



## Effect of seed rate on vegetative growth and yield properties of two varieties of spinach and weeds

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### Abstract

An experiment was conducted at the Agricultural Research Station in Bakrajo-Sulaimaniyah, from 7<sup>th</sup> October, 2013 to 24<sup>th</sup> March, 2014 to investigate the effect of different seed rates (16, 28, 40 Kg ha<sup>-1</sup>) on a number of weeds m<sup>-2</sup> and their dry weight. Furthermore, some vegetative and yield characters of two spinach varieties (local and Syrian) were measured. The experiment designated in factorial randomized complete block design (RCBD-factorial). Comparisons between the means of the characters were carried out according to Duncan's Multiple Range Test at the 5 % level.

Results revealed that 40kg ha<sup>-1</sup> exhibited significant differences in reducing the number and dry weight of weeds at both growth stages [100 and 125 days after spinach seed sowing (DAS)] by 67.86 and 75.82% for weed's number and for weed's dry weight (67.57 and 48.27%) as compared to 16 kg ha<sup>-1</sup>. Also 40 kg ha<sup>-1</sup> was significantly superior in increasing accumulative yield (kg m<sup>-2</sup>), Dry weight (g m<sup>-2</sup>), leaf area (cm<sup>2</sup> plant<sup>-1</sup>), spinach number m<sup>-2</sup> and leaf number plant<sup>-1</sup> by 60.91, 66.56, 57.33, 47.93 and 28.88% as compared to 16 kg ha<sup>-1</sup>, respectively.

The local variety got the highest values in decreasing the number and dry weight of weeds at both growth stages 100 and 125DAS by 43.94 and 51.76% for weed's number and by 19.46 and 30.49% for weed's dry weight, compared to the Syrian variety, respectively. The local variety showed significant differences, as compared to Syrian variety, in accumulative yield (kg m<sup>-2</sup>), dry weight (g m<sup>-2</sup>), leaf area (cm<sup>2</sup> plant<sup>-1</sup>), spinach number m<sup>-2</sup> and leaf number plant<sup>-1</sup> by 49.40, 47.06, 38.64, 30.97 and 21.86%, respectively. To sum up, seeding rate of 40 kg ha<sup>-1</sup> was best in reducing the number and dry weight of weeds, and it caused significant increases in all studied parameters.

### Introduction

Spinach (*Spinacia oleracea* L.) is a member of the Chenopodiaceae (Goosefoot) family. Historically, this vegetable plant's cultivation began in Iran around 400 AD [1]. Spinach is an annual vegetable plant that grows quickly and has the ability to survive over the winter season in temperate regions [2]. It is very versatile since it is commonly used as a salad, cooked vegetable, or as a component of many other cooked meat and vegetable dishes [3].

Spinach has medical benefits and contains high levels of vitamins such as vitamin K and A in the form of beta-carotene, and it is a good source of folate too. Spinach also provides fiber and is low in calories.

From conclusion of some studies illustrate that spinach has contain high levels of antioxidant compounds such as phenolics and carotenoids and it also has a strong antioxidant activity. Lutein and zeaxanthin are two major compounds in spinach; they can be used for protecting against eye diseases such as macular degeneration. In addition, it can be used to reduce the extent of post-ischemic stroke damage to the brain too [4].

The area occupied by spinach in the world is about 867,728 hectares and the total yield annually is about 21 million tons, whereas in Iraq, the total cultivated area is 1321 hectares with a yield of 11177 tons in 2011 [5]. Spinach is cultivated in Kurdistan region, Iraq from October to March. The crop cycle is generally short (130 days). As a consequence, an integrated weed control program must take the planting date and weed spectrum into account, as they determine the choice of weed control strategy.

Weeds are unwanted plants, which are deleterious to crop and they are one of the major factors in reducing crop yield. Common weeds in spinach are annual bluegrass (*Poa annua* L.), annual sowthistle (*Sonchus oleraceus* L.), burning nettle (*Urtica urens* L.), common chickweed, common groundsel (*Senecio vulgaris* L.), common lambsquarters (*Chenopodium album* L.), common purslane, little mallow (*Malva parviflora* L.), London rocket (*Sisymbrium irio* L.), nettleleaf goosefoot (*Chenopodium murale*), pigweeds (*Amaranthus* spp.), prickly lettuce (*Lactuca serriola* L.), and shepherd's-purse [6] and [7].

The spinach planting configuration and low tolerance for weed contamination make spinach susceptible to crop losses caused by weeds because it is a relatively poor competitor against weeds [8] and [9]. In spite of spending a large amount of money and research development to apply herbicide-dominated on weed control and management in the conventional agricultural system, mainstream growers also report that weeds can be a significant problem [10]. Henderson and Bishop (2000) [11] stated, however, that generally low priority has given to weeds in conventional vegetable production in Australia and at the same time weed management costs are not a huge amount of total variable expenses.

Plant density is a major factor determining the ability of the crop to capture resources and generate yield. It can be developed by using a suitable seeding rate. Excessively high plant densities cause the plants to compete for available food and water, whereas extremely low plant densities may provide the opportunity for weed invasion [12]. Density of crops is a critical factor in the crop development and reduces growing weeds and density, and also planting at the maximum population produces a closed canopy which is going to give a priority to the specific crop that is more competitive over weeds, consequently, seed grading and high germination rates are critical for a rapid canopy [13] and [14].

The study demonstrated that there are remarkable differences in the accumulative yield among 10 varieties [15], while Xinping *et al.* (2000) [16] studied that there weren't any significant differences in shoot systems among four captives (Daye, Jianye, Bozha 15 and Lufeng).

Keeping in view the importance of spinach and weeds associated problems, experiment was conducted to evaluate multi-approached weed suppression in spinach with the objective to investigate the effect of different levels of seeding rates and spinach varieties on weeds, vegetative growth and yield of spinach.

## Materials and Methods

The trial was carried out during 2013-2014 at the Agricultural Research Station in Bakrajo-Sulaimaniyah. The experimental field was tilled before planting on 7<sup>th</sup> October, 2013. After that, two varieties of spinach, local and Syrian, were cultivated with a seeding rate of 16, 28 and 40 kg hectare<sup>-1</sup> for each variety in an area of 12 m<sup>2</sup> (3m×4m) and three replicates were used for each seeding rate.

Simultaneously with the cultivation of the spinach seeds, each experimental unit was seeded with seeds from six different weed plants, namely Syrian Cephalaria, Wild Mustard, Lady's Thistle, Wild Radish, Wild Oat and Bermuda.

The spinach seedlings were fertilized with urea fertilizer after 55 days of planting and watering was carried out as required. Neither serious disease, nor pest's pattern was noted during the growing season.

Each experimental unit (3m×4m) was divided into three subdivisions (4m<sup>2</sup> each).

Number of weed plants per square meter of land were counted in the first and second subdivision of each experimental unit by using a quadrat on 100 and 125 DAS, respectively. The weeds were removed from distinct area and brought to the laboratory, dried at 60°C for 72 hours and their dry weight was recorded.

In the third subdivision, the spinach was cut every 10 days starting from 100<sup>th</sup> day post-cultivation and for three times. The spinach was weighed each time in order to calculate the accumulative yield per square meter, which is the sum of spinach plant weight after three times cutting.

Ten spinach plants were randomly taken from each experimental unit for the measurement of vegetative growth characters (leaf area, spinach and leaf number) as following:

1. Accumulative yield (kg m<sup>-2</sup>): Spinach plants were harvested on three times by cutting and their fresh weight were recorded for all of them.
2. Dry weight (g m<sup>-2</sup>): Dried in the oven at 60°C for 72 hours and then weighed by a sensitive electronic balance.
3. Leaf Area (cm<sup>2</sup>): The average leaf area for three leaves from 10 plants was determined by using the gravimetric method (according to [17]) after leaves' weight was taken, a disc (0.78cm<sup>2</sup>) from each leaf was taken and weighed, then calculated by the following equation:

$$S = (G \times s) / g$$

Where: S= Average leaf area (cm<sup>2</sup>), G = Average leaf weight (g), s = Average area of discs given from the leaves (0.78cm<sup>2</sup>), and g = Average weight of discs given from the leaves (g)

4. Spinach number: counting spinach plants from m<sup>2</sup>.
5. Leaf number: Ten spinach plants were randomly taken from each experimental unit.

Spinach dry weight was calculated by first drying the spinach at 60°C for 72 hours and weighing the dried plant and the dry weight was calculated as grams of dried plant per square meter of land.

All treatments were replicated three times in a factorial randomized complete block design (RCBD). The treatments were analyzed using XLSTAT Pro 7.5.3. program (Addinsoft, 2005) and the comparisons among means were carried out by Duncan's multiple range test at P≤0.05 [18].

## Results and discussion

### 1. *Effect of seed rates and different varieties of spinach on weed plants*

Tables (1 and 2) show the effects of seed rates and different spinach varieties on the number and dry weight of weed plants. It can be inferred from the data that increasing the seed rate from 16 to 40 kg ha<sup>-1</sup> had reduced significantly the number and dry weight of weed plants at both 100 and 125 days of growing

stages. The reason might be due to the fact that more spinach plants emerged as the seed rate was increased which reflected adversely on the total number of weeds per unit area, hence inverse on weed dry weight.

Table- 1: Effect of seed rates and different varieties on number of weeds m<sup>-2</sup> at two stages of Spinach growth

Seed rates	Local Variety		Syrian Variety		Effect of Seed rates	
	Growth stages (in days) after planting				100	125
	100	125	100	125		
<b>16 Kgha<sup>-1</sup></b>	3.89 b	6.78 b	10.11 a	22.67 a	<b>7.0 a</b>	<b>14.72 a</b>
<b>28 Kgha<sup>-1</sup></b>	2.94 bc	5.89 bc	3.28 bc	5.67 bc	<b>3.11 b</b>	<b>5.78 b</b>
<b>40 Kgha<sup>-1</sup></b>	2.06 c	3.0 d	2.44 bc	4.11 cd	<b>2.25 b</b>	<b>3.56 c</b>
Effect of Varieties	<b>2.96 b</b>	<b>5.22 b</b>	<b>5.28 a</b>	<b>10.82 a</b>		

Means with the same letter for each factor and interactions are not significantly different at 5% level based on Duncan's Multiple Range Test.

The local variety of spinach plants showed superiority in decreasing of the weed's number and dry weight at both growth stages compared with Syrian variety. In fact, the local variety had a significant role in reducing weed number m<sup>-2</sup> at both growth stages. However, the reduction in weed dry weight was only observed at 125 days after planting for local cultivar. This result could be attributed to the variation of the genetic ability of the local variety competing with weeds for the nutrients and other growth requirements, or may be due to that local variety exhibited a competitive advantage in local environments, highlighting the need to grow locally suitable cultivars.

Table- 2: Effect of seed rates and different varieties on dry weight of weeds m<sup>-2</sup> at two stages of Spinach growth

Seed rates	Local Variety		Syrian Variety		Effect of Seed rates	
	Growth stages (in days) after planting				100	125
	100	125	100	125		
<b>16 Kgha<sup>-1</sup></b>	1.7 b	2.68 b	2.74 a	5.39 a	<b>2.22 a</b>	<b>4.04 a</b>
<b>28 Kgha<sup>-1</sup></b>	1.20 bc	2.08 b	1.0 c	1.16 b	<b>1.09 b</b>	<b>1.62 b</b>
<b>40 Kgha<sup>-1</sup></b>	0.71 c	1.60 b	0.74 c	2.59 b	<b>0.72 b</b>	<b>2.09 b</b>
Effect of Varieties	<b>1.20 a</b>	<b>2.12 b</b>	<b>1.49 a</b>	<b>3.05 a</b>		

Means with the same letter for each factor and interactions are not significantly different at 5% level based on Duncan's Multiple Range Test.

The interaction between 40kg ha<sup>-1</sup> and Local variety has recorded the significant higher effect in both growth stages and for both traits. In contrast, the interaction between 16kg ha<sup>-1</sup> and Syrian variety has shown lowest effective in reducing the number and dry weight of weed in both growth stages.

## 2. Effect of seed rates and different varieties in spinach plants

Results shown in **Table 3, 4, 5, 6 and 7** exhibited that 40kg ha<sup>-1</sup> seed rate has a significant effect on the traits of spinach accumulative yield (kg m<sup>-2</sup>), dry weight (g m<sup>-2</sup>), leaf area (cm<sup>2</sup> plant<sup>-1</sup>), number of spinach m<sup>-2</sup> and the number of leaves plant<sup>-1</sup>, compared to the other treatments (16kg ha<sup>-1</sup> and 28kg ha<sup>-1</sup>). These results in which 40kg ha<sup>-1</sup> was the most successful seed rate among the rest rates may be attributed to the rapid canopy development and establishment which causing high resource capture by increasing the efficiency and ability of spinach competition against weeds, hence caused significant reduction of a vast number and dry weight of weed species (**Table 1 and 2**).

Table- 3: Effect of seed rates and different varieties on accumulative yield kg m<sup>-2</sup> of Spinach plants

Seed rates	Local Variety	Syrian Variety	Effect of Seed rates
<b>16 Kg ha<sup>-1</sup></b>	2.93 bc	1.19 c	<b>2.06 b</b>
<b>28 Kg ha<sup>-1</sup></b>	5.15 ab	2.70 bc	<b>3.93 ab</b>
<b>40 Kg ha<sup>-1</sup></b>	6.87 a	3.68 abc	<b>5.27 a</b>
Effect of Varieties	<b>4.98 a</b>	<b>2.52 b</b>	

Means with the same letter for each factor and interactions are not significantly different at 5% level based on Duncan's Multiple Range Test.

Table- 4: Effect of seed rates and different varieties on Dry Weight g m<sup>-2</sup> of Spinach plants

Seed rates	Local Variety	Syrian Variety	Effect of Seed rates
<b>16 Kgha<sup>-1</sup></b>	397.51 b	163.86 b	<b>280.69 b</b>
<b>28 Kgha<sup>-1</sup></b>	706.56 ab	401.84 b	<b>554.20 ab</b>
<b>40 Kgha<sup>-1</sup></b>	1085.53 a	593.42 ab	<b>839.48 a</b>
Effect of Varieties	<b>729.87 a</b>	<b>386.37 b</b>	

Means with the same letter for each factor and interactions are not significantly different at 5% level based on Duncan's Multiple Range Test.

Table- 5: Effect of seed rates and different varieties on Leaf area cm<sup>2</sup>Plant<sup>-1</sup> of Spinach plants

Seed rates	Local Variety	Syrian Variety	Effect of Seed rates
<b>16 Kg ha<sup>-1</sup></b>	67.38 ab	17.10 b	<b>42.24 b</b>
<b>28 Kg ha<sup>-1</sup></b>	80.36 ab	29.84 ab	<b>55.10 ab</b>
<b>40 Kg ha<sup>-1</sup></b>	94.38 a	101.63 a	<b>99.0 a</b>
Effect of Varieties	<b>80.71 a</b>	<b>49.52 a</b>	

Means with the same letter for each factor and interactions are not significantly different at 5% level based on Duncan's Multiple Range Test.

On the other hand, the two spinach varieties behaved differently in the tested spinach traits, as the local variety produced a significantly higher value in accumulative yield, dry weight, number of spinach and leaf number plant<sup>-1</sup>(Table 3, 4, 6 and 7), while table (5) has not shown any significant differences between local and Syrian Varieties. This feature might be stable between both varieties from the genetic point of view.

Table- 6: Effect of seed rates and different varieties on spinach plant number m<sup>-2</sup>

Seed rates	Local Variety	Syrian Variety	Effect of Seed rates
<b>16 Kg.ha<sup>-1</sup></b>	24.89 b	10.11 c	<b>17.5 c</b>
<b>28 Kg. ha<sup>-1</sup></b>	26.78 b	21.44 b	<b>24.11 b</b>
<b>40 Kg. ha<sup>-1</sup></b>	37.33 a	29.89 ab	<b>33.61 a</b>
Effect of Varieties	<b>29.67 a</b>	<b>20.48 b</b>	

Means with the same letter for each factor and interactions are not significantly different at 5% level based on Duncan's Multiple Range Test.

The interaction between 40kg ha<sup>-1</sup> and local varieties had a significant effect on the accumulative yield, dry weight, leaf area, number of spinach and leaf number, but in leaf area feature the interaction between 40kg ha<sup>-1</sup> and Syrian variety has recorded the higher value. However, the interaction of 16kg ha<sup>-1</sup> with Syrian variety recorded the lowest value in all the properties of the spinach plant.

Table- 7: Effect of seed rates and different varieties on Spinach's leaf number plant<sup>1</sup>

Seed rates	Local Variety	Syrian Variety	Effect of Seed rates
<b>16 Kg.ha<sup>-1</sup></b>	14.33 ab	8.67 b	<b>11.50 b</b>
<b>28 Kg. ha<sup>-1</sup></b>	15.67 a	13.33 ab	<b>14.50 ab</b>
<b>40 Kg. ha<sup>-1</sup></b>	17.33 a	15.00 ab	<b>16.17 a</b>
Effect of Varieties	<b>15.78 a</b>	<b>12.33 b</b>	

Means with the same letter for each factor and interactions are not significantly different at 5% level based on Duncan's Multiple Range Test.

Finally, it is concluded from the aforementioned results that seeding at the rate of 40kg ha<sup>-1</sup> is best to reduce the number and dry weight of weed plants. This seeding rate also increases all the vegetative growth properties of spinach.

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