Research Article

Impact of Growing Methods and Direction of Sowing on the Plant Growth and Seed Production of Ridge Guard (*Luffa acutangula* Roxb)

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Abstract | An experiment on "Impact of growing methods and direction of sowing on the growth and seed production of ridge guard (*Luffa acutangula* Roxb)" was conducted at PARC-National Tea and High Value Crops Research Institute, Shinkiari, Mansehra, Pakistan during the months of April-September, 2019. The experiment was laid out in Randomized Complete Block design (RCBD) with split plot arrangement having three replications. There were 45 plants in each replication. The treatments comprises of two growing methods i.e. vertical growing method and horizontal method which was assigned to the main-plot and two direction of sowings i.e. east to west and north to south which were allotted to the sub-plot. The results of the experiments revealed significant variation among studied parameters. In case of growing methods, maximum vine length (4.55 m), number of leaves vine^{-1} (41.22), number of fruit set vine^{-1} (4.04), fruit weight (2.23 kg), fruit length (41.63 cm), number of seeds fruit^{-1} (648.83), seed weight fruit^{-1} (86.66 g) and seed yield (290.33 kg ha^{-1}) was obtained from plants which were trained vertically whereas minimum vine length (4.16 m), number of leaves vine^{1} (33.49), number fruit set vine^{-1} (3.49), fruit weight (1.88 kg), fruit length (41.63 cm), number of seed fruit^{-1} (470.00), seed weight fruit^{-1} (67.60 g) and seed yield (212.83 kg ha^{-1}) was recorded from horizontal growing method. In case of direction of sowing, maximum vine length (4.44 m), number of leaves vine^{-1} (39.14), number of fruit set vine^{-1} (3.86), fruit weight (2.19 kg), fruit length (46.57 cm), fruit width (9.87 cm), fruit cavity (7.33 cm), number of seeds fruit^{-1} (584.00), seed weight fruit^{-1} (80.83 g) and seed yield (257.50 kg ha^{-1}) was recorded from plants which were planted on ridges in East to West direction. Whereas, minimum vine length (4.27 m), number of leaves vine^{-1} (35.57), number of fruit set vine^{-1} (3.68), number of fruit rot vine^{-1} (1.44), fruit weight (1.92 kg), fruit length (43.46 cm), fruit width (9.80 cm), fruit cavity (7.23 cm), number of seeds fruit^{-1} (534.83), seed weight fruit^{-1} (73.50 g) and seed yield (245.67 kg ha^{-1}) was obtained from plants which were planted in north-south direction. The findings of the present trial indicates that vertical growing method in combination with east to west direction of sowing suited best for seed production of ridge guard.

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Introduction

In Pakistan, traditional system of growing is used for seed production of ridge guard in which vine are allowed to spread on the soil, resulting in fruit decay and disease infestation as the fruit has to stay on ground till maturity (Kalyanrao *et al.*, 2012). In horizontal planting system, more spacing is required for the plant growth, vine are usually damaged during different cultural practice, so yield and

quality of the crop is effected (Rajesh *et al*., 2016). In this regard vertical trailing can play an important role in enhancing seed production of ridge guard by protecting the fruit from direct contact with soil and water (Egun, 2007). Maximum seed yield can be achieved by better exploitation of sunlight by production of higher number of side branches and leaves resulted into better assimilation of carbohydrates. In vertical system, harvesting of fruit is more efficient as compared to horizontal system which requires stoop labor and movements of canopy to expose and harvest the fruit. Previous studies on ridge gourd indicated that vertical system of planting produces lengthy vine, more number of branches, and earliness in flowering and longer fruit than horizontal growing method (Singh *et al*., 2014). Although, the valuable role of vertical growing method in crop production have been proven but little information is available on seed production of Ridge guard.

Under field conditions, seed yield is directly proportional to the intercepted photosynthetic active radiation which depends upon leaf area index of the crop (Planet *et al*., 2000). Main tasks to the agricultural scientists is to increase the production by harvesting the natural resources like light, rains and to quash the pest and disease prevalence using alternate method and technology to reduce the cost of production and save the environment with minimum use of chemicals. Seed production of ridge guard can be enhanced through better light interception and suppress incidence of diseases by modifying the microclimate within crop canopy. Direction of sowing can influence light interception as well as crop canopy microclimate significantly which in turn may change diseases and pest incidence scenario and crop growth parameters. Bhan *et al.* (1995) evaluated different cultivars of Indian mustard and obtained better yield from plants which were planted in east-west direction (963 kg ha^{-1}) as compared to north to south direction. Dhingra *et al.* (1986) reported that wheat planted in north to south direction has positive effect on growth, flowering and seed yield of wheat.

Different researchers reported various row directions for higher yield and quality. These contradictory findings create confusion and needs to be sort out in ridge gourd perse. Keeping in view the explained facts, the present experiment was carried outto find out the effect of growing methods and direction of sowing on the plant growth and seed production of ridge guard.

Materials and Methods

Study area

In order to find out interactive effect of vertical trailing and direction of sowing on the growth and yield of ridge guard cv Pusa green, a field experiment was conducted at National Tea and High Value Crops Research Institute, Shinkiari, Mansehra, KP, Pakistan, during the month of April 2019.

Experimental treatments and design

The layout of the experiment was in randomized complete block design with spilt plot arrangement having three replications. Two growing methods i.e. Vertical growing method (plants were trained upward with the help of bamboos) and horizontal growing method (plants were left on the soil as commonly used in traditional method) were kept in main plots whereas different directions of sowing i.e. east to west and north to south were assigned to sub-plot in both planting system. There were four sub-plots in each replication having an area of 30 m^2 $plot^{-1}$of each with the 40 number of plants $plot^{-1}$with row spacing of 150 cm and plant spacing of 40 cm.

Cultural practices

Nitrogen at the rate of 35 kg ha^{-1}, phosphorus and potassium at the rate 40 and 30 kg ha^{-1} as Urea, single super phosphate and murriate of potash respectively were applied at the time of sowing. Cultural practices i.e. hoeing, weeding, irrigation and pesticides application was carried out uniformly. Data regarding vine length (m), number of leaves $vine^{-1}$, number of fruit set $vine^{-1}$, number of fruit Rot $vine^{-1}$, fruit weight (kg), fruit length (cm), fruit width (cm), fruit cavity (cm), number of seeds $fruit^{-1}$, seed weight $fruit^{-1}$ (g) and seed yield ha^{-1} was recorded during growth and after harvest of crop.

Statistical analysis

All the data of the trial obtained from different parameter were statistical analyzed to find out the level of significance. The mean of different parameters were separated by using statistical software MSTATC at 5 % level of significant (Steel and Torrie, 1980).

Results and Discussion

Vine length (m) and No. of leaves $vine^{-1}$

Statistical analysis of the data showed that growing methods and direction of sowing had significant

effect on vine length and number of leaves vine^{-1} while its interaction had non-significant effect on vine length and number of leaves vine^{-1} (Table 1). In case of growing methods, mean data revealed that maximum vine length and number of leaves vine^{-1} (4.55 m and 41.22) was recorded from plants which were trained vertically whereas minimum vine length and number of leaves vine^{-1} (4.16 m and 33.49) was obtained from plants which were allowed to spread on the ground horizontally. The reduction in vine length in horizontal growing method might be due to disturbance of normal auxin movement which in turn effect phloem transport (Solangi *et al*., 2009). Similar results were obtained by Halli *et al*. (2009) which reports that vertical training of ridge guard improves vine length as compared to traditional horizontal growing method. In case of direction of sowing, lengthy vine and more number of leaves vine^{-1} (4.44 m and 39.14) were obtained from plants which were planted in East to West direction whereas smaller vine length and less number of leaves vine^{-1} (4.27 m and 35.57) were produced from plants which were planted in North to south direction respectively. Highest vine length and number of leaves vine^{-1} in plants planted in East-West direction might be due to better interception of photosynthetically active radiation (PAR) which increases photosynthetic activity and carbohydrates assimilation which is essential for plant growth (Abd EI Maksoud, 2008). These results are in conformity with those of Haque *et al*. (2009) which reported maximum plant growth when planted in East-west direction.

Number of fruit set vine^{-1} and number of fruit rot vine^{-1}

Number of fruit set vine^{-1} and number of fruit rot vine^{-1} was significantly affected by growing methods and direction of sowing whereas its interaction had non-significant effect (Table 1). In case of growing methods, highest number of fruit set vine^{-1} and lowest no of fruit rot vine^{-1} (4.04 and 1.21) was recorded from plants which were trained vertically; whereas, lowest number of fruit rot vine^{-1} and highest number of fruit set vine^{-1} (3.49 and 1.52) were obtained from horizontal growing method. The higher fruit set in vertical growing method might be due to better pollination opportunity as compared to horizontal growing method whereas lower number of fruit rot in vertical growing method might be due to the fact that it prevents the fruit from direct contact with soil and water and preventing them from been infected with pathogens. These results are in conformity with those of Sundriyal *et al*. (2005) and Solangi *et al*. (2009). In case of direction of sowing, more fruit set vine^{-1} and less fruit rot vine^{-1} (3.86 and 1.28) were noted from plants which were planted in East-West direction whereas less fruit set vine^{-1} and more fruit rot vine^{-1} (3.68 and 1.44) were obtained from plants which were planted in North to South direction. Increased fruit set and fruit rot in East-West planted plants might be due better utilization of solar radiation as compared to North-south planted plants (Monem *et al*., 2012). These results are in conformity with those of Borger *et al*. (2010) which reported better yield in East to west planted plants of wheat.

Fruit weight

Statistical analysis of the data showed that growing methods and direction of sowing had significant effect on fruit weight (kg) while its interaction had non-significant effect (Table 2). In case of growing methods, highest fruit weight (2.23 kg) was recorded from plants which were trained vertically whereas lowest fruit weight (1.88 kg) were obtained from horizontal growing method. More fruit weight in vertical method of planting in ridge guard might be due to more growth and less pest and disease attack

Table 1: *Vine length (m), number of leaves vine^{-1}, number of fruit set vine^{-1}, number of fruit rot vine^{-1} as effected by growing methods and direction of sowing.*

Treatments	Vine length (m)	No. of leaves vine^{-1}	No. of fruit set vine^{-1}	No of fruit rot vine^{-1}
Growing methods				
Vertical system	4.55 A	41.22 A	4.04 A	1.21 B
Horizontal system	4.16 B	33.49 B	3.49 B	1.52 A
LSD	0.1671	2.1028	0.1181	0.0899
Direction of sowing				
East to West	4.44 A	39.14 A	3.86 A	1.28 B
North to South	4.27 B	35.57 B	3.68 B	1.44 A
LSD	0.0524	0.9469	0.0925	0.0285

Table 2: *Fruit weight (kg), fruit length (cm), fruit width (cm), fruit cavity (cm) as affected by growing methods and direction of sowing.*

Treatments	Fruit weight (Kg)	Fruit length (cm)	Fruit width (cm)	Fruit cavity (cm)
Growing methods				
Vertical method	2.23 A	48.63 A	09.64 B	7.15 B
Horizontal method	1.88 B	41.40 B	10.03 A	7.41 A
LSD	0.1314	4.9833	0.1543	0.2113
Direction of sowing				
East to West	2.19 A	46.57 A	9.87 A	7.33 A
North to South	1.92 B	43.46 B	9.80 A	7.23 B
LSD	0.0880	0.8824	0.1306	0.0131

on ridge guard in vertical method. These results are in agreement with those of Chukwudi *et al.* (2014) which reported maximum fruit weight in vertical growing method as compared as horizontal growing method. In direction of sowing, maximum fruit weight (2.19 kg) was noted from plants which were planted in east to west direction whereas minimum fruit weight (1.92 kg) was recorded from plants which were planted in north to south direction. These results are in conformity with those of Monem *et al.* (2012) which reported significant increase in fruit weight of mung beans in east-west direction and recorded increase in yield by 16 %. Morcelis *et al.* (2006) also reported better yield of fruit vegetables in case of its plantation in east to west direction and also noted that 1% increment in light results an increase of 0.7 to 1.0 increase in yield of fruit vegetables.

Fruit length (cm)

Analysis of the data indicated that growing methods and direction of sowing had significant effect on fruit length while its interaction had non-significant effect (Table 2). In case of growing methods, maximum fruit length (48.63 cm) was recorded from plants which were trained vertically whereas minimum fruit length (41.40 cm) was obtained from plants which were planted horizontally. These results are in conformity with those Shantappa (2004) who obtained highest fruit length of bitter guard from plants which were planted in vertical growing method. Similar results were recorded by Singh *et al.* (2014) where highest fruit length was obtained from vertical planting system. In direction of sowing, lengthy fruits (46.57 cm) were recorded from plants which were planted in East to west direction whereas smallest fruits (43.46 cm) were obtained from plants which were planted in North to South direction. Maximum fruit length in east-west direction of sowing might be due to better growth which results in better production of more plotosynthate than north to south direction of sowing. These results are in conformity with those of Morcelis *et al.* (2006) which recorded better yield of fruit vegetable when planted in east to west direction.

Fruit width (cm)

Fruit width (cm) was significantly affected by growing methods and direction of sowing whereas its interaction has non-significant effect (Table 2). In case of growing methods, more fruit width (10.03 cm) was recorded from horizontal growing methods whereas less fruit width (9.64 cm) was obtained from vertical growing method. Similar results were obtained by Kalyanrao *et al.* (2012) in pumpkin where maximum fruit width was noted from horizontal growing method. In direction of sowing, maximum fruit width (9.87 cm) was noted from plants which were planted in east-west direction whereas minimum fruit width of 9.80 cm was recorded from plants which were planted in north-south direction. These results are in line with those of Haque *et al.* (2009) which reported minimum fruit width from north to south planted plants due to reduced light levels.

Fruit cavity (cm)

Analysis of the data showed that growing methods and direction of sowing had significant effect on fruit cavity, whereas, its interaction had non-significant (Table 2). In case of growing methods, bigger fruit cavity of 7.41 cm was recorded from plants which were planted horizontally whereas smaller fruit cavity of 7.15 cm was obtained from plants which were trained vertically. Highest fruit cavity in horizontal growing method might be due to the fact that less space is available for the fruit elongation that's why fruit started their growth in spreading nature where they needs to exerts less force as compare to cell

elongation. These results are in conformity with those of Solangi *et al.* (2009) who reported highest fruit cavity from horizontal growing method as compared to vertically trained plants. In case of direction of sowing, maximum fruit cavity (7.33 cm) was recorded from plants which were planted on ridges in east to west direction whereas minimum fruit cavity (7.23 cm) was noted from plants which were planted in north-south direction. More fruit cavity in east to west direction might be due to more light intensity in east-west direction planted plants as compared north-south planting system.

No. of seeds per fruit

Statistical analysis of the data showed that growing methods and direction of sowing had significant on number of seeds fruits^{-1} whereas, its interaction had non-significant effect (Table 3). In case of growing methods, more seeds fruits^{-1} (648.83) were obtained from plants which were trained vertically whereas less seeds fruit^{-1} (470.00) were noted from plants which were planted in horizontal growing method. These results are in line with those of Singh *et al.* (2014) which reported better seeds fruit^{-1} in vertical growing method as compared to horizontal growing method. In case of direction of sowing, maximum seeds fruit^{-1} (584.00) were recorded from plants which were planted in east-west direction whereas minimum seeds fruit^{-1} (534.83) were obtained from plants which were planted in north-south direction. Similar results were also obtained by Wajid *et al.* (2007) where maximum seeds fruit^{-1} were obtained by plants which were planted in east-west direction.

Seed weight fruit^{-1}

Seed weight fruit^{-1} was significant affected by growing methods and direction of sowing while its interaction had non-significant effect (Table 3). In case of growing methods, highest seed weight fruit^{-1} (86.66 g) was recorded from vertical growing method whereas lowest seed weight fruit^{-1} (67.66 g) was obtained from horizontal growing method. These results are in harmony with those of Bhatia *et al.* (2005) who obtained maximum seed weight plant^{-1} from vertical growing method in bottle guard as compared to horizontal growing method. In treatment direction of sowing, maximum seed weight fruit^{-1} (80.83 g) was obtained from plants which were planted on ridges in east to west direction whereas minimum seed weight fruit^{-1} (73.50) was recorded from plants which were planted on ridges in north to south direction. These results are in conformity with those of Jha *et al.* (2012) who reported better seed weight fruit^{-1} in mustard in east to west direction as compared to north to south direction.

Table 3: *Number of seeds fruit^{-1}, Seed weight fruit^{-1} and seed yield (kg ha^{-1}) as effected by growing methods and direction of sowing.*

Treatments	No. of seeds fruit^{-1}	Seed weight fruit^{-1} (g)	Seed yield (kg ha^{-1})
Growing methods			
Vertical system	648.83 A	86.66 A	290.33 A
Horizontal system	470.00 B	67.66 B	212.83 B
LSD	1.4342	1.2421	3.2862
Direction of sowing			
East to West	584.00 A	80.83 A	257.50 A
North to South	534.83 B	73.50 B	245.67 B
LSD	5.6295	3.1385	2.1704

Seed yield (Kg ha^{-1})

Analysis of the data indicates that growing methods and direction of sowing had significant effect on seed yield (kg ha^{-1}) whereas its interaction had non-significant effect (Table 3). In treatment growing methods, highest seed yield (290.33 kg ha^{-1}) was noted from vertical growing meth whereas minimum seed yield (212.83 kg ha^{-1}) was obtained from horizontal growing method. Highest seed yield in vertical growing method might be due to vigorous growth of plant which results in production of more food and their translocation might favor the development of seed yield. These results are in harmony with those of Halli *et al.* (2009) which reported maximum seed yield from vertical planting system in ridge guard. In case of direction of sowing, more seed yield (257.50 kg/acre) was recorded from plants which were planted on ridges in east to west direction whereas less seed yield (245.67 kg/acre) was obtained from plants which were planted on ridges in north to south direction. The highest seed yield in east-west direction might be due to better development of fruit attributes. These results are in conformity with those of Jha *et al.* (2012) which states that maximum seed yield was obtained from mustard planted in east to west direction.

Conclusions and Recommentdations

Out of these two methods, vertical planting system performed better than horizontal planting system due to production of more seeds per fruit, seed weight per

fruit and ultimately the highest seed yield. In case of direction of sowing, plants planted in east to west direction produced the highest seed weight per fruit, No. of seeds per fruit seed yield per acre as compared to North-South direction planted plants. Therefore for better seed production it is recommended that ridge guard should be planted in vertical planting system in east to west direction.

Novelty Statement

This kind of research has been carried out for the first time on vegetable crops in the area. The research presents novel ideas about different planting system which will add new parameters to future research and will improve the quality of fruit produced by this new planting system.

Author's Contribution

Imtiaz Ahmad, Naveed Ahmad and Abdul Waheed: Conceived and designed the experiment, managed, collected and analyzed the data and wrote the paper. **Muhammad Abbas Khan, Noorullah Khan and Fayaz Ahmad:** Conceived and designed the experiment, helped in collection and analysis of data and critically review the paper.

Conflict of interest

The authors have declared no conflict of interest.

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