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Influence of Mulching and Planting Geometry on Seed Quality and Ripe Fruit Rot Incidence of Bell Pepper (*Capsicum annuum* L.).

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Abstract

A experimental trial was conducted at Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan, HP, India during *kharif* season 2013, to evaluate the influence of mulching and planting geometry on seed quality and ripe fruit rot incidence of bell pepper (*capsicum annuum* L.) using cv. Solan Bharpur. Planting geometry comprised of three row layouts and two plant layouts. The different treatments involved in the present studies were, four mulches (No mulch, Black-plastic mulch, Silver-black plastic mulch and Crop residue mulch), three row layouts (Single row 60×45 cm^2, Double row (75+45)×45 cm^2), and Double row (90+30)×45 cm^2) and two plant layouts (Rectangle/square, and Triangle) with constant plant population i.e. 37037 plants ha^{-1}. Thus there were 24 (4×3×2) treatment combinations. The field experiment was laid in Split-Split Plot Design replicated three times while laboratory experiment was conducted in Completely Randomized Block Design (Factorial) with four replications. The results revealed that significantly higher germination percentage (95.66%), seedling length (9.98 cm), seedling dry weight (2.99 mg), seed vigour index-Length and Mass (954.74 and 286.05 respectively) was recorded in treatment combination of silver-black plastic mulch+double row (75+45)×45 cm^2+triangle plant layout. However the interaction effect of mulching and planting geometry on 1000 seed weight and ripe fruit rot incidence % was found to be non significant.

Keywords: Bell pepper, mulching, planting geometry, seed quality

1. Introduction

The Bell pepper (*Capsicum annuum* L.) commonly known as sweet pepper, capsicum, green pepper or Shimla mirch, belongs to family Solanaceae. It originated in Meso-America (Mexico and Central America) and South America which is now cultivated all over the world Bosland (1992). Bell pepper was brought to India by the Portugese from Brazil prior to 1885. It was introduced to Himachal Pradesh by the British in the nineteenth century. Bell pepper is a warm season crop sensitive to low temperatures and frosts. It is cultivated in altitudes that range from sea-level to elevations of 3000 m above mean sea level. The optimal temperature range for pepper is 20 °C to 25 °C Rubatzky and Yamaguchi **(**1999). Bell pepper is mainly cultivated in Himachal Pradesh, Uttar Pradesh, parts of Gujarat, Uttarakhand, Jammu and Kashmir, and parts of West Bengal, Maharashtra and Karnataka Chadha (2005). The agro-climatic conditions in mid hills of Himachal Pradesh are ideally suitable

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for the production of bell pepper as an off season cash crop Choudhary et al. (2009). In Himachal Pradesh, the growing period of bell pepper coincides with monsoon rains thus crop is more prone to diseases due to rain splashes, therefore the quality of fruits and seeds are adversely affected. The production of healthy bell pepper crop depends on the quality of seed. Therefore it is necessary to focus on the essential cultural practices which affect fruit growth and ultimately the seed quality. Among different factors, mulching and planting geometry play an important role as former helps in controlling weed population, reducing the impact of falling rain drops, regulation of soil temperature and conservation of soil moisture, enhanced growth, yield and quality of produce Aggarwal et al. (2003) and Singh et al. (2006), while latter affects competition among crop plants for minerals, nutrients and also important to facilitate aeration and light penetration into crop canopy. Plant biomass production per unit area of land is directly related to solar radiation interception Loomis and Connor (1992). Solar radiation interception depends on leaf area index, which is strongly determined by plant density and arrangement. By keeping these facts in view the present study is designed to evaluate the Influence of mulching and planting geometry on seed quality and ripe fruit rot incidence of bell pepper (*Capsicum annuum* L.).

2. Materials and Methods

The experimental trial was conducted at Khaltoo Experimental Farm and Laboratory of Department of Seed Science and Technology, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan, H.P., India during *kharif* season 2013. The experimental farm is located at an altitude of 1250 meters above mean sea level with latitude of 35.50 N and longitude of 77.80 E in the mid- hill zone of Himachal Pradesh. The present studies comprised of, four mulches (M_1- No mulch, M_2- Black-plastic mulch, M_3- Silver-black plastic mulch and M_4- Crop residue mulch) as main plot treatment, three row layouts (L_1- Single row 60×45 cm^2, L_2- Double row (75+45)×45 cm), and L_3- Double row (90+30)×45 cm^2) as sub-plot treatment and two plant layouts (P_1- Rectangle/square, and P_2 –Triangle) as sub-sub plot treatment. Plastic mulches were laid manually in the experimental field, one day before transplanting date while the crop residue mulch was applied one month after transplanting. The experiment was laid out on 11th April, 2013 in Split-Split Plot Design with twenty four treatments (4×3×2) replicated three times while laboratory experiment was conducted in Completely Randomized Block Design (Factorial) with four replications. Fourty five days old seedlings of bell pepper var. Solan Bharpur were transplanted as per the treatments in a plot having size of 2.25×2.4 m i.e. 5.4 m^2. FYM and fertilizers were applied as per package of practices for vegetable crops, Directorate of Extension Education, Dr. Y. S. Parmar University of Horticulture and Forestry, Nauni, Solan, H.P., India. The observation were recorded on 1000 seed weight (g), germination percentage (%), seedling length (cm), seedling dry weight (mg), seed vigour index-Length and Mass and ripe fruit rot incidence (%). Seed vigour-Length and Mass (SVI-I and II) were calculated as per the formula given by Abdul-Baki and Anderson (1973). The statistical analysis of recorded observations was done as per design of the experiment as suggested by Gomez and Gomez (1984).

3. Results and Dicussion

3.1. Main effect of mulching on seed quality parameters

The analysis of variance indicated highly significant differences for the main effect of mulching on seed quality parameters of bell pepper. Observations recorded on seed quality parameters as affected by mulching are presented in Table 1. Maximum 1000 seed weight (5.50 g) was recorded with silver-black plastic mulch (M_3). This may be due to the bigger and good quality fruits resulting in bold seeds, which ultimately increases the seed weight. Maximum seed germination (94.22%) was obtained with silver-black mulch (M_3). This may be because of seeds obtained from the large healthy fruits that have sufficient food reserves resulting better seed germination. Maximum seedling length (8.72 cm) was recorded with silver-black plastic mulch (M_3). This may be due to the fact that bolder seeds were produced in the silver-black plastic mulch which have good amount of stored food, resulting into better seedling growth. Maximum seedling dry weight (2.51 mg) was recorded with silver-black plastic mulch (M_3). Which may because of better development of fruits and seeds was noticed in silver-black plastic mulch which leads to better seedling growth and higher dry matter accumulation. Silver-black plastic mulch (M_3) resulted in maximum seed vigour index - Length and seed vigour index - Mass (822.98, 237.41 respectively), which may be by cause of the fact that silver-black mulch maintains optimum soil moisture and temperature (Verma et al., 2016) during maturation of seeds and these factors resulted in bold and vigorous seeds formation.

3.2. Main effect of row layout on seed quality parameters

The row layout significantly affects the seed quality parameters of bell pepper as indicated in the Table 1. Maximum 1000 seed weight (5.47 g) was obtained with double row (75+45)×45 cm^2 (L_2). The results are in line with the findings of Dharmatti and Kulkarni (1988). Maximum seed germination (93.66 %) was obtained with double row (75+45)x45 cm^2 (L_2). The similar results were also reported by Hasanuzzaman et al., 2007. Maximum seedling length (8.73 cm) was recorded with double row (75+45)×45 cm^2 (L_2). Similar result was also observed by Uddin et al. (2006). Maximum seedling dry weight (2.56 mg) was recorded with double row (75+45)×45 cm^2 (L_2). The results are in conformity with the findings of Sanchez et al (1993), they reported highest seedling dry weight at 45 cm with in row spacing. Double row (75+45)×45 cm^2 (L_2) resulted in maximum seed vigour index-Length and seed vigour index-Mass (819.09, 240.12 respectively). The results are in

Table 1: Main effect of mulching (M), row layout (L) and plant layout (P) on seed quality parameters and ripe fruit rot incidence (%) of bell pepper cv. Solan Bharpur

Particulars	Characters						
	1000 seed weight (g)	Germination (%)*	Seedling length (cm)	Seedling dry weight (mg)	Seed vigour index- L	Seed vigour index- L	Ripe fruit rot incidence (%)*
Main effect (Mulch)							
M_1	5.16	89.22 (9.49)	7.48	2.20	668.68	196.81	7.17 (2.86)
M_2	5.47	93.44 (9.71)	7.99	2.28	747.60	214.20	4.81 (2.41)
M_3	5.50	94.22 (9.75)	8.72	2.51	822.98	237.41	4.78 (2.40)
M_4	5.26	91.33 (9.60)	8.11	2.35	741.54	215.40	5.92 (2.63)
CD (p=0.05)	0.05	0.02	0.07	0.017	6.95	1.77	0.005
Main effect (Row layout)							
L_1	5.38	92.20 (9.65)	8.02	2.32	740.72	214.24	5.66 (2.57)
L_2	5.47	93.66 (9.72)	8.73	2.56	819.09	240.12	5.69 (2.57)
L_3	5.19	90.29 (9.55)	7.47	2.14	675.79	193.51	5.66 (2.57)
CD (p=0.05)	0.04	0.01	0.06	0.015	6.01	1.53	NS
Main effect (Plant layout)							
P_1	5.33	91.75 (9.63)	7.88	2.24	724.39	206.05	5.66 (2.57)
P_2	5.37	92.36 (9.66)	8.27	2.44	766.01	225.86	5.68 (2.58)
CD (p=0.05)	0.03	0.01	0.05	0.012	4.91	1.25	NS

*Figures in the parenthesis represent square root transformation; M_1: No mulch; M_2: Black plastic mulch; M_3: Silver-black plastic mulch, M_4: Crop residue mulch; L_1: Single row 60×45 cm^2, L_2: Double row (75+45)×45 cm^2; L_3: Double row (90+30)×45 cm^2; P_1: Rectangle/Square plant layout, P_2: Triangle plant layout

contradiction with Kamboj and Sharma (2015) they reported maximum seed vigour index-Length and seed vigour index-Mass with a spacing of 45×45 cm^2.

3.3. Main effect of plant layout on seed quality parameters

The data pertaining to the main effect of mulching on seed quality parameters have been presented in Table 1. It is evident from the data that main effect of row layout significantly influenced the seed quality parameters. Triangle (P_2) plant layout significantly increased the 1000 seed weight (5.37 g), seed germination (92.36%), seedling length (8.27 cm), seedling dry weight (2.44 mg), seed vigour index-Length and seed vigour index-Mass (766.01, 225.86 respectively) as compared to rectangle/square (P_1) plant layout. This may be because triangle (P_2) plant layout allows optimum canopy exposure and reduce the inter and intra plant competition for nutrients, water and light which led to improved plant and fruit growth and ultimately produce high quality seeds.

3.4. Effect of mulching, row layout and plant layout geometry on seed quality parameters

The interaction between mulching, row layout and plant layout (M×L×P) exhibited significant effect on seed quality parameters as indicated in the Table 2. Maximum seed germination (95.66%), seedling length (9.98 cm), seedling dry weight (2.99 mg), seed vigour index-Length and seed vigour index-Mass (954.74, 286.05 respectively) was obtained with silver-black plastic mulch, double row (75+45)×45 cm^2 and triangle plant layout ($M_3L_2P_2$). Which might be due to the interaction of benefits of silver-black plastic mulch higher photosynthetically active radiation (PAR) being reflected back into plant canopy, better weed control, optimum root zone temperature and better nutrient availability to the plants), double row (75+45)×45 cm^2 (optimum spacing led to better growth of plants because of less inter and intra plant competition for nutrients, water and light) and triangle plant layout (may optimise canopy exposure to light and by providing a more uniform area for water and mineral uptake by the roots) which positively affects the plant and fruit growth and led to the production of high quality seeds. However the effect of mulching, row layout and plant layout on 1000 seed weight was found to be non significant.

3.5. Effect of mulching, row layout and plant layout on ripe fruit rot incidence %

The data pertaining to the main effect of mulching on ripe fruit rot incidence (%) have been presented in Table 1. The perusal of data revealed that the use of mulches only tended to reduce the fruit rot incidence. Silver-black mulch (M_3) registered the lowest (4.78%) fruit rot incidence which was found at par with black mulch (M_2), whereas no mulch (M_1) registered the highest fruit rot incidence (7.17%). The ripe fruit incidence was

Table 2: Interaction effect of mulching, row layout and plant layout (M×L×P) on seed quality parameters and ripe fruit rot incidence (%) of bell pepper cv. Solan Bharpur

Particulars	Characters						
	1000 seed weight (g)	Germination (%)*	Seedling length (cm)	Seedling dry weight (mg)	Seed vigour index- L	Seed vigour index- L	Ripe fruit rot incidence (%)*
Interaction Mulching×Row layout×Plant layout (M×L×P)							
$M_1L_1P_1$	5.25	90.33 (9.55)	6.81	2.15	615.78	194.81	7.10 (2.84)
$M_1L_1P_2$	5.24	88.66 (9.46)	7.62	2.35	675.64	208.95	7.20 (2.86)
$M_1L_2P_1$	5.26	90.66 (9.57)	8.05	2.27	730.46	205.80	7.20 (2.86)
$M_1L_2P_2$	5.28	91.00 (9.59)	8.24	2.43	750.44	221.13	7.26 (2.87)
$M_1L_3P_1$	4.94	87.00 (9.38)	6.73	2.00	585.50	174.28	7.13 (2.85)
$M_1L_3P_2$	5.01	87.66 (9.41)	7.46	2.01	654.28	176.19	7.16 (2.85)
$M_2L_1P_1$	5.55	93.33 (9.71)	7.92	2.03	739.20	189.77	4.81 (2.41)
$M_2L_1P_2$	5.59	93.33 (9.71)	7.94	2.24	741.06	209.38	4.81 (2.41)
$M_2L_2P_1$	5.59	94.33 (9.76)	8.25	2.44	778.24	230.81	4.82 (2.41)
$M_2L_2P_2$	5.63	94.66 (9.82)	8.92	2.71	844.36	260.80	4.82 (2.41)
$M_2L_3P_1$	5.22	90.66 (9.57)	7.06	2.07	640.41	187.98	4.82 (2.40)
$M_2L_3P_2$	5.26	93.00 (9.69)	7.85	2.22	730.05	206.46	4.82 (2.40)
$M_3L_1P_1$	5.45	94.33 (9.76)	8.42	2.45	794.61	231.43	4.78 (2.40)
$M3L_1P_2$	5.44	95.65 (9.82)	8.74	2.56	836.45	245.22	4.77 (2.40)
$M_3L_2P_1$	5.58	95.33 (9.81)	9.02	2.52	860.53	240.24	4.77 (2.40)
$M_3L_2P_2$	5.80	95.66 (9.83)	9.98	2.99	954.74	286.05	4.78 (2.40)
$M_3L_3P_1$	5.37	92.00 (9.64)	8.15	2.52	749.81	231.70	4.78 (2.40)
$M_3L_3P_2$	5.36	92.33 (9.66)	8.03	2.55	741.76	235.63	4.77 (2.40)
M_4L1P_1	5.26	91.00 (9.59)	8.32	2.23	757.12	202.93	5.93 (2.63)
$M_4L_1P_2$	5.30	91.00 (9.59)	8.42	2.54	765.90	231.43	5.92 (2.63)
$M_4L_2P_1$	5.32	93.00 (9.69)	8.65	2.43	804.73	226.60	5.92 (2.63)
$M_4L_2P_2$	5.35	93.33 (9.71)	8.75	2.67	816.97	249.51	5.92 (2.63)
$M_4L_3P_1$	5.17	89.00 (9.48)	7.15	2.03	636.35	181.26	5.92 (2.63)
$M_4L_3P_2$	5.19	90.66 (9.57)	7.37	2.21	668.20	200.66	5.92 (2.63)
CD (p=0.05)	NS	0.05	0.19	0.04	17.02	4.34	NS

*Figures in the parenthesis represent square root transformation; M_1: No mulch; M_2: Black plastic mulch; M_3: Silver-black plastic mulch, M_4: Crop residue mulch; L_1: Single row 60×45 cm^2, L_2: Double row (75+45)x45 cm; L_3: Double row (90+30)×45 cm^2; P_1: Rectangle/Square plant layout, P_2: Triangle plant layout

low because of the reason that plastic mulch has created a barrier between pathogen and plant as the disease causing fungus survives in soil and infected plant debris. These results were in line with the findings of Hausbeck et al. (2004) and Kousik et al. (2011). However the main effect of row layout, plant layout and the interaction between mulching, row layout and plant layout (Table 2) on fruit rot incidence (%) was found to be non-significant.

4. Conclusion

Silver-black plastic mulch, double row (75+45)×45 cm^2 and triangle plant layout resulted in better seed quality and use of Silver-black plastic mulch and black plastic mulch can be used for reducing the ripe fruit rot incidence % in bell pepper.

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