EFFECT OF SOWING MEHTODS ON YIELD AND GROWTH OF SPINACH

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ABSTRACT: A study was carried out during 2014-15 to know the effective sowing method for improving the spinach production. The spinach was sown on flat bed system seed broadcasting, flat bed seed drilling in rows, raised bed and ridge bed (furrow). The results revealed that growth and yield components of spinach were significantly ($P<0.05$) influenced by sowing patterns. The spinach crop cultivated under raised bed system ranked 1st with 34.50 cm plant height, 21.00 leaves plant^{-1}, 44.00 g fresh weight of leaves plant^{-1}, 25.00 cm leaf length, took 29.83 days to first cutting, produced 2119.67 kg spinach yield ha^{-1}. The spinach crop cultivated under ridge bed system ranked 2nd and the plants took 31.67 days to first cutting and produced 2074.00 kg spinach yield ha^{-1}. However, crop performance was superior under raised bed as well as ridge bed (furrow) systems while relatively poor crop performance was observed in flat bed (seed broadcasting). It was concluded that raised bed system was effective sowing method for spinach production.

Keywords: Spinach, sowing pattern, flat bed system, raised bed and ridge bed.

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INTRODUCTION

Leafy vegetables are among most important components of human foods having minerals and vitamins which facilitate digestion of other foods and vegetables (Habimana *et al*., 2014). Spinach is a vegetable that is rich in vitamins and minerals. It is a rich source of vitamin A, vitamin C, vitamin E, vitamin K, vitamin B_2, vitamin B_6 and magnesium, manganese, folate, betaine, iron, , calcium, potassium, folic acid, copper, phosphorus, zinc, niacin, selenium protein and omega-3 fatty acids (USDA, 2005). Spinach (*Spinacia oleracea* L.) is an annual dioecious herb belonging to the Chenopodiaceae family. It is the most important highly nutritious green leafy winter vegetable grown in Pakistan on a large scale. Currently, this crop has negligible economic importance throughout the world (Toledo *et al*., 2003).

Sowing method is of great importance for higher crop harvest. The sowing patterns and seed placement strategies have much influence on germination, growth and yield of the crops. Placement of seed on flat beds, raised beds, shady side and sunny side or on top of ridge show variable results. The growers with small land holding generally adopt traditional methods of sowing, whereas, the progressive growers use relatively improved production practices, because they have easy access to the advanced crop production technologies (Ahmad *et al.*, 2000). Traditional sowing methods include broadcasting manually, opening furrows by a local plough and dropping seeds by hand and dropping seeds in the furrow through a bamboo/metal funnel attached to a plough. For sowing in small areas dibbling such as, making holes or slits by a stick or tool and dropping seeds by hand, are practiced. Multi-row traditional seeding devices with manual metering of seeds are quite popular in experienced farmers (Hussain *et al*., 2000), (Vijayakumar and Ramesh, 2005). Traditional sowing methods have various limitations. In manual seeding, it is not possible to achieve uniformity in distribution of seeds. A farmer may sow at desired seed rate but inter-row and intra-row distribution of seeds is likely to be uneven resulting in bunching and gaps in field; poor control over depth of seed placement; it is necessary to sow at high seed rates and bring the plant population to desired level by thinning (Shariti and Amin, 2003). In general, broadcast seeding is not recommended; in any seeding operation, good seed-to-soil contact is needed and a uniform seed placement to optimize germination and emergence. Broadcast seeding results have been variable because of the inability to get the necessary seed-to-soil contact and uniform seed placement. Kovach *et al.*, (1983) reported that type of bed affected the crop yield but bed height marginal impact on crop performance. Leskovar and Stein (2000) suggested ridge sowing of spinach and Waseem *et al.*, (2001) found high spinach yield when broadcasted on ridges (2255 kg ha^{-1}). Wightman *et al.*, (2001) argued that spinach sowing method should be in accordance with the soil type and availability of irrigation water. Ghafoor *et al.*, (2002) total fresh yield of spinach was higher under ridge bed system and Luyen and Preston (2004) also favoured the ridge sowing of spinach.

Siura and Davila (2008) indicated that growth and yield traits of spinach were significantly influenced by the sowing methods, where ridge sowing resulted in highest fresh foliage. Finally the crop stand and grain yields are reduced, weed competition is increased (Johnson *et al.*, 2010). Hence, examining the crop production under different sowing methods is of economic significance. Therefore, the experiment was conducted to investigate the impact of sowing methods on the growth and yield of spinach.

MATERIALS AND METHODS

The experiment was conducted at the experimental area of Horticulture Department, Sindh Agriculture University Tandojam in randomized complete block design (RCBD) replicated thrice. The net plot size used for treatments in each replication was 3 x 3.5m ($10.5m^2$). The land was prepared by giving 2 plowings with cultivator, followed by rotavator for clod crushing and leveling to eradicate the weeds and to make the soil surface uniform for equal distribution of irrigation water. The treatments were sowing of seed on flat bed (seed broadcasting), flat bed (drilling in rows), raised bed and ridge bed (furrow). The treatments were distributed randomly to avoid any variation in the plant growth due to uneven soil fertility in different plots. Spinach variety "Sindhi Palak" was used in the experiment. Nitrogen at the rate of 100 kg ha^{-1} and phosphorus at the rate of 60 kg ha^{-1} were applied. The nitrogen was applied in the form of urea and phosphorus in the form of single super phosphate (SSP). One third of N along with all P was applied at the time of land preparation by mixing in the soil, while the remaining N was divided into two equal doses and was applied with a fortnight interval. Data was recorded on plant height (cm), total number of leaves $plant^{-1}$, leaf length, fresh weight $plant^{-1}$ (g), number of days taken to first cutting, yield ha^{-1} (kg). Data was analyzed statistically using to analysis of variance (ANOVA) technique appropriate for RCB design and means were compared using LSD test (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Plant height (cm):- Data regarding plant height of spinach is presented in Table-1. Analysis of the data revealed that the effect of sowing patterns was significant on plant height of spinach ($P<0.05$). The spinach sown on raised beds produced taller plants (34.50 cm), followed by ridge bed (furrow) pattern (34.00 cm). There was a significant decrease in plant height (32.50 cm) in spinach by planting in flat beds (drilling in rows); while the lowest plant height of 29.50 cm was recorded in spinach cultivated on flat beds (seed broadcasted). Statistically, the differences in plant height of spinach cultivated under raised bed system and ridge bed (furrow) system were non-significant. The study showed that spinach cultivated under raised bed pattern ranked 1st with 34.50 cm plant height, ridge bed system ranked 2nd with 34.00 cm plant height, and crop cultivated under flat bed (drilling in rows) and flat bed (seed broadcasting) ranked 3rd and 4th, respectively. Thus these results are in agreement with the studies carried out by Kovach *et al.*, (1983), Leskovar and Stein (2000), Waseem *et al.*, (2001), and Ghafoor *et al.*, (2002) that ridge sowing resulted in higher spinach yields than rest of the sowing patterns. Similarly Wightman *et al.*, (2001) reported that the effect of sowing patterns on the growth and yield of spinach was remarkable and effect of sowing patterns on spinach was highly significant in terms of total fresh yield. Therefore, Habimana *et al.*, (2014) concluded that the use of the combination treatment of 30 x 15cm can be recommended to farmers to increase spinach production.

Number of leaves per plant:- The effect of sowing patterns on the number of leaves per plant of spinach was significant (Table-1). The spinach crop cultivated on raised beds produced higher number of leaves per plant (21.00) was closely followed by spinach crop cultivated on ridge bed (furrow) pattern with 20.67 average number of leaves per plant. The number of leaves per plant markedly reduced to 19.67 when spinach crop was cultivated in flat bed (drilling in rows); while the lowest number of leaves per plant of 18.00 on flat bed (seed broadcasted). There was a remarkable impact of sowing patterns on the number of leaves per plant in spinach and crop performance for this parameter was higher under raised bed as well as ridge bed (furrow) systems over flat bed (drilling in rows) and flat bed (seed broadcasting). The difference in the number of leaves per plant between raised bed and ridge bed (furrow) was non-significant indicating similarity in crop performance under these two sowing patterns. An overview of previous work by Leskovar and Stein (2000) reported somehow same results that ridge sowing resulted in higher number of spinach leaves per plant than rest of the sowing patterns (Wightman, *et al.*, 2001). Contrary to present results, Waseem *et al.*, (2001) found that broadcast method of sowing produced the most prominent results in developing maximum number of leaves (11.61). Siura and Davila (2008) found that the growth and yield traits of spinach were significantly influenced by the sowing methods. Ridge method resulted in higher crop performance in spinach. Imani (2013) studied the effect of autumn sowing date and planting method on yield and yield components of spinach cultivar. Similarly, Rodríguez *et al.*, (2013) reported significant impact of sowing methods on the growth and yield of spinach. Therefore, Sarkar *et al.*, (2014) recommended that the combination of 1st week of May along with 30 cm × 15

cm spacing should be adopted for commercial cultivation of spinach in medium to upland situation.

Weight of fresh leaves per plant:- Sowing patterns had significant (P<0.05) effect on the fresh weight of leaves per plant of spinach (Table-1). The spinach crop cultivated on raised beds produced maximum fresh weight of leaves plant^{-1} (44.00 g), followed by on ridge bed (furrow) with 43.33 g weight of fresh leaves per plant. The fresh weight of leaves per plant decreased considerably to 41.17 g when the spinach crop was cultivated in flat bed (drilling in rows); while the lowest fresh weight of leaves plant^{-1} of 37.67 g was observed in spinach cultivated on flat bed (seed broadcasted). The crop performance for the weight fresh leaves per plant positively impacted by sowing patterns. Under raised bed and ridge bed (furrow) system the crop produced more fresh weight of leaves as compared to flat bed (drilling in rows) and flat bed (seed broadcasting). The differences in weight of fresh leaves per plant between raised bed and ridge bed (furrow) were non-significant indicating similarity in fresh weight under two sowing systems. Waseem *et al.,* (2001) found that broadcast method of sowing produced the most prominent results in maximum fresh foliage yield of 2255 kg ha^{-1}, and maximum dried foliage yield of 218.7 kg ha^{-1}. The similar results have been reported by Ghafoor *et al.,* (2000), who have reported that the effects of sowing patterns on spinach showed that row spacing caused significantly higher total fresh yield.

Table 1. Plant height, number of leaves and weight of leaves plant^{-1} of spinach under different sowing patterns.

Sowing methods	Plant height (cm)	No. of leaves per plant	Weight of leaves per plant (g)
Flat bed (seed beoadcasting)	29.50^{c}	18.00^{c}	37.67^{c}
Flat bed (drilling in rows)	32.50^{b}	19.67^{b}	41.17^{b}
Raised bed	34.50^{a}	21.00^{a}	44.00^{a}
Ridge bed (Furrow)	34.00^{a}	20.67^{a}	43.33^{a}
S.E.±	0.9129	0.4513	0.8165
LSD $_{(0.05)}$	2.2337	1.1044	1.9979
CV%	3.49	2.83	2.45

In a column means having same letters are non-significantly different at P=0.05.

Table 2. Mean squares of various traits of spinach as affected by different sowing patterns

Source of variances	Degrees of freedom	Plant height	No. of leaves plant^{-1}	Weight of leaves plant^{-1}	Leaf length	Days to first cutting	Yield ha^{-1}
Treatments	3	26.00**	9.22**	41.00**	12.97**	7.67**	98690.1**

**, indicates significant level at 0.01 of probability level

Leaf length (cm):- The length of leaves was significantly influenced (P<0.05) by different sowing patterns (Table-3). The spinach sown on raised beds produced plants with maximum leaf length (25.00 cm), and there was non-significant decrease in leaf length (24.67 cm) when the spinach crop was cultivated on ridge bed (furrow) system. The leaf length lowered considerably to 23.67 cm in plots where the crop was planted in flat bed (drilling in rows); while the minimum leaf length of 21.50 cm was observed in spinach crop cultivated in flat bed (seed broadcasted) system. It was observed that sowing pattern showed significant impact on leaf length of spinach; whereas broadcasting in flat bed showed poor performance in regards to leaf length; while raised bed planting and ridge bed (furrow) planting showed higher performance over rest of the sowing patterns. Statistically, the difference in leaf length of spinach cultivated under raised bed system and ridge bed (furrow) system was non-significant. Similarly, Imani (2013) reported the effect of autumn sowing date and sowing method on yield and its attributes in spinach cultivars. Rodríguez *et al.,* (2013) stated a substantial effect of sowing methods on the growth and yield traits of spinach. Habimana *et al.,* (2014) recommended to farmers that spinach production may be enhanced through the use of the combination treatment of 30 x 15cm. Moreover, Sarkar *et al.* (2014) also described that the combination of 1st week of May along with 30 cm × 15 cm spacing showed superior performance than rest of treatment combinations and that may be proved quite useful for commercial cultivation in medium to upland situation.

Days taken to first cutting: - The sowing patterns had significant (P<0.05) impact on the days taken to first cutting of spinach (Table-3). The spinach crop cultivated on ridge bed (furrow) took maximum days to first cutting (31.67), followed by spinach crop cultivated on flat bed seed broadcasting with 30.50 days to first cutting. The spinach crop cultivated in raised bed took 29.83 days to

first cutting; while the minimum days taken to first cutting (29.00) were observed in spinach cultivated on flat bed (drilling in rows). The results clearly indicated higher crop growth in case of flat bed (drilling in rows) while some delay in reaching the crop to first cutting was observed under ridge bed (furrow) or raised bed systems. The difference in days taken to first cutting between raised bed and flat bed (seed broadcasting) was non-significant (P>0.05). Siura and Davila (2008) found that the growth and yield trait of spinach was significantly influenced by the sowing methods and ridge method which resulted in high crop performance in spinach. Darani *et al.,* (2013) studied the effect of sowing methods on yield and components of spinach, using raised bed sowing and ridge sowing methods. The highest number of days until 50% flowering (56 days), days to maturity equal to 92 days and the highest yield and total weight of the plant were higher under raised bed sowing.

Yield ha^{-1}(kg):- The effect of sowing patterns was significant on the yield per hectare of spinach. The crop cultivated on raised beds produced highest spinach yield ha^{-1} (2119.67 kg), followed by spinach crop cultivated on ridge bed (furrow) system with spinach yield of 2074.00 kg ha^{-1}. The spinach yield ha^{-1} decreased significantly to 2003.67 kg when the crop was cultivated on flat bed (drilling in rows); while the lowest crop yield ha^{-1} of 1814 kg was obtained on flat bed (seed broadcasting). The difference in the spinach yield ha^{-1} between raised bed and ridge bed (furrow) was non-significant (P>0.05) indicating similarity in crop yields under raised bed and ridge bed (furrow) systems. The results of present study are in line with the Kovach *et al.,* (1983) claimed that raised bed heights and widths had positive effects on the crop yield. Leskovar and Stein (2000) reported that ridge sowing resulted in higher spinach yields than rest of the sowing patterns. Waseem *et al.,* (2001) found that broadcast method of sowing produced the most prominent results in all the parameters, giving the maximum plant height (25.58 cm), higher number of leaves (11.61), maximum fresh foliage yield (2255 kg ha^{-1}) and maximum dried foliage yield (218.7 kg ha^{-1}). Wightman *et al.,* (2001) reported significant effect of sowing patterns on the growth and yield. As reported by Ghafoor *et al.,* (2002) who examined the effect of sowing patterns on spinach and reported that the differences among row spacing were highly significant in terms of total fresh yield.

Table 3. Days taken to 1st cutting, leaf length and leaf yield ha^{-1} of spinach under different sowing patterns

Sowing patterns	Days taken to 1st cut	Leaf length (cm)	Leaf yield (kg ha^{-1})
Flat bed (seed broadcasting)	30.50^{b}	21.50^{c}	1814.67^{c}
Flat bed (drilling in rows)	29.00^{c}	23.67^{b}	2003.67^{b}
Raised bed	29.83^{b}	25.00^{a}	2119.67^{a}
Ridge bed (Furrow)	31.67^{a}	24.67^{a}	2074.00^{a}
S.E.±	0.2357	0.2557	43.610
LSD 0.05	0.5767	1.1045	106.71
CV%	0.96	2.38	4.72

In a column means having same letters are non-significantly different at P=0.05.

Conclusions: It was concluded that spinach cultivated on raised bed and ridge bed (furrow) systems to obtain higher crop performances over rest of the sowing methods in terms of yield and its contributing traits in spinach. Therefore, spinach should be cultivated either by raised bed method or by ridge bed method for getting maximum growth as well as yield of this crop.

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