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EARLY EFFECTS OF A CONTROL-RELEASE FERTILIZER ON THE SURVIVAL AND GROWTH OF WILD CHERRY (*PRUNUS AVIUM* L.) SEEDLINGS IN DÜZCE

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ABSTRACT

One-year old nursery grown wild cherry (*Prunus avium* L.) seedlings was planted on a mesic western Black Sea Region site near Akçakoca, DÜZCE. Five different rates (0, 80, 160, 240, and 320 g seedling^{-1}) of a controlled-release fertilizer (Basacote® Plus 6 M, COMPO Benelux, Belgium) were applied to the seedlings in the beginning of April 2009. One and two years after treatments (YAT), fertilizer treatments made no significant effect on seedling survival. A reduced seedling survival was noted for the highest fertilizer rate. Two YAT, the lowest (80 g) rate significantly improved seedling diameter growth when compared to no-fertilization treatment. Similar to the survival, fertilizer treatments made no significant effect on foliage C and N concentrations and C/N ratio. Use of the lowest rate is recommended for this type of fertilizer for early seedling growth. High rates of this CRF may be toxic to young seedlings and therefore not recommended. Looking into the effects of the fertilizer at lower rates (< 80 g seedling^{-1}) is also recommended for future studies for greater cost-efficiency and environmental safety. Applying CRFs should also be coupled with an effective weed control for enhanced seed survival and growth. Wild cherry has a high demand for site conditions. Therefore, planting this broadleaved tree species on inland sites with poor physical edaphic conditions should be avoided.

Keywords: Basacote, early seedling performance, fertilizer rate, western Black Sea Region

DÜZCE'DE KONTROLLÜ SALIMLI BİR GÜBRENİN YABANİ KİRAZIN (*PRUNUS AVIUM* L.) YAŞAMA VE BÜYÜMESİ ÜZERİNDEKİ ÖN ETKİLERİ

ÖZET

Bu çalışmada, Akçakoca, DÜZCE yakınlarında nemli bir Batı Karadeniz Bölgesi sahasına dikilen bir yaşındaki yabani kiraz (*Prunus avium* L.) fidanları kullanılmıştır. 2009 yılının Nisan ayında fidanlara kontrollü salımlı bir gübrenin (KSG) (Basacote® Plus 6 M, COMPO Benelux, Belgium) beş farklı dozu (0, 80, 160, 240 ve 320 g fidan^{-1}) uygulanmıştır. Denemden bir ve iki yıl sonra, gübreleme denemeleri fidan yaşama yüzdesi üzerinde önemli bir etki yapmamıştır. En yüksek gübre dozu fidan yaşama yüzdesinin bir miktar düşürdüğü tespit edilmiştir. Denemenin ikinci yılı sonunda gübre atılmayan fidanlara kıyasla en düşük dozlu deneme (80 g) fidan çapını önemli oranda artırmıştır. Gübreleme işlemleri yaşama yüzdesinde olduğu gibi C ve N fidan yaprak besin elementi yoğunluklarında ve C/N oranında önemli bir etki yapmamıştır. Bu sonuçlar çerçevesinde, dikimden sonraki ilk dönemlerde, yaban kiraz fidan büyüme performansının artırılmak için KSG en düşük dozunun uygulanması önerilmiştir. Bu gübrenin yüksek dozları genç fidanlara zarar verebileceğinden dolayı kullanılmaması önerilir. Daha düşük işlem maliyet ve çevre güvenliği için gelecekteki çalışmalarda bu KSG'nin daha düşük dozlarının ((< 80 g fidan^{-1}) denenmesi önerilir. Yüksek bir fidan yaşama ve büyüme performansı için KSG uygulamalarının yanında etkili bir diri örtü mücadelesinin de yapılması gerekmektedir.

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Anahtar kelimeler: Batı Karadeniz Bölgesi, basacote, gübre dozları, ön fidan performansı

1. INTRODUCTION

Wild cherry (WCh) is a rare native broadleaved tree species growing in the mixed forests of the European and Turkish forests with a distinct scattered distribution (Russel, 2003, Eşen et al., 2005). This tree species has important ecological (biodiversity, wildlife habitat), economical (wood), and socio-cultural functions. Therefore, WCh is listed among the "valuable broadleaved tree species" of Europe. Recently, research has focused on seed germination, herbaceous weed control, and early seedling growth performance of cherry species in Turkey (Eşen et al., 2006, Esen et al., 2007, Eşen et al., 2009, Eşen et al., 2011a). Growing the species on productive forest sites and some marginal agricultural sites is highly recommended in Europe and Turkey (Eşen et al. 2005; Eşen et al., 2011b, Hemery et al., 2008, Savill et al., 2009).

Recently planted broadleaved tree species frequently experience a "transplant shock", reducing seedling survival. Moisture and nutrient deficiencies in the soil exacerbate the negative effect of transplant shock on young seedlings (Jacobs et al., 2005). These stresses are felt more intensively by "site-demanding" valuable broadleaved tree species including wild cherry (Hemery et al., 2008, Savill et al., 2009). Therefore, enhancing availabilities of moisture and nutrients in the soil is the key to achieving high survival and growth rates for the young seedlings of these tree species (Savill et al., 2009).

Fertilization is the most common method to enhance the nutritional status of the soil (Jacobs et al., 2005). The responses of broadleaved tree species including wild cherry to fertilization in survival and growth are however inconsistent (Hipps et al., 1994, Kupka, 2003; Jacobs et al., 2005, Jensen et al., 2007). Jacobs et al. (2005) attributed these inconsistent reports in the literature to the variable types and application techniques employed in these studies. Conventional agricultural fertilizers release nutrients immediately to the soil solution only a small fraction of which is acquired by plant (Jacobs et al., 2005). In addition, large amounts of nutrients discharged to the soil solution at once might accumulate to toxic levels in the rhizosphere for seedlings. Unwanted vegetation benefits from broadcast application of conventional fertilizers more than tree seedlings unless an effective weed control is employed (Jacobs et al, 2005).

Alternatively, controlled-release fertilizers (CRF) release available nutrients gradually over a long period time (3-18 months) with a greater uptake efficiency and environmental safety (Jacobs et al., 2005). Newly planted tree seedlings thus greatly benefit from this steady and long-lasting supply of nutrients. CRFs also reduce leaching of nutrients and negative effects on the environment (Jacobs et al., 2005).

Although effects of controlled-release fertilizers on the survival and growth of conifers and some N. American broadleaved tree species have been studied (Jacobs et al., 2005), little information exists on their effects in young wild cherry plantations in Europe and Turkey. The present study assesses the early effects of six different rates of a polymer-coated controlled-release NPK fertilizer on the survival, growth and nutritional response of one- and two-year old wild cherry seedlings planted on two different western Black Sea Region sites in northern Turkey.

2. MATERIALS AND METHODS

2.1. Site description

Two different experiments were carried out in the western Black Sea Region. The first site is on a relatively inland and low-elevation (248 m asl) site located near Düzce (41^0 18.346'N; 31^0 25.454'E) in the Cumayeri Chiefship of the Düzce Forestry Directorate in the western Black Sea Region (BSR) of Turkey whereas the second site lies on a high-elevation (1100 m asl) site located near Alaplı, Zonguldak (41^0 03.667'N; 31^0 36.800'E) in the Bendere Chiefship of the Karadeniz Ereğlisi Forestry Directorate. The Cumayeri site is an inland site with a mean annual temperature and precipitation of 13°C and 1100 mm, respectively (Anonymous, 2008a). The site had a degraded oak coppice prior to the experiment. Soil is heavy (clay) with a low drainage. On the Bendere site, the mean annual temperature and precipitation on the site are 13°C and 1100 mm, respectively (Anonymous, 2008b). The site had a closed, mature pure eastern beech (*Fagus orientalis* Lipsky) in the overstory and dense purple-flowered rhododendron (*Rhododendron ponticum* L.) in the understory. Fertile, loamy soil was the characteristic feature on the site. The various soil chemical characteristics of the experimental site were summarized in Table 1. For site preparation, the experimental site were raked to eliminate competing vegetation and subsequently ripped to the first one-meter soil depth to enhance rhizospher using a bulldozer in the autumn of 2007 prior to the onset of the experiment.

Table 1. Various characteristics of the soil between 0-20 cm on the Cumayeri and Bendere experimental sites in the western Black Sea Region of Turkey.

Site	pH	Bulk Density (g cm^{-3})	C (%)	N (%)	P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	CEC (cmol $_c$ kg_1)
			…………….Total…………..			……….Exchangeable.……			
Cumayeri	5.8	1.6	5.4	0.32	230	130	550	220	33
Bendere	5.5	1.2	5.8	0.41	280	130	420	270	26

2.2. Planting Material

In 2006, seeds were obtained from 40-50 year-old wild cherry trees growing in Hallı and Gümeli (41^{o}05'09''N; 31^{o}28'00''E) of Karadeniz Ereğlisi, Zonguldak between 400-800 m elevations. Seeds were germinated, and germinated seedlings were grown at the Zonguldak Devrek State Forest Nursery (41^{o}13'30''N; 31^{o}57'35''E) in 2007 using standard operations employed by forest nurseries in Turkey.

For the Bendere site, the first group of one-year old seedlings was lifted in the fall of 2007 from nursery beds after dormancy was initiated. For the Cumayeri site, a second group of one-year old seedlings that were of the same origin as those planted on the Bendere site was similarly lifted from the same nursery in the fall of 2008. Following pruning, the roots of all of the bareroot seedlings were burlapped and maintained moist until they were planted. Seedlings were stored at 3^{o}C in a cold in Düzce University Faculty of Forestry room for a short-term until they were carefully transferred to the planting site. Seedlings were planted within rows with 3 x 3 spacing on both sites. Each seedling row contained 19-21 seedlings in total.

2.3. Treatments

Treatments consisted of five different rates (0, 80, 160, 240, and 320 g seedling^{-1}) of a CRF (Basacote® Plus 6 M, COMPO Benelux, Belgium), containing 16% N, 18% P, 12% K, 2% MgO, and 5% S and trace elements (Anonymous, 2011). These treatments were consistently applied to the one- and two-year old wild cherry seedlings planted on the low-elevation (Cumayeri, Düzce) and high-elevation site (Bendere, Kdz. Ereğlisi), respectively, in the beginning of April 2009 after leaves of seedlings were fully out. The within- and between-rows on the two experimental sites were manually maintained weed-free using a hand sickle during the entire experiment.

2.4. Measurements

Initial height and ground line diameter (henceforth termed diameter) were measured for each seedling at the beginning and end of the experiment. Neither the initial diameter nor height of the seedlings differed significantly among the treatments at the beginning of the experiment. Seedling survival (%) was computed for each of the treatments. Also, relative diameter and height growth rate of seedlings in each treatment was computed with the following formula (Radosevich et al., 2007):

$$RGR\ (\%) = [((G_2 - G_1)/G_1)*100]$$

where:

RGR = Relative growth (diameter or height) rate of a seedling from the beginning and end of the experiment

G_1 = Seedling diameter (mm) or height (cm) at the beginning of the experiment

G_2 = Seedling diameter (mm) or height (cm) at the end of the first or second growing season

Leaf nutrient analyses were carried out for C and N using randomly selected 15 seedlings on each treatment row. Eight to ten leaves from upper, middle, and lower crown were gathered from each seedling. Following air-drying, the leaf samples were ground with a conventional coffee grinder and then dried at 80^{o}C and weighed into 100-200 mg aliquots for total C analysis, and 500-mg aliquots each for analysis of N (Jones and Case, 1990, Yildiz et al., 2010).

Two sets of soil samples were obtained with randomly determined positions on each study site using 100 cm^3 core samplers (Yildiz and Esen 2006). For soil moisture content and bulk density assessments, one sample set was dried at 105^0C in the lab for 24 h. The remaining set of the sample was air-dried and prepared for chemical analysis (Yildiz and Esen, 2006).

Total C concentrations were determined with a dry combustion method in a LECO CNS 2000 Carbon Analyzer (Nelson and Sommers, 1996). Following digestion, samples were analyzed for total soil N with the micro-Kjeldahl method (Kjeltec Auto 1030 Model) (Nelson and Sommers, 1980, Bremner, 1996). Following digestion in nitric and perchloric acids, samples were analyzed for total soil P and total S using a Spectronic Colorimeter (Kuo, 1996, Tabatabai, 1996). Exchangeable cations (K, Ca, Mg) were extracted with ammonium acetate (Suarez, 1996). Calcium and Mg were assessed with a Perkin-Elmer Atomic Absorption Spectrometer whereas potassium was determined using a Jenway Flame Photometer. Cation exchange capacity (CEC) was determined from NH4OAc extraction (Sumner and Miller, 1996). Air-dried samples placed in deionized water were used to determine soil pH with a pH meter (Thomas, 1996).

2.5. Experimental design and statistical analysis

A randomized complete block design with four blocks was employed. Each seedling row made up an experimental unit. The experimental treatments were randomly assigned to the seedling rows. Effects of the treatments on seedling survival, growth, and nutrition were analyzed using one-way analysis of variance (ANOVA). Data were checked to determine that the variables were normally distributed and the variances were homogeneous. Duncan mean separation test was employed to separate treatment means. Results for ANOVA were considered significant at $p \leq 0.05$.

3. RESULTS

Almost total seedling mortality occurred on the inland (Cumayeri) site two years after treatment (YAT) regardless of treatments. Therefore, the Cumayeri site was excluded from analysis, and only the data of Bendere site was reported in this manuscript. For the Bendere site, treatments made no significant differences on mean seedling survival rate both one and two years after treatment (YAT) (Table 2). The lowest mean seedling survival for the highest fertilizer rate was however noted. Seedling survival in general decreased a little from one to two YAT. Unlike survival, there were significant growth differences for seedlings one and two YAT. The seedlings with the 80- and then 240-g Basacote averaged significantly greater mean diameters (57 and 44%, respectively) when compared to the seedlings with the greatest fertilizer rate one YAT (Table 2).

Table 2. Effects of different rates of a slow release fertilizer on the survival and growth of two-year old wild cherry seedlings planted in Bendere in the western Black Sea Region of Turkey one and two years after treatments (YAT).

Fertilizer Rate (g $seedling^{-1}$)	Survival (%)	Diameter (mm)	Height (cm)	H/D Ratio
--------1 YAT--------				
0	71 a[1] (±11)	16.7 ab (±1.2)	92 a (±6)	54 a (±2)
80	83 a (±3)	20.5 a (±0.6)	114 a (±3)	56 a (±2)
160	80 a (±7)	17.4 ab (±1.5)	106 a (±11)	61 a (±2)
240	82 a (±9)	18.9 a (±1.7)	115 a (±16)	59 a (±4)
320	66 a (±2)	13.1 b (±0.9)	84 a (±10)	63 a (±4)
--------2 YAT--------				
0	68 a[1] (±14)	19.6 b (±1.3)	126 b (±8)	64 b (±1)
80	79 a (±5)	26.0 a (±1.0)	162 ab (±3)	63 b (±2)
160	69 a (±10)	24.6 ab (±1.9)	162 ab (±13)	65 b (±3)
240	75 a (±11)	25.4 ab (±2.8)	171 a (±20)	69 ab (±1)
320	56 a (±3)	19.9 ab (±0.8)	147 ab (±9)	74 a (±2)

[1] Means within the same column with different letters within the same experimental site are significantly different ($p \leq 0.05$),

[2] Mean separations after logarithmic transformation were used.

The superiority of the 80- and 240-g-Basacote treatments continued for the second-year seedling diameter and height, respectively (Table 2). The seedlings with the former fertilizer rate had a significantly greater (33%) mean diameter when compared to those with no fertilizer. The seedlings with the 240-g fertilizer averaged a 36% greater height growth than the control seedlings two YAT. The seedlings with the greatest fertilizer rate averaged a significantly greater (≥14%) sturdiness ratio when compared to those with 80 and 240 g fertilizer and no fertilizer (Table 2). There were no significant differences among treatments for foliage C (mean concentration across treatments: 48%), N (2.3%), and C/N ratio (21).

4. DISCUSSION

The total seedling mortality on the Cumayeri site is probably attributed to the poor growing conditions on this site. Unlike mesic and favorable conditions of the Bendere site, the Cumayeri site had interior conditions coupled with poor physical edaphic conditions (higher soil bulk density, heavier texture). These stresses probably resulted in the unsuccessful establishment of WCh that has high demand for growing conditions (Hemery et al., 2008, Savill et al., 2009).

Controlled release fertilizers have clear advantages in providing a gradual nutrient supply to recently planted tree seedlings over conventional agricultural fertilizers with instantaneous nutrient availability (Jacobs et al. 2005). Jacobs et al. (2005) applied Osmocote®, a controlled release fertilizer, at rates varying between 15-75 g $plant^{-1}$ to recently planted one-year old bareroot seedlings of black walnut (*Juglans nigra* L.), white ash (*Fraxinus americana* L.), and yellow-poplar (*Liriodendron tulupifera* L.) in southern Indiana in USA. The seedlings with the 60-g-rate had a substantially greater mean GLD and height growth in one and two YAT when compared to the non-fertilized seedlings regardless of tree species. A 25-g Osmocote also increased the survival and growth of one-year old downy birch (*Betula pubescens* Ehrh.) seedlings six YAT in Iceland (Oskarsson et al., 2006).

Similar to the previous studies, application of CRF enhanced early seedling growth to a certain extent (Table 2). Fertilizer application significantly improved seedling diameter growth only at the lowest rate when compared to non-fertilization treatment. Increasing rate beyond the 80-g per seedlings did not make a further improvement in growth. In fact, fertilizer reduced survival and growth at the highest rate, suggesting toxic effects for young WCh seedlings (Table 2). The adverse effects of high fertilizer rates on broadleaved tree seedlings have been reported previously (Williams and Hanks 1994). High nutrient concentrations in the rhizosphere that was resulted from high fertilizer rates can damage the root system of seedlings, decreasing survival and growth (Jacobs et al., 2005, Oskarsson et al., 2006).

A disadvantage of CRF in comparison to traditional agricultural fertilizers is their high sale price. A 50-kg traditional fertilizer is currently sold at 60-65 TL whereas a 25-kg CRF (Basacote) is sold for 250-270 TL in the market. Therefore, studying effects of lower rates of CRF (< 80-g per seedling) is recommended in future for greater cost-efficiency.

The critical levels of macronutrients for broadleaved tree plantations have not been well-established (Schuler and Robison, 2008). Foliar nutrient concentrations may therefore not be reliable indicators of possible nutrient deficiencies in plants. An increase in a nutrient concentration in plant foliage might result from the positive effect of fertilization on limiting nutrients or the plant’s “luxury consumption”. This might explain the lack of fertilization effects on the foliar nutrients analyzed in the present study. Schuler and Robison (2008) similarly found no significant correlations between the foliage N, P, and K concentrations and the growth of young yellow-poplar seedlings.

5. CONCLUSIONS

Basacote – a controlled release fertilizer – clearly improves early growth of young wild cherry seedlings at low rates (i.e. 80 g per seedling) and therefore is recommended. Higher rates do not provide further enhancement in growth and in fact makes toxic effects at high rates (i.e. 320 g per seedling). Looking into the effects of the fertilizer at lower rates (< 80-g per seedling) is recommended for future studies for greater cost-efficiency. Applying CRFs should also be coupled with an effective weed control for enhanced seed survival and growth. Wild cherry has a high demand for site conditions. Therefore, planting this broadleaved tree species on inland sites with poor physical edaphic conditions should be avoided.

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