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Effect of ridges height on the growth, yield and root rot control of different chili cultivars in mansehra

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Abstract

Root rot disease caused by *Phytophthora nicotianae* has serious threat to chili (*Capsicum annuum L.*). Annually, this disease causes billions of dollars loss due to damage of crops throughout the world. This experiment was evaluated on the "effect of ridges height on the growth and root rot control of chili cultivars in Mansehra" during 2016. The Randomized Complete Block Design (RCBD) was used with two factors factorial arrangement having three replications. Four chili cultivars i.e. Sundari, Ghotki, Skyline-2 and P-6 were tested for their tolerance against root rot disease. Different ridges height i.e. flatbed, 20, 30 and 40 cm were used. Different parameters including plant height, numbers of branches plant^{-1}, number of fruits plant^{-1}, fruit length, number of seeds fruit^{-1}, root length, root rot incidence, plant mortality, 1000 seed weight, fruit weight plant^{-1}, and yield were studied in the experiment. The result showed that increase in ridges height decreased in root rot disease. Throughout the experiment all other cultivars were found susceptible to root rot disease except cultivar P-6. Maximum plant height (92.86 cm), numbers of branches (14.87), root length (29.53 cm), number of fruit plant^{-1} (204.33), minimum disease incidence (12.33%), and plant mortality (10.00%) , fruit weight plant^{-1} (785.87 g), and yield per hectare (23.57 ton ha^{-1}) were recorded in P-6 on ridges height 40 cm. The cultivar P-6 was recommended for plant growth parameter enhancing yield and reducing percent root rot disease incidence with 40 cm ridge height in Mansehra.

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Introduction

Chili (*Capsicum annuum L.*) belongs to family Solanaceae. Chili ranked third in production after Potato and tomato (Naz *et al.,* 2006). It is originated from Brazil and tropical South America (Bhuvaneswari *et al.,* 2013). In Pakistan, chili is cultivated on area of 64829 hectares with total production of 143153 tones. In Punjab area under cultivation of chili is 5652 hectares with production 9077. In Sindh, production of chili was 127544 tons that was cultivated on an area of 54618 hectares.

In Balochistan area under cultivation is 4149 hectare with the production of 6120 tons, and in Khyber Pakhtunkhwa (KPK) Province chilies are grown on area of 410 hectares with total production of 412 tones (GPMN, 2016).

Well drained, silt clay loam soil, with adequate supply of the essential nutrients is suitable for better production of Chili (Alabi, 2006). Chilies are rich source of Vitamin A and C, it is also called Capsule of Vitamin C containing appreciable quantity of calcium, phosphorus and iron. Chili pungency is due to capsaicin which is consisting of seven closely related alkaloids (Bosland, 1992).

Root rot disease has serious threat to chili which affects the production of chili. The *Phytophthora capsici* oomycete of plant pathogen infect the leaves, fruits, stems and roots of chili plant (Lee *et al.,* 2001). Annually this disease causes billions of dollars loss due to damage of crops throughout the world (Oelke *et al.*, 2003). *Phytophthora capsici* attack different species of chili, potato, and other members of the solanaceae family and Cucurbitaceae family (Fatima *et al.*, 2009; Glosier *et al.*, 2008).

The practice of fungicides causes several problems e.g. threats to human and plant health and resistance of pathogens to these chemicals. Further, effective fungicides are costly and may not be easily available in the market. Cultural method is one of the best options (Mehboob *et al.*, 1998). The development of tolerant cultivars is one of the cheapest and effective controls (Saleem *et al.*, 1998).

During rainy weather root rot disease spread rapidly which caused heavy loss in chili production (Ristaino, 1991). The climatic condition of Mansehra is favorable for the spread of Root rot disease.

There has been no systematic study conducted to find out the extent of control of these diseases through crop management practices in Mansehra. This study was attempted to search for varietal tolerance against chilies root rot and find out if the disease could be controlled through optimum ridges height, besides studying their effect on chilies growth.

Materials and methods

The experiment was conducted during spring 2016 at Agriculture Research station Baffa, Mansehra from the behalf of The Agriculture University of Peshawar, Pakistan.

Soil analysis

Soil sample up to 25 cm were taken randomly from different parts of the experimental field before transplanting of the seedlings and observed in the soil science laboratory at Agriculture research station Baffa. Mansehra for physico-chemical analysis. Physico-chemical analysis of experimental soil is shown in Table 1.

Table 1. Physico-chemical analysis of experimental soil.

Determination	Quantity
Nitrogen (%)	0.042
Phosphorus (mg kg^{-1})	9.00
Potassium (mg kg^{-1})	110
Organic matter (%)	0.83
Ph	7.3
Texture class	Clay loam

Preparation of land and nursery raising

First the nursery of chilies was raised in glass house. Seeds were sown in modulated trays and were frequently irrigated with sprinkler till germination.

After the development of 5 to 6 leaves, seedlings were then transplanted into the well prepared field.

Experimental design

The experiment was comprised of two factors. Ridges height was one factor, while various Cultivars was the second factor and was laid out in Randomized Complete Block design (RCBD) having sixteen treatments, which were replicated three times. The four selected cultivars were Sundari, Ghotki, Skyline-2, P-6. Cultivar Sundari originated in Korea, Ghotki and Skyline-2 in Sindh, Pakistan and P-6 in Switzerland.

These cultivars were tried for their tolerance against root rot disease. Five weeks old nursery was transplanted on 12 May 2016. The field was naturally infested and the previous chilies were destroyed by root rot disease in the same field. Each treatment consisted of two rows which contained 5 plants in each row. The plot size was kept 3 m^2 and plant to plant and row to row distances were kept 40 and 75 cm, respectively.

The materials used and the procedure followed is out-lined below.

Factor A: Ridges Height	Factor B: Cultivars
H_0 = flatbed	C_1 = Sundari
H_1 = 20 cm	C_2 = Ghotki
H_2 = 30 cm	C_3 = Skyline-2
H_3= 40cm	C_4 = P-6

Parameters

The following parameters were studied in the experiment.

Plant height (cm): Five plants were selected randomly in each treatment of each replication, and their height was taken with the help of measuring tape and average was calculated.

Number of branches plant^{-1}: Number of branches plant^{-1}were recorded by counting branches of five randomly selected plants and then average were determined.

Number of fruit plant^{-1}: Five plants were randomly selected in each treatment of each replication, fruits were counted and average was computed.

Fruit length (cm): The average fruit length was taken by measuring the fruit from randomly selected plants and their average was calculated.

Root length (cm): The root length of randomly selected plants was measured through meter rod from the base of the root to the tip of root in each treatment and their average was calculated.

Percent root rot incidence: Plants were regularly observed for symptoms of root rot disease occurrence. These symptoms include, sudden wilting of entire plant, rapid and permanent wilting of the leaves without notable color change. Leaf lesions expended rapidly to become dark green, irregular shaped. The brown lesions at lower stem also rapidly expanded toward upper parts of the plant. Root of chili became soft blackish brown and odorless type of decay involves in all tissues. Small water soaked spherical lesions become enlarged to cause rooting and wrinkled of the fruits. The data was determined by the following formula.

$$\text{root rot incidence (\%)} = \text{Infected plants} / \text{Total plants} \times 100$$

Mortality %: The data was recorded by the following formula.

$$\text{Mortality (\%)} = \text{Dead plants} / \text{Total plants} \times 100$$

Fruit weight per plant (kg): The yield per plant was obtained by weighing total number of fruits obtained from each selected plant and their average was calculated.

Yield per hectare (kg ha^{-1}) was worked out by the following formula:

$$\text{Yield kg.ha}^{-1} = \frac{\text{Yield per sub plot (kg)}}{\text{Area of sub plot (m)}^2} \times 10000\ \text{m}^2$$

No of seeds fruit^{-1}: The fruit were selected on random basis in each plant and by counting number of seeds obtained from selected fruit and then the average was calculated.

1000 seeds weight: 1000 seeds weight were taken by weighting the 1000 seeds obtained from randomly selected fruit and their average was calculated.

Statistical analysis

The collected data was statistically analyzed by using Computer software 8.1 statistics as described by Jan *et al.* (2009) and means separation among the treatments was done by using LSD at 0.5 level of probability.

Results

Growth behavior

The data regarding plant height, Number of branches/plant (Table 2) showed significant differences among to cultivars and ridges height, The cultivar P-6 attained maximum plant height ((90.13 cm) and was statistically at par with Sundari, Skyline-2, While Ghotki showed minimum plant height (65.04 cm). in case of increasing ridges height (40 cm), increased the plant height (80.75 cm) followed by ridges height 30 cm (80.13cm), while minimum plant height (74.66 c cm) was recorded in flatbed.

Whereas, cultivar P-6 gave maximum numbers of branches plant^{-1} (14.45) followed by Sundari (12.38).

Minimum branches plant^{-1} was recorded in Ghotki and Skyline-2. In case of ridges height (40 cm) maximum number of branches plant^{-1} was recorded (11.67) on, while minimum number of branches plant^{-1}(10.90) were recorded in flatbed.

Table 2. Effect of ridges height on Growth behavior, Yield and yield components of chili cultivars.

Cultivars	Plant height (cm)	Number of branch Plant^{-1}	Number of fruits Plant^{-1}	Yield (tons ha^{-1})
Sundari	84.11 b	12.38 b	165.03 b	17.13 b
Ghotki	65.04 d	9.23 c	158.15 c	10.95 c
Skyline-2	74.15 c	9.34 c	160.87 bc	11.56 c
P-6	90.13 a	14.45 a	193.12 a	21.78 a
LSD at P≤0.01	0.9217	0.5161	5.7200	1.2603
Ridges height (cm)				
0	74.66 c	10.90 b	158.98c	14.01 c
20	77.89 b	11.29 ab	168.10b	15.15bc
30	80.13 a	11.54 a	171.97b	15.66 ab
40	80.75 a	11.67 a	178.12a	16.60 a
LSD at P≤0.01	0.9217	0.5161,	5.7200	1.2603

Yield and yield components

Maximum number of fruits/plant (193.12) was recorded in cultivar P-6 followed by Skyline-2, whereas Ghotki gave the lowest ((158.15) of all (Table 2). In case of ridges height, maximum number of fruits plant^{-1} (178.12) was noted on ridges height 40 cm, while minimum number of fruit plant^{-1} (158.98) were recorded in check plot (0 cm). Similarly, the highest yield (21.78 tons ha^{-1}) was obtained from P-6 cultivars followed by Sundari, while minimum yield (10.95 tons ha^{-1}) was obtained from Ghotki. In cases of ridges height, the maximum yield (16.60 tons ha^{-1}) was recorded on ridge height 40 cm, while the lowest yield (14.01 tons ha^{-1}) was observed in flatbed.

Fruits physical characteristics

The highest fruits length (12.08 cm) was obtained from Sundari cultivars, followed (8.22 cm) by P-6, while minimum fruit length (5.37 cm) was noted in Ghotki (Table 3). Whereas, the ridges height (20 cm) gave maximum fruit length (8.23 cm) on ridges height 20 cm, which is statistically similar to ridges height 30 cm (8.16 cm) and 40 cm (8.03 cm). The minimum fruit length (7.69 cm) was recorded in flatbed. In term of fruit weight treatment were significant different from one another[1]. In case of cultivars, the highest fruit weight plant^{-1} was recorded (768.85 g) in cultivar P-6, followed by Sundari (733.62 g), while the lowest fruit weight plant^{-1} was recorded in Ghotki (645.23g). In the mean table 1, when ridges height (40 cm) increased that gives maximum fruit weight plant^{-1}, while minimum fruit weight plant^{-1} (679.88) was observed in flatbed. Likewise, significant differences were found in number of seeds fruit^{-1} in various cultivars. The highest numbers of seeds fruit^{-1} was obtained by Ghotki (110.57) followed by Sundari (109.81), P-6 given lowest (98.18) in all. Whereas, maximum numbers of seeds fruit^{-1} (105.56) was recorded on ridges height 20 cm which is statistically similar with ridges height 30 cm (104.91) and 40 cm (104.65), while minimum seed fruit^{-1} (102.72) were found in flatbed. Likewise, the mean showed that maximum 1000 seeds weight was found (4.18 g) in P-6 and Ghotki (4.14 g), while minimum seeds weight was found in Sundari (3.20g) and (3.27g) Skyline-2. While no significant differences were recorded on ridges height.

Table 3. Effect of ridges height on fruits Physical Characteristics.

Cultivars	Fruits length (cm)	Fruit weight Plant^{-1} (g)	Number of Seeds fruit^{-1}	1000 seeds weight (gm)
Sundari	12.08 a	733.62 b	109.81 a	3.20 b
Ghotki	5.37 d	645.23 c	110.57 a	4.14 a
Skyline-2	6.48 c	649.62 c	99.27 b	3.27 b
P-6	8.22 b	768.85 a	98.18 b	4.18 a
LSD at P≤0.01	0.4515	6.9685	2.2455	0.2753
Ridges height (cm)				
0	7.69 b	679.88 c	102.72 b	NS
20	8.23 a	697.60 b	105.56 a	NS
30	8.16 a	702.64 b	104.91 ab	NS
40	8.03 ab	717.20 a	104.65 ab	NS
LSD at P≤0.01	0.4515	6.9685	2.2455	

Root length and root rot incidence

maximum root length (25.00 cm) was recorded in cultivar P-6 (Table 4), followed by Sundari (23.73 cm), while minimum root length was recorded in Ghotki (21.50 cm)m which was statistically similar with Skyline-2 (21.85 cm). Meanwhile, the ridges height (40 cm) showed maximum root length (26.81 cm), while the minimum root length (16.84) was recorded in flatbed. Likewise, the maximum root rot incidence was observed in cultivar Ghotki (56.67%), which is statistical similar to Skyline-2 (55.25%), while lowest disease incidence was observed in cultivar P-6 (17.41%). whereas, it is observed from Table 2. Increase in ridge height (40 cm), resulted decrease in incident. The minimum root rot incidence was found (36.50) on ridge height 40 cm. Maximum root rot was found (45.50) in flatbed.

Mortality

Out of four cultivars the maximum mortality % was observed in cultivar Ghotki (49.17 %), and Skyline-2 (46.67 %) (Table 4), whereas minimum mortality % was noted in cultivar P-6. The ridges height also effected the plant mortality %. The highest mortality

% was found (39.17%) in flatbed as compare the rest of all ridges height.

Discussion

By comparing the means for yields component and growth characters were investigated. During the field experiment, the maximum plant height was recorded in cultivar P-6 because it is tolerant to Phytophthora root rot. The current experiment is in agreement with Parwada *et al*., (2011), while Jetawat *et al*., (2016) recommended that increasing the size of ridges height led to increase in plant height. In present study P-6 was found tolerant to root rot diseases which increased the number of branches plant^{-1}. The difference in numbers of branches plant^{-1} among cultivars might be due to their genetic make-up (Hasanuzzaman *et al.,* 2007). Mehboob *et al.,* (1998) also reported that number of branches increased with increase in ridges height. The variations in number fruit plant^{-1} among cultivars might be due to the influence of the growing environment as well as extent of tolerant and susceptibility to root rot disease of any cultivar (Sharma and Rastogi, 1993). Mehmood *et al.* (1999) and Alam *et al.* (1996), who reported that yield of chilies increased with increase in ridges height. In this experiment out of four cultivars tested, P-6 was found tolerant to root rot. It showed lowest disease incidence and maximum yield, while other three cultivars were found comparatively susceptible to root rot disease.

Table 4. Effect of ridges height on root Length and root rot incidence mortality.

Cultivars	Root length (cm	Root rot incidence (%)	Mortality (%) in Field
Sundari	23.73 b	34.75 b	30.00 b
Ghotki	21.50 c	56.67 a	49.17 a
Skyline-2	21.85 c	55.25 a	46.67 a
P-6	25.00 a	17.41 c	15.00 c
LSD at P≤0.01	1.0971	1.9996	5.0208
Ridges height (cm)			
0	16.84 d	45.50 a	39.17 a
20	23.40 c	42.25 b	35.83 ab
30	25.03 b	39.83 c	34.17 ab
40	26.81 a	36.50 d	31.67 b
LSD at P≤0.01	1.0971	1.9996	5.0208

The result could be due to its tolerance against root rot disease, similar results were reported by many researchers Kim *et al.* (2009) who observed resistance of chilies cultivars to root rot disease in chilies. The difference in fruit length among cultivars may be due to genetic make-up. Naz *et al.* (2007) who reported that fruit weight plant^{-1} increased with increase in ridges height. Bakht *et al.*, (2007) who investigated that maize grown on ridges had more cob length more than flat bed. P-6 gave maximum yield compared to Sundari, Ghotki and Skyline-2. The increase on ridges height resulted in decrease in incidence of disease. Naz *et al.* (2009) who also reported that increase in ridges height decreases % diseased in chili crop. Naz *et al*., (2007) who reported that fruit weight plant^{-1} increased with increase in ridges height. The reduction in numbers of seeds fruit^{-1} might be due to reduction in fruit length and diameter of the fruit. Lemma (1998) and Marcelis and Baan Hofman-Eijer (1997), also stated that seed number fruit^{-1} is one factor that determine fruit size of chilies. The variation in seed weight among the cultivars might be due to the genetic makeup of cultivars. Current result are similar with Bosland and Votava (2000) who reported that some cultivars of Chili seed can contain up to 60% of the dry weight of

the fruit which makes it an important economic part of the crop. The increase in root length with increase in ridge height may be due to loosen and aerated soil in ridges that exerts maximum tolerance against root growth and penetration in the soil. Dhliwayo and Chiunzi (2004) and Gomes (1999), who also reported that increase in ridges height increased root length in Sweet potato. . Our results are in agreement with Ali *et al.*, (2014), who reported the effect of various cultivars on the management of root rot. The difference in mortality among the cultivars might be due to genetic make-up. Tolerance to diseases is mainly hereditarily controlled factor and different varieties vary in tolerance to different diseases. These results indicated that cultivar P-6 had maximum plant height (90.13 cm) numbers of branches (14.45) number of fruit plant^{-1} (193.12) root length (25.00 cm), fruit weight plant^{-1} (768.85g), yield per hectare (21.78 ton ha^{-1}), and minimum root rot incidence (17.41%), minimum mortality % (15%).

Conclusion

In our study, cultivar P-6 was superior with respect to yield and other growth parameters and was comparatively root rot disease tolerance for the growers of Mansehra. Likewise 40 cm ridges height is recommended for good yield ha^{-1} of chilies which reduce root rot disease attack in chilies cultivars. Cultivar “Ghotki” and “Skyline -2” had minimum yield and were very susceptible to root rot disease attack.

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