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EFFECTS OF CONTROL-RELEASE FERTILIZER IN A WILD CHERRY PLANTATION: FIFTH-YEAR RESULTS

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ABSTRACT

Fertilization can improve survival and growth of tree seedlings, and their tolerance to pests in the forest, and may mitigate impact of climate change on trees. Positive effects of fertilization on young seedlings are even more pronounced in fast-growing tree species. Control-release fertilizers are superior to the traditional agricultural fertilizers, providing tree seedlings a slow, sustainable, and safe nutritional support. Wild cherry (*Prunus avium* L.) is a native and important element of the moist western Black Sea Region forests of Turkey. This broadleaved tree species grows fast and has important ecologic and economic functions and services. This papers reports the fifth-year results of a young wild cherry plantation fertilized at different rates with a control-release fertilizer on a mesic western Black Sea Region site. A control-release fertilizer (Basacote® Plus 6 M, COMPO Benelux, Belgium) was applied in a one-year old wild cherry plantation at five different rates (0, 80, 160, 240 ve 320 g seedlings^{-1}) in the spring of 2009. Five years after treatment (YAT), fertilizer rates did not make a significant effect on survival and growth for wild cherry. Earlier positive fertilization effects on seedling growth reported two YAT did not appear to be sustained after five years. The toxic effect of high-rate fertilizer in the early assessment was also noted to a lesser degree five YAT. Mechanism by which control-release fertilizer affects survival and growth of young wild cherry seedlings seems to be complex and/or site-specific. Inherent site fertility and lack of successive fertilization might account for the lack survival and growth enhancement in cherry by fertilization.

Keywords: long-term, *Prunus avium,* seedling survival and growth, wild cherry

YABANİ KİRAZ DİKİM SAHASINDA KONTROLLÜ SALINIMLI GÜBRENİN ETKİLERİ: BEŞİNCİ YIL SONUÇLARI

ÖZET

Gübreleme fidan yaşama yüzdesi ve büyümesini ile fidanların zararlılara dayanıklılığını artırmakla beraber iklim değişikliğinin ağaçlar üzerindeki etkisini ise azaltabilmektedir. Gübrelemenin genç fidanlar üzerindeki olumlu etkileri özellikle hızlı gelişen türlerde ortaya çıkmaktadır. Geleneksel tarım gübrelerine kıyasla, kontrollü salınımlı gübreler fidanlara yavaş, devamlı ve güvenilir bir besin takviyesi sağlamaktadır. Yabani kiraz (*Prunus avium* L.) Türkiye'nin nemli Batı Karadeniz Bölgesi ormanlarının önemli ve doğal bir unsurudur. Hızlı gelişen bu yapraklı ağaç türü topluma birçok ekolojik ve ekonomik fayda ve hizmet sağlamaktadır. Bu çalışmada, 2009 ilkbaharında Batı Karadeniz Bölgesi'ndeki bir yaşında fidanlarla kurulan yabani kiraz dikim sahasında beş farklı dozda (0, 80, 160, 240 ve 320 g fidan^{-1}) uygulanan kontrollü salınımlı bir gübrenin (Basacote® Plus 6 M, COMPO Benelux, Belçika) beşinci yıl sonuçları ele alınmıştır. Denemeden beş yıl sonra, farklı gübre dozlarının yabani kiraz yaşama yüzdesi ve büyümesi üzerinde önemli bir etki yapmadığı tespit edilmiştir. Denemenin ikinci yılında, yabani kiraz büyümesinde görülen önemli olumlu etkiler denemenin beşinci yılında kaybolmuştur. Önceki değerlendirmede de not edilen yüksek dozlu gübrelemenin fidan değişkenleri üzerindeki olumsuz etkisi azalmakla beraber beşinci yılsonunda da görülmüştür. Kontrollü salınımlı gübrelemenin, yaban kiraz yaşama yüzdesi ve büyümesi üzerindeki etkisinin karmaşık ve sahaya özgü bir mekanizmaya sahip olduğu anlaşılmaktadır. Sahada mevcut yetişme ortamı verimliliği ile gübrelemenin tek bir yılda yapılması ve sonrasında tekrarlanmaması bu çalışmada elde edilen sonuçları etkileyen etmenler olabilir.

Anahtar Kelimeler: fidan canlılığı ve büyümesi, *Prunus avium,* yabani kiraz, uzun dönem.

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INTRODUCTION

Increasing human population intensifies the competition among various uses of land at the expense of forest land and puts more pressure on remaining forestland, especially in industrial tree plantations for higher unit wood productivity (Hedwall et al., 2014). Soil productivity is a key element of the sustainable productivity in industrial tree plantations (Jacobs et al., 2005). Soils with poor nutrient contents pose a significant management problem, limiting tree growth dramatically. Fertilization is the most common practice employed to increase unit productivity on industrial plantation sites (Hedwall et al., 2014). Foresters have long used traditional agricultural fertilizers to improve soil productivity on their lands (Jacobs et al. 2005). Although traditional fertilizers discharge large amounts of nutrients to the soil solution after a rain, young tree seedlings can take advantage of only small portion of the available nutrients in the soil solution. Rapid discharge of nutrients from traditional fertilizers can also result in phytotoxic concentrations in the soil (Jacobs et al., 2005, Oskarsson et al., 2006). Drought events following activation of traditional fertilizers in the soil exacerbate these toxic effects on sites where drought for seedlings. In addition, rapid and high nutrient availability in the soil solution on plantation sites often favor herbaceous weeds and create a serious forest management problem (Jacobs et al., 2005, Oskarsson et al., 2006).

Controlled-release fertilizers on the other hand discharge nutrients slowly over a long time period (Jacobs et al., 2005). Slow pace of nutrient discharge provide seedlings with a better uptake efficiency and prevent fertilizer phytotoxicity and enhanced weed competition from occurring (Jacobs et al., 2005). Eşen et al. (2012) compared the early effects of controlled-release fertilizer applied at rates varying between 80-320 g seedling^{-1} and no-fertilization on the one- and two-year survival, growth and nutritional status of young seedlings of wild cherry – an environmentally and economically important native broadleaved tree species of Turkey (Eşen et al., 2005). No significant survival effect was found among the treatments in this study one and two years after treatment (YAT). The 80- and 240-g rate however increased mean seedling diameter and height significantly when compared to the no-fertilization treatment two YAT. Phytotoxic effects were also manifested at the highest rate in this study (Eşen et al., 2012).

Although fertilization appears to be beneficial for early tree survival and growth, these positive effects may not carry over into longer period: Brix (1983) reported that fertilization increased biomass production of Douglas-fir (*Pseudotsugamenziesii* (Mirb.) Franco) in the first 3-4 years. The enhanced growth by fertilization however disappeared in the seventh year (Brix 1983). Fertilization at planting in conjunction with low-intensive site preparation did not also enhance the 10-year growth of loblolly pine (*Pinus teada* L.) in southeastern US (Nilsson and Allen 2003). Controlled-release fertilizer (Osmocote®) applied at ≤ 25 g seedling^{-1} however increased the survival and growth of the seedlings of *Betula pubescens* Ehrh., *Larix sibirica* Ledeb. and *Picea sitchensis* (Bong.) Carr. six years after treatment (YAT) in Iceland (Oskarrson et al. 2006). 113 grams of magnesium ammonium phosphate per seedling also brought about a substantial growth increase for ponderosa pine *(Pinus ponderosa* Dougl. ex Laws.) 18 YAT (Cochran et al., 1991).

This study aimed to assess the long-term results of a previous fertilization trial (Eşen et al., 2012) where six different rates of a polymer-coated controlled-release NPK fertilizer (Basacote®) on young seedlings of wild cherry in a plantation in the western Black Sea Region of Turkey five YAT and compare the early and fifth year results.

METHODS AND MATERIALS

The study was originally carried out on a mesic, fertile western Black Sea Region forest in Turkey in 2009 (Eşen et al. 2012). The site is situated on an elevated (1100 m asl) eastern beech (*Fagus orientalis* Lipsky) site in Bendere Chiefship of Karadeniz Ereğlisi Forestry Directorate of Zonguldak Regional Forestry Directorate (Figure 1; 410 03.667'N; 310 36.800'E). Mean annual temperature and precipitation on the site are 13°C and 1100 mm, respectively (Anonymous, 2008). A closed, mature pure beech in the overstory and dense purple-flowered rhododendron (*Rhododendron ponticum* L.) in the understory were the characteristics vegetation on the site prior to the trial. The ph and bulk density of loamy soil on the site are 5.5 and 1.2 g cm^{-3}, respectively. The site was raked and then ripped a bulldozer for site preparation in the fall of 2007 before the experiment. More detailed information on the site characteristics can be found in Eşen et al. (2012).

Figure 1. Study site in Bendere Chiefship of the Karadeniz Ereğlisi Forestry Directorate of the Zonguldak Regional Forestry Directorate

A controlled-release fertilizer (Basacote® Plus 6 M, COMPO Benelux, Belgium, containing 16% N, 18% P, 12% K, 2% MgO, and 5% S and trace elements, URL1, 2016) was applied to the one-year old wild cherry seedlings of Hallı and Gümeli (Krdz. Ereğlisi) origin at five different rates (0, 80, 160, 240, and 320 g seedling-1) in early April 2009. Herbaceous weed competition was eliminated manually during the study. Height and ground line diameter of each cherry seedlings were measured prior to treatments and five YAT (Eşen et al., 2012). Five YAT, percent seedling survival, relative diameter and height growth rate, and height-to-diameter ration (H/D) of seedlings in each treatment was calculated. The study used a randomized complete block design with four replications. The experimental unit was the seedling row. The fertilizer-rate applications were randomly assigned to seedling rows. Treatment effects on the dependent variables were analyzed with one-way analysis of variance (ANOVA). Data were checked to determine that the variables were normally distributed and the variances were homogeneous. Treatments means were separated with Duncan MST at $p \leq 0.05$. Data was analyzed using the Statistical Analysis Software (SAS, 1996). More detailed information on the materials and method of the original study can be found in Eşen et al. (2012).

RESULTS AND DISCUSSION

The comparison of the control (no fertilization) seedlings between the original and the present study allowed assessing wild cherry seedlings' performance in terms of survival and growth from the first-year to fifth-year

(Table 1 and 2). Seedling survival did not demonstrate a large difference from the first to fifth year with little decrease between the original and present study. However, mean seedling diameter and height were more than two-fold in this period (Table 1 and Table 2).

Eşen et al. (2012) reported that fertilization did not make a difference for seedling survival yet made significant differences for mean height, diameter, and H/D of wild cherry two years after treatment. Overall, 80 g per seedling was the best fertilization rate in terms of seedling survival and growth and financial terms two years after treatment (Eşen et al. 2012). However, this gain disappeared in the present study (Table 1 and 2). Similar conclusions were also reported for other tree species in the past studies. Oskarsson et al. (2006) compared the effects of traditional and controlled-release fertilizers on the first and six-year volume indices of seedlings of *Betula pubescens* Ehrh., *Larix sibirica* Ledeb. and *Picea sitchensis* (Bong.) Carr. and concluded that seedlings demonstrated no significant benefit from fertilization regardless of fertilizer when compared to the control. Oskarsson et al. (2006) therefore recommended application of fertilizer in plantations only during the establishment phase.

Nilsson and Allen (2003) also reported that no significant difference was found between fertilized and nonfertilized plots for loblolly pine (*Pinus teada* L.) survival 18 YAT. Moreover, Antony et al. (2011) stated that fertilization improved dbh of 10-14 years old loblolly pine (*Pinus taeda* L.) trees in a plantation yet the differences between the fertilized trees and the non-fertilized trees decreased. Also, Brix (1983) reported that fertilization increased biomass production of Douglas-fir (*Pseudotsugamenziesii* (Mirb.) Franco) in the first 3-4 years, yet these differences disappeared in the seventh year. Fertilization (300 kg ha^{-1} N) significantly increased annual diameter and height of *Abies magnifica* in the first ten years yet no difference was found later in a 30 year study (Zhang et al., 2005). Fertilization effects on tree growth generally may not be large and fade away in the long term except that it is integrated with other site preparation practices (Headwall et al., 2014, From et al., 2015).

The level of the inherent fertility of the site and the number of fertilizer applications are among the key factors that determine the effects of fertilization on tree seedlings (Hyvönen et al., 2008; Hedwall et al., 2014). Multiple applications of multi-nutrient fertilizers benefit growth when trees are young when compared to single application (Hedwall et al., 2014). The area that the current study was carried out is under the influence of the typical coastal oceanic Black Sea climate where precipitation is relatively ample (annual precipitation >1100 mm) and site conditions are favorable for tree growth especially for soil nutrients (Yildiz et al., 2010). Therefore, the lack of significant improvement in tree survival and growth in the current study might be explained by the relative abundance of soil nutrients and precipitation on the study site and using single fertilizer application as opposed to multiple.

Fertilization appeared to be toxic at the highest rate both two (Eşen et al., 2012) and five years after treatment (Table 2) although this difference was nonsignificant. However, the toxic effects of the highest-rate on the seedlings seemed to slightly decrease from year two to year five (Table 2). Increased seedling mortality due to high-fertilizer rates has also been reported for other broadleaved tree species including *Betula pubescence* Ehrh. (Oskarsson et al., 2006). Excessive salt accumulation in the upper layer of the soil layer where seedling roots are most abundant can reduce water potential of the soil substantially and in turn decrease water uptake for young seedlings which are extremely susceptible to water stress. (Brockley, 1988; Burdett, 1990; Oskarsson et al., 2006).

CONCLUSIONS

Application of controlled-release fertilizer did not make significant difference for survival and growth of wild cherry seedlings five YAT. Site-specific conditions, inherent site fertility, and single fertilizer application might account for this outcome. Data suggests that application of fertilizer at very high rate might be toxic. Application of fertilization on the coastal Black Sea Region sites where site conditions are generally favorable may not enhance seedling survival and growth as much as desired for wild cherry. Mechanism by which control-release fertilizer affects survival and growth of young wild cherry seedlings seem to be complex and/or site-specific. Multiple fertilizer applications should be tested in future studies.

Table 1. Effects of various fertilization treatments on mean, height (H), root-collar diameter (D), vigor index (H/D), and survival rate of *Prunus avium* L. one year after treatment (reproduced from Eşen et al. 2012).

Amount of Fertilizer (g)[1]	Height (cm)	Diameter (mm)	H/D (mm/mm)	Survival (%)
0	92 ±6 a[1]	16.7 ±1.2 ab	54 ±4 a	71 ±11 a
80	114 ±3 a	20.5 ±0.6 a	56 ±2 a	83 ±3 a
160	106 ±11 a	17.4 ±1.5 ab	61 ±2 a	80 ±7 a
240	115 ±16 a	18.9 ±1.7 a	59 ±2 a	82 ±9 a
320	84 ±10 a	13.1 ±0.9 b	63 ±4 a	66 ±2 a

[1]Means within the same column with different letters are significantly different (p≤ 0.05)

Table 2. Effects of various fertilization treatments on mean, height (H), root-collar diameter (D), vigor index (H/D), relative height and root-collar diameter growth rates (RHG and RDG, respectively), and survival rate of seven-year-old of *Prunus avium* L. five years after treatment.

Amount of Fertilizer (g)[1]	Height (cm)	Diameter (mm)	H/D (mm/mm)	RHG[3] (%)	RDG (%)	Survival (%)
0	217 ±8 a[2]	37 ±2 a	63 ±4 a	963 ±120 a	572 ±70 a	63 ±17 a
80	252 ±10 a	44 ±1 a	61 ±2 a	778 ±127 a	726 ±82 a	67 ±5 a
160	263 ±18 a	43 ±4 a	64 ±2 a	1260 ±251 a	719 ±63 a	60 ±8 a
240	256 ±19 a	46 ±5 a	59 ±2 a	1371 ±283 a	819 ±91 a	74 ±9 a
320	216 ±10 a	34 ±1 a	66 ±4 a	1014 ±232 a	654 ±39 a	63 ±7 a

[1] Treatment effect was not significant (p> 0.05);[2] Means within the same column with different letters are significantly different (p≤ 0.05); [3]Arcsin transformed values were employed for separation of the means for this variable and nontransformed values were used for actual means.

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