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Determination of Suitable Sowing Dates for Spinach Production in Van Ecological Condition

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Abstract: To determine the appropriate sowing time in Van conditions for the cultivation of spinach in this study conducted two years, three sowing dates for autumn sowing-spring harvest (mid-October, the beginning and middle of November), four sowing dates for spring sowing-spring harvesting (mid-March , beginning, middle and end of April) were conducted. The first year, cv. Meridian and cv. Spinoza were used in the study and in the second year only cv. Spinoza was used in the study. Among the seed sowing times within the first year, the highest total yield (average 40.0 t ha^{-1}) was obtained by sowing in the middle of October. The first year the average yield of cv. Spinoza was 3.1 t ha^{-1} higher than that of cv. Meridian. Among the seed sowing times in the second year, the highest total yield (45.7 t ha^{-1}) was obtained again from the time of sowing in mid-October. In both years, spring sowing encountered the problem of bolting.

Key words: Spinach, Sowing date, Yield, Bolting

Van Ekolojik Koşullarında Ispanak Üretimi için Uygun Ekim Zamanlarının Belirlenmesi

Özet: Van koşullarında ıspanak yetiştiriciliği için uygun ekim zamanlarını belirlemek amacıyla iki yıl yürütülen bu çalışmada, sonbahar ekimi-ilkbahar hasadında üç ekim zamanı (Ekim ayı ortası, Kasım ayı başı ve ortası), ilkbahar ekimi-ilkbahar hasadında ise dört ekim zamanı (Mart ayı ortası, Nisan ayı başı, ortası ve sonu) uygulanmıştır. Birinci yıl Meridian ve Spinoza çeşitleri, ikinci yıl ise sadece Spinoza çeşidi kullanılmıştır. İlk yıl tohum ekim zamanları içerisinde en yüksek toplam verim, ortalama 4.00 t/da ile Ekim ayı ortası ekim zamanından elde edilmiştir. İlk yıl Spinoza çeşidinin ortalama verimi, Meridian çeşidinin ortalama veriminden 0.31 t/da daha yüksek bulunmuştur. İkinci yıl tohum ekim zamanları içerisinde en yüksek toplam verim, 4.57 t/da ile yine Ekim ayı ortası ekim zamanından elde edilmiştir. Her iki yılda da ilkbahar ekimlerinde sapa kalkma sorunuyla karşılaşılmıştır.

Anahtar kelimeler: Ispanak, Ekim zamanı, Verim, Sapa kalkma

Introduction

Spinach (*Spinacia oleracea* L.) is an important leafy vegetable both worldwide and in Turkey with a 14 958 727 t and 225 342 t of production on 24 thousands and 895 thousands ha area, respectively (Anonymous 2009). Spinach, dioecious species with both male and female plants, is an herbaceous leafy vegetable in the family of *Amaranthaceae*, formerly *Chenopodiaceae* (Gunay 1992; Vural et al 2000; Salk et al. 2008). Spinach has been producing in Anatolia since the period of Ottoman Empire (Solak 2008).

It is an annual plant (rarely biennial), which grows to a height of up to 30 cm. Spinach may survive over winter in temperate regions. The leaves are alternate, simple, ovate to triangular-based, very variable in size from about 2–30 cm long and 1–15 cm broad, with larger leaves at the base of the plant and small leaves higher on the flowering stem (Gunay 1992; Vural et al 2000; Salk et al. 2008).

Leafy vegetables are an important part in the human diet. Spinach has a high nutritional value and is an important source of minerals and is extremely rich in antioxidants, especially when fresh, steamed, or quickly boiled (Gunay 1992; Vural et al 2000; Salk et al. 2008). It is also a rich source of vitamin A,

vitamin C, vitamin E, vitamin K, magnesium, manganese, folate, betaine, iron, vitamin B_2, calcium, potassium, vitamin B_6, folic acid, copper, protein, phosphorus, zinc, niacin, selenium and omega-3 fatty acids.

Spinach is a quick-maturing, cool season crop grown for fresh and processing market; its optimum growth temperature requirement is 15-20 ºC (Gunay 1992; Vural et al 2000; Salk et al. 2008), and the minimum temperature for seed germination is 2 ºC, optimum temperature for seed germination is 21 ºC (Uzun et al. 2001). It is resistant to low temperatures and endures to winter conditions. High temperature (30 ºC -35 ºC) and drought reduce yield and deteriorate the quality in spinach (Gunay 1992; Vural et al 2000; Salk et al. 2008). Spinach is a typical long-day plant; therefore, late spring sowing could be problematic for spinach production. Spinach is a long-day plant that produces its best vegetative growth under cool temperature than short day length; long days especially coupled with temperatures above 25 ºC cause the plant to bolt and flower, which is detrimental to spinach production (Waseem and Nadeem 2001). Spinach is grown as an autumn and spring crop. As a cool-season plant, it also stands pre-winter sowing well. The spinach production in Van province is not sufficient. In Van climatic condition, sowing dates for spinach production has not been studied sufficiently. Therefore, in order to increase the quality and quantity of spinach production, the present study aimed to determine suitable sowing dates for spinach production in Van ecological condition.

Material and Methods

Field experiments were conducted in two production seasons in Van ecological conditions. The province of Van is located between 37º55' and 39º24' north longitude and 42º05' and 44º22' east latitude and at an altitude of 1720 m above sea level. It has a continental climate (Table 1), with the highest average temperature in July (22.5 º C) and the lowest average temperature in January (-4.0 º C) (Anonymous 2008).

Soil was calcareous and poor for organic matter and had a clayish-loamy structure and low salt content. Soil was slightly alkaline and had poor nitrogen and phosphorous contents and adequate potassium content. Soil tillage was performed by shallow ploughing (30 cm) followed by rotary harrowing. Fertilization was carried out by spreading 4 t ha^{-1} of manure, 100 kg N ha^{-1} (as ammonium sulphate) and 100 kg P_2O_5 ha^{-1} (as triple super phosphate). Phosphorous and half of nitrogen were applied at sowing; the other half of nitrogen was applied depending on seedling emergence and growth. Sowing was conducted manually in rows (25cm) at the rate of 50 kg seed ha^{-1} at three times pre-winter (mid-October, early-November, and mid-November) and four times in spring (mid-March, early-April, mid-April, and late-April). The sowing depth was around 2 cm. The randomized complete block design was used in three replications. The size of each plot was 2 m^2. The first year two standard spinach varieties (cv. Spinoza and cv. Meridian) were tested; in the second year only cv. Spinoza was used in the experiment because of lower yield performance of cv. Meridian. Seedling emergence time was determined when the cotyledons emerged and grew parallel to soil. The experiment was ended when spinach had approximately 9 leaves. The percentage of bolted plants was also observed throughout the culturing period. Analysis of variance was performed to evaluate differences in measured parameters. Thereafter, parameters were compared by Duncan's multiple range test.

Table 1. Some climatic data belonging to Van province in two production seasons and long term

	Total Precipitation (mm)			Average temperature (ºC)			Days number covered with snow			Frozen days number		
Months	First year	Second year	Long term	First year	Second year	Long term	First year	Second year	Long term	First year	Second year	Long term
October	82.0	56.2	45.4	11.6	11.8	10.3	-	-	1	-	-	-
November	38.5	82.9	47.5	4.6	5.5	4.3	5	6	4	11	5	10
December	5.1	51.3	32.1	1.0	1.0	-1.1	8	12	13	25	4	21
January	23.4	17.0	38.3	0.3	-2.5	-4.0	23	9	25	30	29	29
February	43.8	28.2	7.7	0.4	-2.5	-3.6	6	12	23	4	25	25
March	24.4	46.2	3.4	2.6	0.9	0.7	18	1	14	2	10	18
April	36.2	32.6	107.4	8.4	9.5	7.2	-	-	2	-	-	3
May	23.9	28.0	54.8	14.9	14.3	12.9	-	-	8	-	-	-

Results and Discussion

While the fastest seedling emergence time was obtained from the latest sowing time in the spring, the slowest seedling emergence time was obtained from the mid-October sowing in the first year (Table 2).

Table 2. Seedling emergence time (day) for Meridian and Spinoza spinach cultivars sown in different times in the first production season.

	Seedling emergence time (day)		
Sowing dates	Meridian	Spinoza	Average
October 15th	13	13	13 de***
November 1st	38	38	38 b
November 15th	45	45	45 a
March 20th	20	20	20 c
March 31st	18	18	18 c
April15th	14	14	14 d
May 1st	10	10	10 e
Average	23	23	

*** P<0.001

Autumn sowings had longer vegetation time than spring sowings in the first year (Table 3). The highest total yield (40.05 t ha^{-1}) and marketable yield (36.95 t ha^{-1}) were obtained from the time of sowing in mid-October in the first year (Table 4 and 5). On the other hand, the last two sowing dates in the spring had highest bolting rates compared to the other sowing dates (Table 6).

Table 3. Vegetation time (day) for Meridian and Spinoza spinach cultivars sown in different times in the first production season.

	Vegetation time (day)		
Sowing dates	Meridian	Spinoza	Average
October 15th	199	199	199 a***
November 1st	192	192	192 b
November 15th	179	179	179 c
March 20th	65	65	65 d
March 31st	61	61	61 e
April15th	58	58	58 f
May 1st	49	49	49 g
Average	115	115	

*** P<0.001

Table 4. Total yield (t ha^{-1}) for Meridian and Spinoza spinach cultivars sown in different times in the first production season.

	Total yield (t ha^{-1})		
Sowing dates	Meridian	Spinoza	Average
October 15th	34.59	45.40	40.05 a***
November 1st	10.80	17.80	14.34 b
November 15th	12.06	14.10	13.08 b
March 20th	17.67	21.05	19.37 b
March 31st	17.00	22.83	19.92 b
April15th	21.98	18.37	20.18 b
May 1st	13.41	9.91	11.67 b
Average	18.24	21.35	

*** P<0.001

5. Marketable yield (t ha^{-1}) for Meridian and Spinoza spinach cultivars sown in different times in the first production season.

	Marketable yield (t ha^{-1})		
Sowing dates	Meridian	Spinoza	Average
October 15th	31.71	42.18	36.95 a***
November 1st	9.99	16.82	12.41 b
November 15th	9.49	11.00	10.25 b
March 20th	16.71	19.97	18.35 b
March 31st	15.33	20.90	18.12 b
April15th	20.66	17.75	19.21 b
May 1st	12.69	9.09	10.19 b
Average	16.64	19.86	

*** P<0.001

Table 6. Bolting rates (%) for Meridian and Spinoza spinach cultivars sown in different times in the first production season.

	Bolting rates (%)		
Sowing dates	Meridian	Spinoza	Average
October 15th	0.91	4.74	2.83 d***
November 1st	0.88	15.60	8.25 c
November 15th	1.50	25.98	13.78 b
March 20th	0.22	1.50	0.86 d
March 31st	2.73	19.80	11.27 b
April15th	11.65	28.65	20.16 a
May 1st	9.63	28.79	19.21 a
Average	3,94 b	17.87 a***	

*** P<0.001

Similar to first year, while the fastest seedling emergence time was obtained from the latest sowing time in the spring, the slowest seedling emergence time was obtained from the mid-October sowing in the second year (Table 7). Similar to first year, autumn sowings had longer vegetation time than spring sowings in the second year (Table 7). Similar to first year, the highest total yield (45.71 t ha^{-1}) and marketable yield (36.52 t ha^{-1}) were obtained again from the time of sowing in mid-October in the first year (Table 7). On the other hand, the last two sowing dates in the spring had highest bolting rates compared to the other sowing dates (Table 7).

Table 7. Seedling emerge time, vegetation time, total yield, marketable yield, and bolting rate of Spinoza spinach cultivar sown in different times in the second production season.

Sowing dates	**Seedling emergence time (day)**	**Vegetation time (day)**	**Total yield (t ha^{-1})**	**Marketable yield (t ha^{-1})**	**Bolting rate (%)**
October 15th	26 c***	211 a***	45.71 a***	36.52 a***	10.7 c***
November 1st	45 b	195 b	37.90 ab	29.52 b	3.7 c
November 15th	52 a	181 c	31.54 b	24.35 c	7.7 c
March 15th	22 d	76 d	28.72 b	23.29 c	10.8 c
March 31st	20 d	74 e	25.57 b	17.69 d	56.3 b
April15th	18 e	73 e	6.63 c	1.94 f	91.3 a
April 30th	16 f	58 f	6.92 c	4.49 e	16.0 c
Average					

*** P<0.001

Sowing spinach seed in rows had some advantageous because it eased the weeding in the earlier stages of growth compared to broadcast sowing. In the present study, although autumn sowings had longer vegetative time than spring sowing, mid-October sowing had highest total and marketable yield. Van had a harsh winter (Table 1); however, spinach at rosette stage endures cold temperatures when covered by snow. For spinach in Italy, Peruzzi et al (2004) indicated that crop cycle is very short (60 days) when

sown in September and at the end of winter, whereas crop cycle is longer when sown in winter. Waseem et al. (2000) and Waseem and Nadeem (2001) did not determine significant variations in case of different sowing dates in spinach grown in Pakistan. However, these researchers observed that the maximum flesh foliage as well as dried weight was obtained from October sowing. Imai and Tiga (1994) noted that type of cultivation had significant effect on yield of spinach in an organic farm: autumn plant-spring harvest had better results than spring sowing-summer harvest.

Bjelic and Moravcevic (2006) indicated that pre-winter sowing significantly increased the earliness of spinach, but decreased its yield in Belgrade region of Serbia. These researchers mentioned that spinach was ripe for picking 3-4 weeks earlier than the spring sowing; early spinach is a highly appreciated product which can be placed easily and at a high price.

In the present study, it has been noted that although crop cycle was longer in pre-winter sowing, their yield were comparatively higher than those of spring sowing. In the present study, spring sowings also encountered the problem of bolting. Citak and Sonmez (2010) also determined that autumn season gave the better results in terms of spinach growth, and yield in Antalya-Turkey, which has warmer winter. Elia et al. (1998) obtained 18.34 t ha^{-1} spinach yields from cv. Gladiator sown mid-November and harvested early March in open-field conditions at Bari, Italy. Gulser (2005) obtained 8.40 to 22.28 t ha^{-1} spinach yields from cv. Meridian sown mid-March and harvested early June in open-field conditions at Van, Turkey. Williams et al. (2003) obtained up to 32.5 t fresh weight yield for spinach grown over winter (May-September) in New Zealand.

Over-winter spinach production might have some more advantageous than late and spring spinach productions. Howard et al (2002) determined total phenolic content and antioxidant capacity of 11 commercial cultivars and 15 advanced breeding lines of spinach over to growing season known to vary in biotic and abiotic stresses. These researchers found that over-winter spinach, which was planted in late fall and harvested in the spring, had much higher levels of total phenolics and antioxidant capacity than spinach planted in early fall and harvested in late fall, indicating that growing conditions, as well as biotic and a biotic stresses, influenced phenolic metabolism.

In conclusion, mid-October sowing in spinach could be suggested for Van ecological condition because of increased yield and decreased bolting rate.

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