therefore, the effect of the herbicide on the way of application × buffer type was very significant (P<0.01) (Table 1). In order of highest GR, MGT, GRı and SVI; herbicide + MES hydrate in germination medium (98.17%), herbicide + phosphate buffer in seed pre-application (2.40 days), herbicide + purified water in germination medium (50.23), and herbicide + MES hydrate in germination medium (586.59) (Table 2). As can be seen in Table 2, the effect of the herbicide application method differed in terms of germination-related characters (except MGT) according to the herbicide doses used. Therefore, the effect of herbicide application method × herbicide dose was very important (P<0.01) (Table 1). The highest GR, MGT, GRI and SVI respectively; herbicide in germination medium + control dose (98.89%), herbicide pre-application to seed + 60 ppm (2.41 days), herbicide in germination medium + 0 ppm (50.59) and herbicide in germination medium + 0 ppm (1812.58) (Table 2). The effect of the buffer type, except GR, did not differ according to the herbicide doses used (Table 1). The highest GR was obtained with 96% of phosphate buffer buffer type + 40 ppm dose.

In terms of germination-related characters, the effect of imazamox herbicide application method differed according to the buffer type and doses used, except for MGT and GRI. Therefore, the effects of the herbicide application method × buffer type × dose were very important (P<0.01) (Table 1). The highest GR was found in the germination medium in herbicide + MES hydrate + 0 and 40 ppm applications (99.33%), and the lowest GR was determined in the seed pre-application herbicide + MES hydrate + 40 ppm (74.33%) applications. In terms of SVI; The highest SVI was obtained in the germination medium with herbicide + MES hydrate + 0 ppm application (1956.24) and the lowest in the germination medium in the herbicide + MES hydrate + 60 ppm application (120.63).

Seedling Growth Characters

When RL, SL, RDW and SDW were examined, the main effect of the sources of variation (except SDW) and the effect of the double and triple interactions of these sources of variation differed according to the examined characteristics (Table 1).

When evaluated according to the application method on the basis of the averages, the highest RL was obtained in the form of herbicide application in the germination medium with 2.91 cm, SL was obtained in the pre-application herbicide on the seed with 3.50 cm, the herbicide application on the seed with KYA 0.011 g and the pre-application herbicide on the seed 0.032 g in LYA. The lowest KU was determined as 2.45 cm pre-application herbicide, SL with 2.76 with herbicide in germination medium, RDW with 0.007 g pre-application herbicide and SDW with 0.26 herbicide application in germination medium (Table 2). Based on the averages according to the buffer type, the highest RL, SL, RDW and SDW were 2.80 cm (MES hydrate), 3.27 cm (phosphate buffer), 0.010 g (phosphate buffer and purified water) and 0.030 g (MES hydrate) respectively. The lowest SL, RDW and SDW were obtained, respectively, 2.51 cm (phosphate buffer), 2.97 cm (MES hydrate), 0.007 g (MES hydrate) and 0.028 g (phosphate buffer and pure water) (Table 2).

When evaluated according to imazamox dose based on the averages, the highest RL, SL, RDW and SDW were obtained in the control (0 ppm) with 7.67 cm, 7.67 cm, 0.020 g and 0.053 g. The lowest RL, SL, RDW and SDW were obtained at 60 ppm herbicide doses of 0.94 cm, 1.45 cm, 0.004 g and 0.019 g, respectively (Table 2).

In terms of seedling-related characters (except for RDW), the effect of the application method of imazamox herbicide differed according to the buffer type used. Therefore, the effect of the herbicide on the way of application × buffer type was very significant (P<0.01) (Table 1). In order of highest RL, SL, RDW and SDW; herbicide + MES hydrate (3.12 cm) in the germination medium, herbicide + pure water (3.84 cm) in the pre-application to the seed, herbicide + pure water and phosphate buffer (0.012 gr) in the germination medium, and herbicide + MES hydrate (0.034 g) in the pre-treatment of the seed. (Table 2). As seen in Table 2, the effect of the herbicide application method differed in terms of the characters related to the seedling according to the herbicide doses used. Therefore, the effect of herbicide application method × herbicide dose was very important (P<0.01) (Table 1). The highest RL, SL, RDW and SDW respectively; It was observed that herbicide + control dose (0 ppm) was applied in the germination medium with 9.76 cm, 8.56 cm, 0.030 gr and 0.062 gr (Table 2). The effect of the buffer type in terms of RL, SL, RDW and SDW differed according to the herbicide doses used (Table 1). MES Hydrate buffer type + 0 ppm dose (8.23 cm), pure water + 0 ppm dose (7.54 cm), phosphate buffer + 0 ppm dose (0.024 gr) and phosphate buffer + 0, respectively. It was obtained with a dose of ppm (0.061 g).

The effect of the application of imazamox herbicide in terms of characters related to the seedlings differed according to the buffer type and doses used. Therefore, the effects of the herbicide application method × buffer type × dose were very important (P<0.01) (Table 1). The highest RL was found in the herbicide + MES hydrate + 0 ppm applications (10.66 cm) in the germination medium, and the lowest RL in the herbicide + phosphate buffer + 60 ppm (0.44 gr) applications in the germination medium. In terms of SL; The highest SL was obtained in the herbicide + MES hydrate + 0 ppm applications (9.03 cm) in the germination medium, and the lowest in the herbicide + phosphate buffer + 60 ppm (0.69 gr) applications in the germination medium. In terms of RDW; The highest RDW was obtained in the germination medium in the herbicide + phosphate buffer + 0 ppm applications (0.034 gr) and the lowest in the seed pre-application herbicide + MES hydrate + 60 ppm (0.002 gr) applications. The highest SDW was observed in the herbicide + phosphate buffer + 0 ppm applications (0.077 gr) in the germination medium, and the lowest SDW was observed in the herbicide + phosphate buffer + 60 ppm (0.010 g) applications in the germination medium.

Table 1. *Variance Analysis Results and LSD Values Of Germination Characteristics*

	Sources of variations	[1]GR	[2]MGT	[3]GRI	[4]SVI	[5]RL	[6]SL	[7]RDW	[8]SDW
Method of Application (M)	**DF**	1	1	1	1	1	1	1	1
	MS	6669.44	13.65	1236.62	76979.24	7.65	19.52	0.001	0.001
	F	375.86	287.46	224.94	14.03	30.33	84.31	177.98	26.37
	p	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Buffer solution Type (B)	**DF**	2	2	2	2	2	2	2	2
	MS	184.52	0.33	56.66	19992.86	1.09	1.11	0.00	0.00
	F	10.39	7.019	10.30	3.64	4.32	4.79	35.55	1.52
	p	0.00	0.001	0.00	0.02	0.01	0.01	0.00	0.21
Dose (D)	**DF**	3	3	3	3	3	3	3	3
	MS	225.55	0.33	78.77	13523288.39	398.75	329.64	0.002	0.009
	F	12.71	6.97	14.33	2465.28	1581.20	1423.76	581.55	228.84
	p	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MxB	**DF**	2	2	2	2	2	2	2	2
	MS	240.19	0.16	8.32	65396.59	0.39	1.981	0.00	0.00
	F	13.53	3.41	1.51	11.92	1.54	8.55	0.47	4.92
	p	0.00	0.03	0.22	0.00	0.21	0.00	0.62	0.009
MXD	**DF**	3	3	3	3	3	3	3	3
	MS	143.14	0.11	29.45	1802307.37	55.33	26.05	0.001	0.002
	F	8.06	2.35	5.35	328.55	219.43	112.55	226.83	50.02
	p	0.00	0.07	0.002	0.00	0.00	0.00	0.00	0.00
BxD	**DF**	6	6	6	6	6	6	6	6
	MS	150.41	0.03	4.88	10616.29	0.80	0.51	0.00	0.00
	F	8.47	0.76	0.88	1.93	3.20	2.21	18.98	8.57
	p	0.00	0.596	0.506	0.08	0.006	0.04	0.00	0.00
MxBXD	**DF**	6	6	6	6	6	6	6	6
	MS	145.12	0.03	6.49	41033.52	0.80	1.18	0.00	0.00
	F	8.17	0.69	1.18	7.48	3.17	5.11	3.30	4.69
	p	0.00	0.65	0.32	0.00	0.006	0.00	0.005	0.00
Error	**DF**	120	120	120	120	120	120	120	120
	MS	17.744	0.047	5.49	5485.48	0.25	0.23	0.000004	0.000041
LSD $_{(0.05)}$	**M**	1.39	0.07	0.77	24.44	0.17	0.16	0.0006	0.0021
	B	1.70	0.09	0.95	29.93	0.20	0.19	0.0008	0.0026
	D	1.97	0.10	1.09	34.56	0.23	0.23	0.0009	0.0030
	MXB	2.41	0.12	1.34	42.33	0.29	0.28	0.001	0.003
	MXD	2.78	0.14	1.55	48.88	0.33	0.32	0.001	0.004
	BXD	3.40	0.18	1.90	59.87	0.41	0.39	0.001	0.005
	UXTXD	4.82	0.25	2.68	84.66	0.57	0.55	0.002	0.007
Coefficient of Variation (%)		4.63	11.15	5.04	13.82	18.73	15.37	20.99	21.95

[1]GR; Germination rate, [2]MGT; mean germination time, [3]GRI; germination rate index, [4]SVI; seedling vigor index, [5]RL; root length, [6]SL; shoot length, [7]RDW; root dry weight and [8]SDW; shoot dry weight.

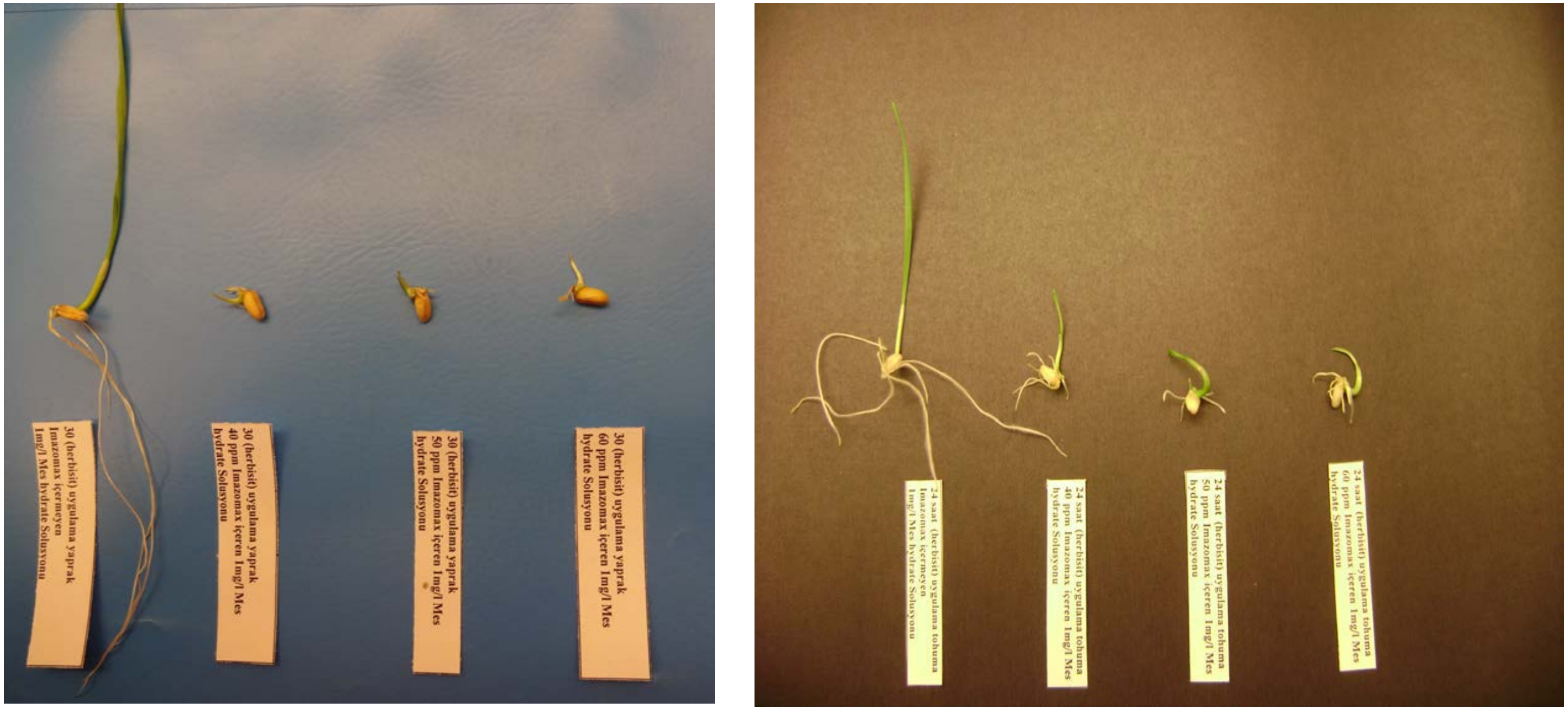
Table 2. *Mean comparison of different method of applicatin, buffer solution type and dose of IMI on germination and seedling growth parameters of wheat*

Method of Application	Buffer solution Type	Dose (ppm)	[1]GR	[2]MGT	[3]GRI	[4]SVI	[5]RL	[6]SL	[7]RDW	[8]SDW
Herbicide in germination medium	MES Hydrate	0	99.33	1.56	51.26	1956.24	10.66	9.03	0.024	0.056
		40	99.33	1.67	49.51	136.00	0.64	0.73	0.005	0.028
		50	95.33	1.69	48.44	133.48	0.61	0.79	0.004	0.013
		60	98.67	1.69	49.19	120.63	0.56	0.66	0.004	0.009
		Mean	98.17	1.65	49.60	586.59	3.12	2.80	0.0096	0.026
	Phosphate buffer	0	98.67	1.66	49.22	1726.37	8.81	8.68	0.034	0.077
		40	96.67	1.68	48.43	165.49	0.77	0.95	0.006	0.011
		50	98.33	1.77	47.81	139.73	0.59	0.83	0.004	0.013
		60	98.00	1.70	48.84	111.09	0.44	0.69	0.003	0.010
		Mean	97.92	1.70	48.57	535.67	2.66	2.79	0.012	0.028
	Pure water	0	98.67	1.54	51.28	1755.15	9.81	7.98	0.031	0.052
		40	97.33	1.57	50.34	145.61	0.63	0.87	0.005	0.014
		50	98.00	1.64	49.60	143.06	0.59	0.88	0.004	0.014
		60	96.00	1.61	49.69	177.72	0.81	1.05	0.006	0.016
		Mean	97.50	1.59	50.23	555.39	2.96	2.70	0.012	0.024
	Mean	0	98.89	1.59	50.59	1812.58	9.76	8.56	0.030	0.062
		40	97.78	1.64	49.43	149.03	0.68	0.85	0.005	0.018
		50	97.22	1.70	48.62	138.76	0.60	0.83	0.004	0.013
		60	97.56	1.66	49.24	136.48	0.61	0.80	0.004	0.0122
		Mean	97.86	1.65	49.47	559.21	2.91	2.76	0.011	0.026
Pre-application to seed Herbicide	MES Hydrate	0	85.33	1.98	44.29	991.60	5.79	5.85	0.005	0.046
		40	74.33	2.13	44.85	281.27	1.35	2.44	0.006	0.031
		50	76.67	2.29	40.91	278.20	1.41	2.18	0.004	0.028
		60	81.33	2.14	41.73	274.07	1.33	2.05	0.002	0.032
		Mean	79.42	2.14	42.95	456.29	2.47	3.13	0.004	0.034
	Phosphate buffer	0	90.33	2.32	45.85	1173.30	5.62	7.36	0.014	0.045
		40	95.33	2.22	45.06	350.71	1.30	2.38	0.005	0.023
		50	80.00	2.50	39.90	286.37	1.34	2.25	0.005	0.022
		60	80.00	2.56	39.76	266.47	1.20	2.12	0.007	0.023
		Mean	86.42	2.40	42.64	519.21	2.37	3.53	0.008	0.028
	Pure water	0	90.33	2.01	47.01	1126.48	5.35	7.09	0.013	0.043
		40	90.67	2.16	46.39	443.33	1.73	3.18	0.006	0.030
		50	92.33	2.33	45.57	429.25	1.72	2.92	0.006	0.030
		60	74.33	2.52	41.97	254.62	1.27	2.15	0.004	0.026
		Mean	86.92	2.25	45.24	563.42	2.52	3.84	0.007	0.032
	Mean	0	88.67	2.10	45.72	1097.13	5.58	6.77	0.011	0.045
		40	86.78	2.17	45.43	358.44	1.46	2.67	0.006	0.028
		50	83.00	2.37	42.13	331.28	1.49	2.45	0.005	0.027
		60	78.56	2.41	41.15	265.05	1.27	2.11	0.004	0.027
		Mean	84.25	2.26	43.61	512.97	2.45	3.50	0.007	0.032

Table 2. *continued*

Method of Application	Buffer solution Type	Dose (ppm)	[1]GR	[2]MGT	[3]GRI	[4]SVI	[5]RL	[6]SL	[7]RDW	[8]SDW
Mean	MES Hydrate	0	92.33	1.77	47.78	1473.92	8.23	7.44	0.014	0.051
		40	86.83	1.90	47.18	208.63	1.00	1.58	0.005	0.029
		50	86.00	1.99	44.68	205.84	1.01	1.49	0.004	0.020
		60	90.00	1.91	45.46	197.35	0.95	1.36	0.003	0.020
		Mean	88.79	1.89	46.27	521.44	2.80	2.97	0.007	0.030
	Phosphate buffer	0	94.50	1.99	47.53	1449.83	7.21	8.02	0.024	0.061
		40	96.00	1.95	46.75	258.10	1.04	1.66	0.005	0.017
		50	89.17	2.13	43.86	213.05	0.97	1.54	0.004	0.018
		60	89.00	2.13	44.30	188.78	0.82	1.41	0.005	0.016
		Mean	92.17	2.05	45.61	527.44	2.51	3.16	0.010	0.028
	Pure water	0	94.50	1.78	49.15	1440.81	7.58	7.54	0.022	0.048
		40	94.00	1.86	48.36	294.47	1.18	2.03	0.006	0.022
		50	95.17	1.98	47.59	286.16	1.15	1.90	0.005	0.022
		60	85.17	2.06	45.83	216.17	1.04	1.60	0.005	0.021
		Mean	92.21	1.92	47.73	559.40	2.74	3.27	0.010	0.028
	Mean	0	93.78	1.85	48.15	1454.86	7.67	7.67	0.020	0.053
		40	92.28	1.90	47.43	253.73	1.07	1.76	0.005	0.023
		50	90.11	2.03	45.37	235.02	1.04	1.64	0.005	0.020
		60	88.06	2.04	45.20	200.77	0.94	1.45	0.004	0.019
		Mean	91.06	1.96	46.54	536.09	2.68	3.13	0.009	0.029

[1]GR; Germination rate, [2]MGT; mean germination time, [3]GRI; germination rate index, [4]SVI; seedling vigor index, [5]RL; root length, [6]SL; shoot length, [7]RDW; root dry weight and [8]SDW; shoot dry weight.



A **B**

Figure 1: *Determination Of The Herbicide Dose To Be Used For Selection, Application To Seed; A: Adding Herbicide To The Germination Water; B: Deep Soaking For 24 Hours In Herbicide Solution.*

4. Discussion

Weeds compete with cultivated plants in terms of water, mineral substances and area and cause yield losses at various rates. Weeds cause a decrease of approximately 30% in wheat yield. One of the effective ways to combat weeds is the use of chemicals herbicide. However, for a system in which all weeds are removed as a result of the use of herbicides and only the wheat plant survives, the appropriate selection method is at the beginning of this process.

This research was carried out to determine the optimum dose for in vivo selection of the effect of imazomax herbicide on wheat germination and seedling growth. At the end of the examinations, it was observed that the control applications in all solutions caused an increase in the MGT and a decrease in all of the other examined properties in the 24-hour waiting process. The probable reason for this may be that the substances in the seed and necessary for germination passed into the environment by diffusion, thus reducing the germination rate of the seed. At the end of the examinations made in the form of the application in which the herbicide is kept continuously in the germination medium, it was observed that there was no difference between the control applications of the buffer solutions. When the herbicide doses were compared according to the average of the buffer solutions, an increase in MGT was observed due to the increase in the herbicide dose, and a significant decrease was observed in other features other than this feature. Again, the effect of the herbicide was more on the characteristics of the grass (root and shoot length and weight), which are closely related to plant growth rather than seed germination. At the end of the examinations made in terms of these properties, the most growth and development inhibition occurred in the medium prepared in phosphate buffer solution and containing 60 ppm imazomax.

Imidazolinones are one of five families of chemical herbicides that inhibit AHAS. The other four families are sulfonylurea, triazolo pyrimidine, Pyrimidinyl thiobenzoates, and sulfonyl amino-carbonyltriazolinones (Pang et al., 2002). Imidazolinones include imazapyr, imazapic, imazetapir, imazamox, imazametabenz, and imazaquin. As the names suggest, all imidazolinones have an imidazole moiety in their molecular structure (Hershey et al., 1999). In field studies in the USA, it has been reported that the imidazolinone herbicide is effective in the control of *Aegilops cylindrica* in wheat fields, *Sorghum bicolor* and *Sorghum halepense*, which is difficult to control in corn fields (Shaner et al., 1984). Also, Brassica kaber, Pluchea camphorata, Bromus secalinus, Lolium multiflorum. and Echinochloa crusgalli, it has been determined that it can be used successfully in the control of many weeds in the rice field (White and Hackworth, 1999). Plants resistant to midazolinones, sulfonylureas,triazolopyrimidines and pyrimidyloxybenzoates can be found in maize (*Zea mays* L.) (Newhouse et al., 1991), *Arabidopsis thaliada* (L.) Heynh (Mourad et al.,1993), sugar beet (*Beta vulgaris* L.) (Wright and Penner 1998), canola (*Brassica napus* L.) (Swanson et al., 1989a), cotton (*Gossypium hirsutum* L.) (Rajasekaran et al., 1996), soybean (*Glycine max* L.) (Sebastian et al., 1989), tobacco (*Nicotiana tabacum* L.) (Creason and Chaleff 1988), and bread wheat (Newhouse et al., 1992).

In line with the results obtained above, it was recommended to germinate the seeds for herbicide resistant selection in a germination medium prepared in phosphate buffer solution and containing 60 ppm imazomax.

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Conflict of Interest Statement

The authors declare that there is no conflict of interest between them.

Author Contributions

KH designed and analyzed the research. AT an MA carried out the preparation of the tables. All authors contributed to the writing of the article and took part in the publication process of the article and read and approved it.

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