**Effect of Chitosan and Mulching on Yield attributing characters and Yield**

**Of Sweet pepper**

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**Key words: Paddy straw mulch, Plant growth, Silver plastic mulch.**

**Abstract**

Field experiments were carried out to study the effect of Chitosan and mulching on yield attributing characters and yield of sweet pepper (CV. Indra) in Rayagada district of Southern Odisha during September-January of 2019-20 and 2020-21. The experiments were laid out in Factorial Randomized Block Design with three replications and twelve treatments viz., T1: No mulch + No Chitosan, T2: No mulch + Chitosan @ 20 PPM, T3: No mulch + Chitosan @ 40 PPM, T4: No mulch + Chitosan @ 60 PPM, T5: Silver Plastic mulch + No Chitosan, T6: Silver Plastic mulch+ Chitosan @20 PPM, T7: Silver Plastic Mulch + Chitosan @ 40 PPM, T8: Silver Plastic Mulch + Chitosan @ 60 PPM, T9: Paddy Straw Mulch @ 7.5 t/ha + No Chitosan, T10: Paddy Straw mulch @ 7.5 t/ha + Chitosan @ 20 PPM, T11: Paddy Straw Mulch @ 7.5 t/ha + Chitosan @ 40 PPM, T12: Paddy Straw Mulch @ 7.5 t/ha + Chitosan @ 60 PPM. The present study revealed that the maximum plant height (46.71 cm), maximum fruiting branches (8.20), maximum fruit weight (106.80 g), polar diameter (7.75 cm), shoulder diameter (6.51 cm) and fruit yield (31.55 t/ha) was recorded with Silver Plastic Mulch + Chitosan @ 40 PPM. The less the number of days required for flowering (21.9 days) and fruiting (52.7 days) by application of Chitosan @ 60 PPM with silver plastic mulching, the fruit can reach the market early and can fetch a higher price which was directly related to higher return to the farmer.

**Introduction:**

Sweet pepper (*Capsicum annuum* var. *grossum*) is one of the non pungent and high value commercial vegetable crop in India belongs to the family Solanaceae. It has high nutritive value, especially vitamin A (683mg/100g) and C (175mg/100g) along with capsanthin and β-carotene, which acts as a potential antioxidant. Considering its high nutritive value and export potential, it is imperative to take attempt for its successful cultivation in the country.

In India capsicum was grown on an area of 34 thousand hectares with an annual production of 534 thousand MT during 2019-20 and 37 thousand hectares with an annual production of 563 thousand MT during 2020-21. In Odisha it was grown on an area of 0.48 thousand hectares with an annual production of 6.99 thousand MT during the year 2019-20 and 0.56 thousand hectares with an annual production of 7.9 thousand MT during the year 2020-21. (Department of Agriculture and Farmers Welfare, 2019-20 and 2020-21)

Chitosan is obtained through the alkaline hydrolysis and by partial deacetylation of chitin, which is a polymeric component present in the skeletal structure of arthropods, algae, crustaceans and fungi (Podile and Neeraja, 2011). Chitosan and its oligosaccharides upgrade photosynthesis by opening up the activity of various enzymes of carbon and nitrogen metabolism as well as light and dark reaction of photosynthesis (Dong et al., 2004). Ahmed et al. 2016 reported foliar spray of Chitosan had enhanced the endogenous concentration of phytohormones *e.g*. gibberellic acid and auxin.

Mulching is necessary to reduce water evaporation from the soil surface, maintain proper soil temperature for better root development in winter season and check weed growth. It also increases water and fertilizer use efficiency (Liakatas et al., 1986; Tarara, 2000). Diaz Perez and Dean Batal, 2002 reported black mulch had the lowest light reflectance (10% photo synthetically active radiation (PAR) compared to silver plastic mulch (55% PAR). Keeping this point in the mind field experiment was laid out to study the effect of Chitosan and mulching for the vertical growth of the production and productivity of sweet pepper in the Rayagada district of Odisha.

**Materials and Methods:**

**Experimental site and planting materials:** The field experiment was conducted during the winter season of 2019-20 and 2020-21 at Majhighariani Institute of Professional Studies, Rayagada, Odisha. The cultivar selected was Indra (F1 Hybrid) of Syngenta. Seeds were sown in pro trays on 1st September of 2019 and 2020. The seedlings were transplanted on 30 DAS.

**Main plot preparation:** Main plot was crossed harrowed twice, after which FYM was applied @ 20 t/ha a fortnight before transplanting. Then the plot was divided into three replications each having twelve small plots of dimension 2.5m X 2m. The N: P: K doses followed were, 175:75:150 kg/ha. The sources of nitrogen, phosphorous and potash were Urea, DAP and MOP respectively. 1/3rd of nitrogen, full dose of phosphorous and potash was applied as basal dose, remaining 2/3rd doses of nitrogen were applied in two equal splits at 30 and 45 DAT.

**Treatment:** The experiment was laid out in the factorial Randomized Block Design with three replications and twelve treatments. In factor 1 there were different Mulching materials (No mulch, Silver Plastic mulch (25µ), Paddy straw mulch) and in factor 2 there were foliar spray of different doses of Chitosan (Control, 20 PPM, 40 PPM, 60 PPM).

**Observation taken (From Experiment No. 1&2)**

**Vegetative growth:** The vegetative parameters like plant height, number of fruiting branches, days to first flowering, days to 50% flowering were recorded at 15 days interval from five randomly selected inner rows competitive plants in each treatment and replication.

**Yield attributing and Yield:** The yield attributing characters likedays to first harvest, individual fruit weight and diameter, number of fruits harvested and fruit yield per plant was recorded from five randomly selected inner rows competitive plants in each treatment. Again, fruit yield per plot was recorded from which yield per hectare was calculated.

**Result and Discussion:**

**Plant height and number of fruiting branches:**

***Effect of Chitosan:***

The present finding reveals that with an increase in the concentration of Chitosan there was increase in plant height (Table No.1). The maximum plant height (45.91 cm) was recorded in Chitosan @ 60 PPM compared to the control (36.92 cm) and the present finding was in agreement with Mondal *et al*. (2011), when Chitosan was sprayed at 100 PPM there was increase in plant height of Indian spinach at 50 and 80 DAS. The stimulating effect of Chitosan on plant growth was attributed to an increase in the availability and uptake of water and essential nutrients through adjusting cell osmotic pressure and reducing the accumulation of harmful free radicals by increasing antioxidants and enzyme activities (Guan et al., 2009).

The number of fruiting branches per plant was directly related to the number of fruits per plant as well on fruit yield per plant, thus affecting the yield per hectare. The finding indicated that Chitosan at 40 PPM recorded the maximum number of fruiting branches per plant (6.47) compared to control (5.4). It might be due to increase in the key enzyme activities of nitrogen metabolism (nitrate reductase, glutamine synthetase and protease) and increased photosynthesis by Chitosan application as reported by Gornik et al., 2008; Mondal et al., 2012). El Tantawy, 2009 reported positive response and increased in plant height and number of fruiting branches per plant with increasing concentration of Chitosan in tomato.

***Effect of Mulching:***

The silver plastic mulch had higher plant height (42.22cm) as compared to paddy straw mulch (41.74cm) (Table No. 1). Similarly, the number of fruiting branches was maximized (6.43/plant) in paddy straw mulch compared to silver plastic mulch (5.90/plant). From this result, it can be concluded that mulching materials have certain role with plant growth and development. This finding was in conformity with Komla, 2013 that by application of organic mulch resulted in increased plant height, canopy size and stem diameter in the dry season in sweet pepper. Thakur et al., 2000 reported Lantana leaves and grass mulches maintained a higher number of branches in Capsicum and similar result was recorded in tomato mulched with paddy straw (Gandhi and Bains, 2006). The highest plant height was observed in chilli mulched with rice straw followed by sugarcane bagasse and wheat straw (Norman et al., 2011) and in Pepper mulched with grass and Sawdust (Dauda, 2011).

**Interaction effect of chitosan and mulching:**

There was significant difference observed in plant height and number of fruiting branches when sweet pepper was applied to mulching materials along with Chitosan spray (Table 1). Paddy straw mulch had recorded highest plant height (48.62 cm) with a combination of Chitosan @ 60 PPM and was at par with the treatment combination of paddy straw mulch and Chitosan @ 40 PPM, Silver plastic mulch with Chitosan @ 40 PPM and 60 PPM. While considering number of fruiting branches, silver plastic mulch in combination with Chitosan @ 40 PPM recorded maximum number branches per plant (8.20) compared to control (5.40).

**Days to first flowering and first harvesting:**

***Effect of Chitosan with no mulching:***

The present findings indicate spraying of Chitosan had induced early flowering and fruiting in sweet pepper. It was observed that Chitosan @ 60 PPM reduced the number of days to first flowering (27.2 days) and first harvesting (57.2 days) (Table No.1) compared to control 32.2 and 61.3 days respectively. This finding was supported by Ohta et al., 1999, where soil application of Chitosan flake at 1% (w/v) at sowing time had shortened flowering time and increased the number and weight of flowers in Lisianthus and induced earlier flowering in Wishbone flower (Ohta et al., 2004).

***Effect of Mulching with no Chitosan:***

During the investigation it was reported that mulching materials had positive effect for early flowering and fruiting. Silver plastic mulch required less number of days (25.2) for flowering and fruiting followed by paddy straw mulch *i.e*, 25.4 days (Table No.1) compared to control i.e., 32.2 and 61.3 days respectively. Earlier fruiting (7 to 14 days and up to 21 days) depending on geographic location, soil type, and plastic mulch was reported earlier by Bhella, 1986 in tomato and Stephenson and Bergman, 1963 in peppers. Higher and early fruiting was reported in silver colored polythene mulch and straw mulch compared to control in okra by Saha et al. 2020. Early flowering tomato crops with organic mulches (Ravindra Kumar and Shrivastav, 1998) and faster plant growth with early fruiting hot pepper was studied by Vos and Sumarni, 1997 with straw mulching.

***Interaction effect of chitosan and mulching:***

The combination of mulching and spraying of Chitosan had shown positive response for bearing early flowers and fruits in sweet paper. Among the treatment combination, Silver plastic mulch with Chitosan @ 60 PPM had taken less duration of flowering (21.9) and fruiting (52.7) followed by the treatment silver plastic mulch with Chitosan @ 40 PPM i.e., 22.6 and 53.2 days respectively. Maximum days for first flowering (32.2) and fruiting (61.3 days) was recorded in the control plots (Table No.1).

**Effect of Chitosan and Mulching on yield parameter of Sweet pepper.**

***Effect of Chitosan with no mulching*:**

The present finding revealed that Chitosan had a significant effect on yield attributing characters of sweet pepper like number of fruits per plant, fruit polar and shoulder diameter and single fruit weight. Chitosan @ 60 PPM was recorded the highest value for the traits like number of fruits per plant (7.758), fruit polar diameter (6.09 cm) and shoulder diameter (5.14 cm), single fruit weight 984.55 g) compared to control i.e., 6.357, 5.30 cm, 4.39 cm and 47.63g, respectively (Table No.2). There was a positive response and increased value recorded on fruit size, individual fruit weight and number of fruits per plant with increasing concentration of Chitosan @ 2, 4 and 6 cm3/l in Sweet pepper (Ghoname et al., 2010) and in tomato up to 100 PPM (Sultana et al. 2017).

***Effect of Mulching with no Chitosan:***

Silver plastic mulch was recorded the highest number of fruits per plant (8.633), average single fruit weight (85.15 g), fruit polar diameter (6.34 cm) and shoulder diameter (5.25 cm) followed by paddy straw mulch *i.e*, 8.670, 63.61 g, 5.49 cm, 4.75 cm and control i.e., 6.357, 47.63 g, 5.30 cm and 4.39 cm respectively. Komala, 2013 reported that among the organic mulches, rice husk mulch was the most effective treatment in increasing the weight of fruits per plant, total fruit yield and mean fruit weight per plant in sweet pepper. Vos and Sumarni, 1997 reported hot pepper had obtained increased fruit weight with straw mulching. Corresponding result was obtained from tomato plants under straw mulch (Gandhi and Bains, 2006), bell pepper with grass mulch (Manuel et al., 2000), sweet pepper with grass mulch (Dauda, 2011). The highest number of tomato fruits per plant was obtained in rice husk mulch over rice straw, grass straw and sawdust mulch (Nkansah et al., 2003. In sweet pepper highest mean fruit diameter was recorded on the grass mulch (Dauda, 2011).

***Interaction Effect Chitosan and Mulching:***

Among the treatment combination, Chitosan @ 40 PPM along with silver plastic mulch was superior by producing the highest number of fruits/plant (13.003), single fruit weight (106.80 gm), fruit polar (7.75 cm) and equatorial diameter (6.51 cm) followed by silver plastic mulch plus Chitosan @ 20 ppm i.e., 10.673, 93.34g, 6.69 cm and 5.54 cm respectively. Chitosan @ 60 PPM with paddy straw mulch was at par with it for the characters like fruit polar and equatorial diameter.

**Effect of Mulching and Chitosan on Yield:**

**Effect of Chitosan:**

During the present investigation Chitosan @ 60 PPM recorded the highest yield (11.78 t/ha) compared to control, i.e., 8.77 t/ha (Table No.2) and was supported by Ghoname et al., 2010, that Chitosan promoted the growth and yield of sweet pepper. Increased yield may be due increased photosynthesis by Chitosan application as reported by Mondal et al., 2012. According to Chibu and Shibayama, 2003 and Gornik et al., 2008, Chitosan had a significant effect on yield as it fastens physiological processes and improve the transportation of nitrogen in the functional leaves resulting in improved vegetative growth and development.

**Effect of Mulching:**

Mulched plots had recorded significantly higher yield than the control plots. Maximum fruit yield (14.37 t/ha) was recorded from the plot applied with silver plastic mulch followed by paddy straw mulch (14.30 t/ha) and was supported by Saha et al. (2020) in okra crop. There was an increase in yield of Bell pepper with reflective mulch (Hutton et al., 2005), plastic mulch (Iqbal et al., 2009), straw mulch (Vos and Sumarni, 1997) reported earlier. Many researchers had reported that there was an increase in yield (normally two to three times that of unmulched soils) depending on geographic location, soil type, plastic mulch used in crop like tomatoes (Bhella, 1986) and peppers (Stephenson and Bergman, 1963). Plastic film mulches proved to increase fruit yield and quality of pepper (Dodd et al., 2000; Gough, 2001).

***Interaction effect of Chitosan and Mulching:***

The combination of mulching and Chitosan had a significant effect in increasing the yield of sweet pepper. Among the treatment combination Chitosan @ 40 PPM with silver plastic mulch had reported highest fruit yield (31.55 t/ha) compared to control (8.77 t/ha). There was a gradual increase in yield with increasing concentration of Chitosan up to 40 PPM after which it was declined. The plots applied with both mulching and Chitosan had significantly higher yield than the plots applied only mulches or only Chitosan. From this it was clear that the combination of mulching and Chitosan had a positive effect on higher yield (Table No.2).

**Conclusion:**

It can be concluded that foliar application of Chitosan at vegetative stage with silver plastic mulching enhances plant growth, which resulted increased fruit yield in Sweet pepper. Among the different concentrations, Chitosan @ 40 PPM with silver plastic mulch had recorded highest number of fruiting branches, yield attributing characters and yield over other treatments. Whereas, Chitosan @ 60 PPM with paddy straw mulch had superiority among other treatment for plant height. The less the number of days required for flowering and fruiting the fruit can reach the market early and can fetch a higher price which is directly related to higher return to the farmer.

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 **Table1. Effect of Chitosan and Mulching on growth parameter of Sweet pepper (Polled data of 2019-20 and 2020-21).**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatment** | **Plant height (90DAT)****(cm)** | **Number of fruiting branches/plant****(90DAT)** | **Days to 1st flowering** | **Days to 1st harvest** |
| **T1.** No mulch + No Chitosan | 36.92 | 5.40 | 32.2 | 61.3 |
| **T2.** No mulch + Chitosan @ 20PPM | 39.65 | 6.30 | 29.7 | 58.3 |
| **T3.** No mulch + Chitosan @ 40PPM | 42.28 | 6.47 | 28.8 | 58.7 |
| **T4.** No mulch + Chitosan @ 60PPM | 45.91a | 6.23 | 27.2 | 57.2 |
| **T5.** Silver Plastic mulch + No Chitosan | 42.22 | 5.90 | 25.2 | 55.3 |
| **T6.** Silver Plastic mulch + Chitosan @ 20 PPM | 43.81 | 6.70 | 24.6 | 54.2 |
| **T7.** Silver Plastic Mulch + Chitosan @ 40 PPM | 46.71a | 8.20a | 22.6 | 53.2 |
| **T8.** Silver Plastic Mulch + Chitosan @ 60 PPM | 46.08a | 7.47a | 21.9 | 52.7 |
| **T9.** Paddy Straw Mulch @ 7.5t/ha + No Chitosan | 41.74 | 6.43 | 25.4 | 55.7 |
| **T10.** Paddy Straw mulch @ 7.5t/ha + Chitosan @ 20 PPM | 43.07 | 6.53 | 24.3 | 54.9 |
| **T11.** Paddy Straw Mulch @ 7.5t/ha + Chitosan @ 40 PPM | 46.79a | 6.87 | 23.8 | 54.1 |
| **T12.** Paddy Straw Mulch @ 7.5t/ha + Chitosan @ 60 PPM | 48.62a | 6.73 | 23.1 | 54.0 |
| **Mean** | **43.65** | **6.60** | **25.7** | **55.8** |
| **LSD** | **4.34** | **0.92** | **1.03** | **2.29** |

**Table 2. Effect of Chitosan and Mulching on yield parameter of Sweet pepper (Polled data of 2019-20 and 2020-21).**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Treatment** | **No. of fruits per plant** | **Single fruit weight (g)** | **Fruit****polar diameter (cm)** | **Fruit shoulder****diameter (cm)** | **Yield per plant (kg)** | **Yield per plot (kg)** | **Yield per Hectare (t)(Y/ha)** |
| **T1.** No mulch + No Chitosan | 6.357 | 47.63 | 5.30 | 4.39 | 0.245 | 4.39 | 8.77 |
| **T2.** No mulch + Chitosan @ 20PPM | 6.635 | 62.20 | 5.64 | 4.52 | 0.309 | 4.97 | 9.94 |
| **T3.** No mulch + Chitosan @ 40PPM | 7.417 | 67.77 | 5.77 | 4.72 | 0.332 | 5.25 | 10.51 |
| **T4.** No mulch + Chitosan @ 60PPM | 7.758 | 84.55 | 6.09 | 5.14 | 0.440 | 5.89 | 11.78 |
| **T5.** Silver Plastic mulch + No Chitosan | 8.633 | 85.15 | 6.34 | 5.25 | 0.341 | 7.19 | 14.37 |
| **T6.** Silver Plastic mulch + Chitosan @ 20 PPM | 10.673 | 93.34 | 6.69 | 5.54 | 0.504 | 10.43 | 20.86 |
| **T7.** Silver Plastic Mulch + Chitosan @ 40 PPM | 13.003a | 106.80a | 7.75a | 6.51a | 0.604a | 15.78 | 31.55a |
| **T8.** Silver Plastic Mulch + Chitosan @ 60 PPM | 8.628 | 83.63 | 6.27 | 5.39 | 0.482 | 12.77 | 25.53 |
| **T9.** Paddy Straw Mulch @ 7.5t/ha + No Chitosan | 8.670 | 63.61 | 5.49 | 4.75 | 0.339 | 7.15 | 14.30 |
| **T10.** Paddy Straw mulch @ 7.5t/ha + Chitosan @ 20 PPM | 8.048 | 79.73 | 5.56 | 5.01 | 0.358 | 9.06 | 18.11 |
| **T11.** Paddy Straw Mulch @ 7.5t/ha + Chitosan @ 40 PPM | 10.061 | 82.79 | 6.07 | 5.00 | 0.522a | 10.87 | 21.73 |
| **T12.** Paddy Straw Mulch @ 7.5t/ha + Chitosan @ 60 PPM | 8.885 | 85.29 | 7.22a | 5.98a | 0.531a | 9.31 | 18.61 |
| **Mean** | **8.731** | **78.54** | **6.18** | **5.18** | **0.417** | **8.59** | **17.17** |
| **LSD** | **1.58** | **9.87** | **0.740** | **0.67** | **0.073** | **0.99** | **1.99** |