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Effect of different planting densities and mulches on soil properties under Konkan agro-climatic conditions

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Abstract
Chilli is a vegetable and spice crop grown all over the world. An investigation entitled "Growth and yield performance of promising local chilli genotype to different spacing and mulching under Konkan agro-climatic conditions" was undertaken at Experimental farm, College of Horticulture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli during two successive *kharif* seasons *of* 2021 and 2022 by considering the potential of promising local chilli genotype. A field experiment was conducted in split plot design consisting of three main treatments *i.e.* S_1 (30 cm x 30 cm), S_2 (45 cm x 30 cm) and S_3 (60 cm x 30 cm) and three sub treatments *i.e.* M_1 (no mulch), M_2 (polyethylene mulch) and M_3 (organic mulch *i.e.* gliricidia mulch). A composite soil sample was drawn from experimental area to a depth of 0-30 cm and analyzed for chemical properties before transplanting and after 120 days from transplanting. The observations were recorded on various soil properties. The results revealed that soil parameters showed varying effects and the highest soil pH was recorded in S_2M_3 *i.e.* at 45 cm x 30 cm spacing with organic mulch (gliricidia mulch) (6.07), S_1M_3 *i.e.* at 30 cm x 30 cm spacing with organic mulch (gliricidia mulch) (6.07) and S_3M_2 *i.e.* at 60 cm x 30 cm spacing with polyethylene mulch (6.07) and the highest soil EC was reported in S_3M_3 *i.e.* at 60 cm x 30 cm spacing with organic mulch (gliricidia mulch) (0.129 dS/m) and S_2M_3 *i.e.* at 45 cm x 30 cm spacing with organic mulch (gliricidia mulch) (0.129 dS/m). The highest available nitrogen content (290.06 kg/ha) and available potassium content (325.65 kg/ha) in the soil was noted in S_2M_3 *i.e.* at 45 cm x 30 cm spacing with organic mulch (gliricidia mulch) (290.06 kg/ha). However, available phosphorous content exhibited non-significant variations. From the data recorded during the investigation revealed that local chilli genotype DPL CA-8 was performed better at 45 cm x 30 cm spacing with organic mulch (gliricidia mulch) during *kharif* seasons under Konkan agro-climatic conditions and resulted in improvement of soil fertility.

Keywords: Local chilli genotype, planting density, mulches, soil properties

Introduction
Chilli is one of the popular solanaceous vegetable crops cultivated in most parts of the world. It is the most widely used universal spice and named as wonder spice. It is one of the important and worthwhile commercial vegetable crops play a vital role in the world economy. It belongs to genus *Capsicum.* It is used as the most important ingredient in different cuisines around the world, as it adds pungency both at green stage as well as at red ripe stage, improves taste, flavour and colour to the dishes. The fruits are an excellent source of health-related phytochemical compounds and contains good amount of other antioxidants such as vitamin A, B-complex group of vitamins such as niacin, pyridoxine (vitamin B_6), riboflavin and thiamin (vitamin B_1) and flavonoids like β-carotene, α-carotene, lutein, zea-xanthin and cryptoxanthin.
Among different planting densities and mulches, optimum planting density enabling them to grow uniformly, through effective use of moisture, nutrients and light and helps to obtain maximum yield (Rupali and Kumar, 2017) [8]. Similarly, different mulches have variable effects on soil properties and improve crop production by enhancing soil quality by conserving soil moisture, enhancing soil biological activities, and improving the chemical and physical properties of soil. Organic mulches are an attractive option to improve soil organic matter through their biodegradation and easy availability. It improves vegetative growth, blooming and number of fruit per plant which leads to early maturity and early harvest (Sathiyamurthy *et al.*, 2017) [9]. Also in Konkan region, large variability in chilli genotypes has been reported and mostly grown in *kharif* season. However, due to heavy rains and high humidity, the improved and hybrid varieties of chilli do not show better performance during *kharif* season. Considering the above points, the present study aimed to investigate the proper spacing and effective mulch treatment for increasing soil nutritional quality under Konkan agro-climatic

conditions.

Materials and Methods

A field experiment conducted on "Growth and yield performance of promising local chilli genotype to different spacing and mulching under Konkan agro-climatic conditions" during two successive *Kharif* seasons of 2021 and 2022 at Experimental farm, College of Horticulture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist – Ratnagiri (M.S.). Local chilli genotype DPL CA- 8 was collected from the Goa state (Gavdongari, Cancona, Goa) for investigation from farmer's field based on their phenotypic characters with respect to growth, flowering and yield performance. Treatments were combinations of three different spacing and three mulch types. Various spacing *viz.,* 30 cm x 30 cm (S_1), 45 cm x 30 cm (S_2) and 60 cm x 30 cm (S_3) with three different mulches *viz.,* no mulch (M_1), polyethylene mulch (M_2) and organic mulch (gliricidia mulch) (M_3). Treatments were arranged in split plot design with four replications. Polyethylene mulch and gliricidia mulch were laid in the experimental field one day before transplanting of seedling and after 45 days of planting, seedlings were transplanted in the main field. Various intercultural operations *viz.*, nutrient management, weeding, earthing up as well as plant protection were carried out. The data were recorded on various growth and yield characters and subjected to statistical analysis using Analysis of Variance (ANOVA) technique (Panse and Sukhatme, 1985) [7].

Soil analysis

The soil analysis of the experimental plot was done for assessing its suitability for cultivation of chilli during both the seasons. A composite soil sample was drawn from experimental area to a depth of 0-30 cm and analyzed for chemical properties before transplanting and after 120 days from transplanting and the data recorded is presented in Table 1.

Table 1: Soil nutrient status before experimentation

Soil parameters	Year	
	2021	2022
Soil pH	5.41	5.40
Soil EC (dS/m)	0.122	0.124
Available nitrogen (kg/ha)	281.84	279.42
Available phosphorous (kg/ha)	13.34	12.27
Available potassium (kg/ha)	319.32	321.65

Results and Discussion

Soil properties, including soil pH, EC, available nitrogen, available phosphorous and available potassium were evaluated for the effect of spacing, mulching and their interactions in order to assess the changes in soil nutritional quality before and after field experimentation. The details of pooled data recorded during both the seasons are presented in Table 2.

Effect of planting density on soil parameters

The data presented in Table 2 revealed that the soil pH, EC and available potassium showed non-significant variation among different planting densities, whereas, the highest available nitrogen content in the soil was recorded in S_2 *i.e.* (45 cm x 30 cm) (282.30 kg/ha) which was statistically at par with S_3 *i.e.* (60 cm x 30 cm) (282.16 kg/ha) and the lowest available nitrogen content was recorded in S_1 *i.e.* (30 cm x 30 cm) (281.55 kg/ha), while the highest available phosphorous in the soil was observed in S_3 *i.e.* (60 cm x 30 cm) (12.95 kg/ha) whereas, S_2 *i.e.* (45 cm x 30 cm) (12.67 kg/ha) exhibited the lowest available phosphorous in the soil.

This might be due to the positive effect of wider spacing. Distribution of roots in the soil plays an important role in increasing nutrient uptake from the soil. Also, at wider spacing, plants get more space to spread and easily absorb nutrients from the soil. The results are in agreement with the report of Islam *et al*. (2011) [3] and Thakur *et al.* (2018) [11] in sweet pepper.

Effect of mulches on soil parameters

The data presented in Table 2 regarding the effect of mulching on various soil parameters showed significant variation among different mulches.

Soil pH

The data recorded on soil pH varied significantly and the highest soil pH was recorded in M_3 (organic mulch *i.e.* gliricidia mulch) (5.86) and found significantly superior over rest of the treatments, while the lowest soil pH was noted in M_1 (no mulch) (5.43). The increase in soil pH range was recorded in organic mulch (gliricidia mulch), whereas the decreasing trend was observed in unmulched plots. The increase in soil pH under gliricidia mulch was explained by its faster leaf decomposition. Similar result of increasing soil pH under gliricidia mulch was also observed by Makumba *et al*. (2006) [5] in maize.

Soil EC (dS/m)

The data presented Table 2 revealed that effect of mulching had a significant influence on soil EC. The treatment M_3 (organic mulch *i.e.* gliricidia mulch) (0.129 dS/m) exhibited the highest soil EC significantly superior over all other treatments, whereas the lowest soil EC was recorded in M_2 (polyethylene mulch) (0.122 dS/m).

Available nitrogen (kg/ha)

Crucial role of nitrogen for being main constituent of all amino acids in proteins and lipids, the structural compounds of cells and chloroplast made it the most essential macronutrient for good plant establishment and expected growth. Data presented in Table 2 revealed that the mulching reported significant effect on available nitrogen in soil and the highest available nitrogen content was observed in M_3 (organic mulch *i.e.* gliricidia mulch) (289.45 kg/ha) which was significantly superior over rest of the treatments. However, the lowest available nitrogen content was recorded in M_1 (no mulch) (278.06 kg/ha).

The increase in available nitrogen might be due to higher amount of nitrogen content in leaves and the favourable soil conditions and might have helped the mineralization of soil nitrogen leading to build-up of higher available nitrogen. Similar results were also given by Bah and Rahman (2001) [2], Uddin and Khalequzzaman (2003) [13], Adekiya (2017) [1] in tomato, Kumar *et al*. (2019) [4] in stevia and Yadav *et al*. (2020) [15].

Available phosphorous (kg/ha)

The data pertaining to available phosphorous exhibited that the highest available phosphorous content in the soil was

observed in M_3 (organic mulch *i.e.* gliricidia mulch) (14.19 kg/ha) which was found significantly superior over rest of the treatments, while the lowest available phosphorous content in the soil was noticed in M_2 (polyethylene mulch) (12.01 kg/ha).

This might be due to the application of potassium through gliricidia leaves which increased the availability of phosphorus in the soil. During decomposition of leaves, various organic acids was produced which solubilize phosphatase and other phosphate bearing minerals and thereby lowers the phosphate fixation and increase its availability. Similar results were observed by Adekiya (2017) [1] in tomato and Kumar *et al*. (2019) [4] in stevia.

Table 2: Effect of planting densities and mulches and their interactions on soil parameters after last harvesting (Pooled data 2021-2022)

Treatments	Soil parameters				
	Soil pH	Soil EC (dS/m)	Available nitrogen (kg/ha)	Available phosphorous (kg/ha)	Available potassium (kg/ha)
Effect of planting densities					
S_1	5.64	0.125	281.55	12.71	320.43
S_2	5.66	0.124	282.30	12.67	319.93
S_3	5.65	0.125	282.16	12.95	320.40
S.E.m ±	0.005	0.0003	0.17	0.06	0.42
CD at 5%	NS	NS	0.60	0.22	NS
Effect of mulches					
M_1	5.43	0.123	278.06	12.13	318.10
M_2	5.65	0.122	278.50	12.01	317.51
M_3	5.86	0.129	289.45	14.19	325.16
S.E.m ±	0.005	0.0002	0.21	0.10	0.20
CD at 5%	0.015	0.0007	0.64	0.31	0.62
Interaction effects of planting densities and mulches					
S_1M_1	5.41	0.124	277.29	12.04	319.10
S_1M_2	5.43	0.124	278.19	11.91	317.95
S_1M_3	6.07	0.128	289.17	14.18	324.26
S_2M_1	5.46	0.121	278.36	12.14	317.26
S_2M_2	5.45	0.122	278.49	11.80	316.89
S_2M_3	6.07	0.129	290.06	14.07	325.65
S_3M_1	5.42	0.124	278.54	12.22	317.95
S_3M_2	6.07	0.121	278.83	12.32	317.69
S_3M_3	5.45	0.129	289.13	14.31	325.56
S.E.m ±	0.008	0.0004	0.37	0.18	0.36
CD at 5%	0.026	0.0012	1.11	NS	1.07

Available potassium (kg/ha)

The data in respect of the available potassium varied significantly at different mulching treatments and the highest available potassium content was recorded in the treatment M_3 (organic mulch *i.e.* gliricidia mulch) (325.16 kg/ha) and found significantly superior over all other treatments. However, the lowest available potassium content was noted in M_2 (polyethylene mulch) (317.51 kg/ha).

The buildup of soil available potassium by the application of potassium through gliricidia green leaves might be due to the fact that gliricidia leaves contains higher amount of K and it is deposited in the soil and due to applied potassium through gliricidia mulch, the solubilizing action of certain organic acids produced during decomposition results in greater capacity to hold potassium in the available form. Similar results were observed by Adekiya (2017) [1] in tomato and Kumar *et al*. (2019) [4] in stevia.

Interaction effect of planting densities and mulches on soil parameters

Soil pH

The pooled data obtained on soil pH exhibited significant variation and the highest soil pH was recorded in S_2M_3 *i.e.* at 45 cm x 30 cm spacing with organic mulch (gliricidia mulch) (6.07), S_1M_3 *i.e.* at 30 cm x 30 cm spacing with organic mulch (gliricidia mulch) (6.07) and S_3M_2 *i.e.* at 60 cm x 30 cm spacing with polyethylene mulch (6.07) and found significantly superior over rest of the treatment combinations and the lowest soil pH was noted in S_1M_1 *i.e.* at 30 cm x 30 cm spacing without mulch (5.41).

Soil EC (dS/m)

The highest soil EC was reported in the treatment combination S_3M_3 *i.e.* at 60 cm x 30 cm spacing with organic mulch (gliricidia mulch) (0.129 dS/m) and S_2M_3 *i.e.* at 45 cm x 30 cm spacing with organic mulch (gliricidia mulch) (0.129 dS/m) which was statistically at par with S_1M_3 *i.e.* at 30 cm x 30 cm spacing with organic mulch (gliricidia mulch) (0.128 dS/m). Furthermore, S_2M_1 *i.e.* at 45 cm x 30 cm spacing without mulch and S_3M_2 *i.e.* at 60 cm x 30 cm spacing with polyethylene mulch (0.121 dS/m) exhibited the lowest soil EC.

Available nitrogen (kg/ha)

The pooled data presented in Table 2 revealed that the highest available nitrogen in the soil was noted in S_2M_3 *i.e.* at 45 cm x 30 cm spacing with organic mulch (gliricidia mulch) (290.06 kg/ha) which was statistically at par with S_1M_3 *i.e.* at 30 cm x 30 cm spacing with organic mulch (gliricidia mulch) and S_3M_3 *i.e.* at 60 cm x 30 cm spacing with organic mulch (gliricidia mulch) (289.17 kg/ha and 289.13 kg/ha), whereas, the treatment combination S_1M_1 *i.e.* at 30 cm x 30 cm spacing without mulch (277.29 kg/ha) recorded the lowest available nitrogen content in the soil.

The increase in available nitrogen due to incorporation of gliricidia green mulch and might be due to higher amount of

nitrogen content in leaves of gliricidia and the favourable soil conditions under green mulch might have helped the mineralization of soil N leading to build-up of higher available nitrogen. Similar result was also given by Vidyavathi *et al*. (2011) [14].

Available phosphorous (kg/ha)

The data presented in Table 2 regarding the interaction effect of spacing and mulching revealed that the difference in various treatment combinations with respect to available phosphorous in the soil was found non-significant.

Available potassium (kg/ha)

The highest available potassium in the soil was observed in the treatment combination S_2M_3 *i.e*. at 45 cm x 30 cm spacing with organic mulch (gliricidia mulch) (325.65 kg/ha) which was statistically at par with S_3M_3 *i.e*. at 60 cm x 30 cm spacing with organic mulch (gliricidia mulch) (325.56 kg/ha). However, S_2M_2 *i.e.* at 45 cm x 30 cm spacing with polyethylene mulch (316.89 kg/ha) recorded the lowest available potassium content in the soil.

The leaves of gliricidia contain 2.4% nitrogen and 1.8% potassium and these leaves decompose relatively fast, providing nitrogen and potassium. Similar results were observed by Tolanur and Badanur (2003) [12], Surekha and Rao (2009) [10], and Nawlakhe and Mankar (2009) [6] and Yadav *et al*. (2020) [15].

Conclusion

The results of the experiment showed that soil properties *viz.* soil pH, EC, available nitrogen, available phosphorous and available potassium were significantly improved by the application of different plant densities and mulches. Considering the effect of different planting densities and mulches, the local chilli genotype DPL CA-8 was performed better at 45 cm x 30 cm spacing with organic mulch (gliricidia mulch) and resulted in improvement of soil fertility with addition of nutrients to the soil under Konkan agro-climatic conditions.

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