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Green Pepper Growth and Yield Response to the Integration of Mulching Materials and Row Plant Spacing

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Abstract: An experiment was conducted at the Crops Research Station of the Kenya Agricultural and Livestock Research Organization Alupe, Busia County. The experiment was performed to find out the most suitable mulching material and an ideal spacing for green pepper cultivation under Busia County Conditions. The experiment was laid out in a Factorial Randomized Block Design with three replications. The treatments comprised of four mulching materials viz. black plastic mulch, transparent plastic mulch, straw mulch and bare soil which was the control with three row spacings viz. 30 x 50 cm, 40 x 40 cm and 50 x 40 cm. Data collected was subjected to SAS statistical software for analysis and means separated using LSD at P≤0.05. Significant responses on plant height and number of branches per plant were observed for both seasons due to spacing and mulching treatments. The highest branches (6.97) per plant were recorded in the 40 by 40 cm spacing under the transparent mulch with the lowest (2.83) shown under the same spacing in the straw mulch of California Wonder variety. The widest spacing elicited the highest number of fruits per plant (7.37) in the black plastic mulch while only a mean of 1 fruit per plant was recorded in the mulch control during the short rain season. The highest fruit mean yield per plant of 1556 g and 1533 g was recorded in the widest spacing (50 by 40cm) during the long and short rain seasons respectively. Therefore this study recommends the use of plastic mulches at wider spacing.

Keywords: Green pepper; Mulching; Fruit yield; Row spacing.

1. Introduction

Green pepper (Capsicum annuum) is one of the most important vegetables that are consumed worldwide, after tomatoes and onions. It is in the Solanaceae family in the genus Capsicum native to South America specifically Brazil where it is thought to be the original home of peppers [1]. Green pepper cultivation is still under small scale cultivation that supplies local markets in the country as a small fraction goes for export. Considering the crops high nutritive value and the export potential successful cultivation in the country should be attempted [2]. However, presently farmers grow green pepper without maintaining proper planting space. Consequently, high percentage of undersized, unmarketable fruit and incidence of pest and diseases have been noticed which is a bottle neck for obtaining good returns. Mulching is employed to cover the soil surface with different materials to obtain high biological activity, retain soil moisture and to achieve a good control of weeds.

The row spacing affects the light interception and also influences the space available for weeds and crops to grow. Row spacing can also influence the shape of green pepper canopy and branching, thereby influencing flowering and fruiting as well as crop competitiveness with weeds. Row spacing is often determined by the type of planting and harvesting equipment available, and will result in different crop yields and can influence overall economic return. There are meager attempts on morphological, phenological and yield attributes under different spacings. Further, green pepper is one of the crop among the other crops that response drastically to the increase of soil temperature/ light reflectance produced with the use of mulches. Gutal, *et al.* [3] observed that the use of plastic mulches in agriculture helped to increase the production per unit area for all types of crops as poly ethylene mulch films in crease soil temperature 5-7 °C facilitating faster germination and better root proliferation, in addition to checking weed growth, preserving the soil structure, retaining soil moisture and increasing CO^2 con tents around the plants.

Knowledge of crop response to population density is useful for management decisions and it provides the basis for assessing the effects of intra- species competition [4]. Crop (cultivars) with vigorous growth habit are usually planted at a wider row spacing to avoid competition among neighboring plants and also to prevent mutual shading in

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plant canopies. Plant densities beyond certain thresholds can adversely affect fruit quality and encourage disease development in pepper plants. Plant population primarily affects the amount of radiation intercepted per plant. Light quality as modified by different plant populations may also play an important role on early plant growth and partitioning responses in plants [5]. The yield advantage due to narrow spacing is usually attributed to the development of a full canopy in early development stages [6]. These full canopies, in turn, intercept more radiation and have a greater photosynthetic production than the partial canopy development that is usually observed in wider row spacing. Crop yields decrease with increasing weed competition. A strong relationship exists between the duration of competition and the competition pressure exerted on the crop, which reduces yield [7, 8]. Keeping this in view, the present investigation was planned to determine the effect of different row spacing techniques in combination with mulch application on growth and yield of green pepper.

2. Materials and methods

2.1. Site Description

Field conducted during 2015 short and long growing seasons at the Crops Research Station of the Kenya Agricultural and Livestock Research Organization Alupe, Busia County which is situated at latitude 0.30° N, longitude 34.07° E with an elevation of 1157 m above sea level. The average annual relative humidity for the period from March, 2015 to March 2016 ranged between 73.6% and 78.9%. Average annual rainfall (mm) at the study area ranged from 49.6 to 215.8 mm with average annual maximum and minimum air temperatures ranging from 29.1 to 35.9 and 16.9 to 18.3°C respectively.

2.2. Experimental Design

The experiment was laid out in a Factorial Randomized Block Design with three replications. The treatments comprised of four mulching materials viz. black plastic mulch, transparent plastic mulch, straw mulch and bare soil which was the control with three row spacings viz. 30 x 50 cm, 40 x 40 cm and 50 x 40 cm.

2.3. Cultural Practices

The land was cleared prior to sowing of seeds. Ploughing and harrowing were performed on the land before nursery beds were made. The green pepper seedlings were transplanted after 30 days on the bed on 23rd March, 2015 for the long rain season and 26th September, 2015 for the short rain season to the main experimental field. Black plastic mulch and the transparent mulch of 0.25 µm thickness were used and spread over the beds. Corresponding to the position of the hole for planting, incisions were made on the plastic mulching materials and the plants were carefully pushed through the slits to keep the foliage and stem uncovered. The straw mulch treatment was sourced from the finger millet straw from the previous season crop and spread to a thickness of 10 cm. The row spacings were carefully measured and maintained according to the treatment. All the necessary cultural practices and plant protection measures were followed uniformly for all the plots and treatments during the experimentation period. Observations were recorded on the height of plant (cm), number of lateral branches per plant, fruit length (cm), fruit mass per plant (g) and fruits per plant.

2.4. Data Analysis

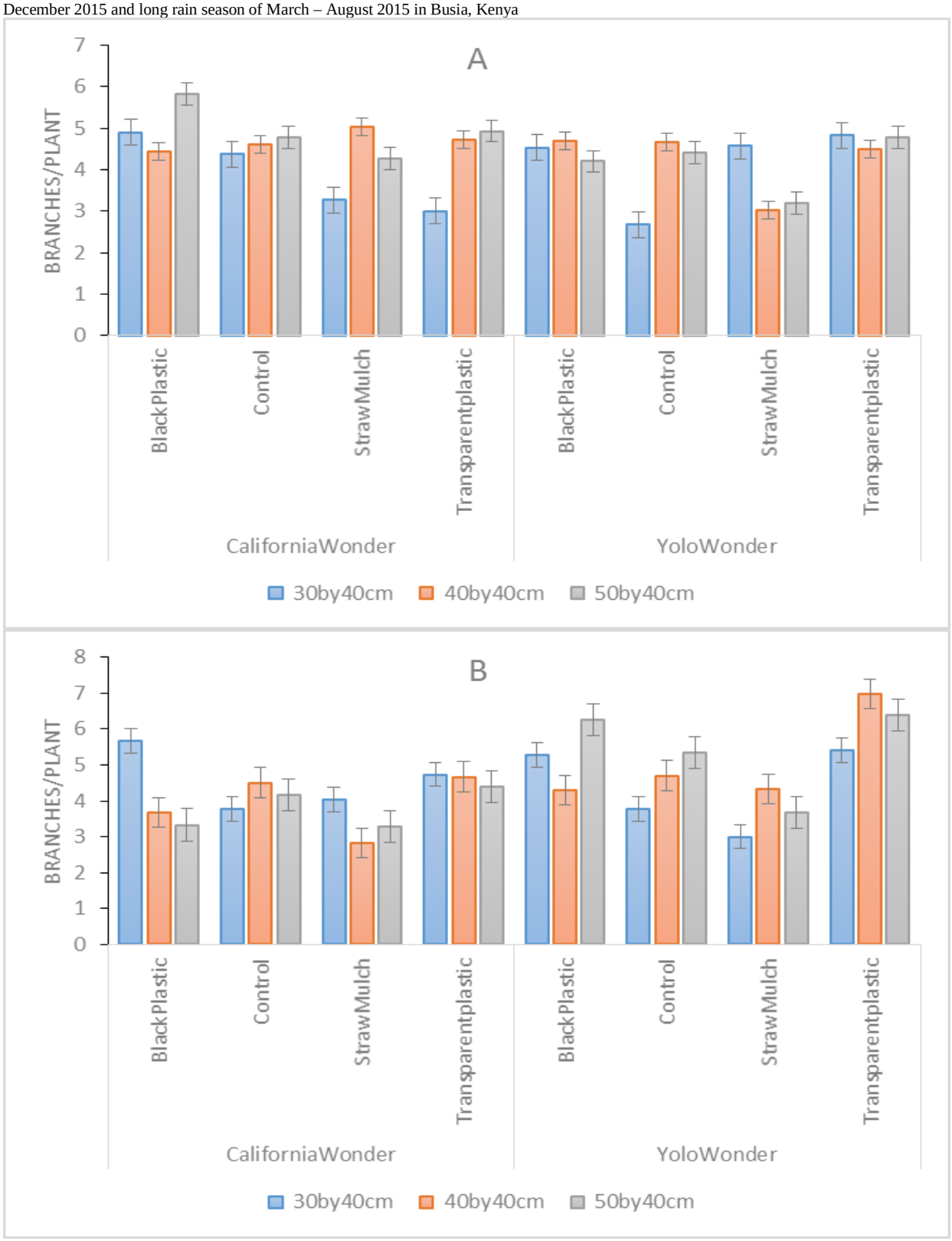
To determine the significance of spacing and mulching material interaction effects, data were analyzed separately for each season by conducting an ANOVA using proc GLM from SAS software. Whenever the treatment was significant, least significance differences (LSD) was used for mean separation at $p \leq 0.05$.

3. Results

3.1. Number of Branches

The number of branches per plant differed significantly ($p \leq 0.05$) for both seasons. The highest number of branches (5.83) were on the 50 by 40 cm spacing under the black plastic mulch of California Wonder variety during the long rain season. During the short rain season a maximum average of 6.97 was recorded at 40 by 40 cm spacing in the transparent plastic mulch of Yolo Wonder variety. The lowest number of branches per plant (2.67) was elicited in the mulch control of the narrowest spacing under Yolo Wonder variety during the long rain season while Yolo Wonder variety during the long rain season while the same spacing under the straw mulch during the short rain season of Yolo Wonder variety showed the lowest branch number (3).

Figure-1. The influence of spacing and mulching materials on the number of branches per plant during the short rain season of September – December 2015 and long rain season of March – August 2015 in Busia, Kenya



3.2. Plant Height

Significant differences in the plant height of green pepper was recorded for both seasons due to the treatment combination. The tallest plants were observed in the 30 by 40 cm spacing in the transparent mulch of Yolo Wonder variety at 37.3 cm which was however not significantly different from the straw mulch at the same spacing during the long rain season. The shortest plants were recorded under the narrowest spacing in the mulch control in both varieties. For the short rain season, the narrowest spacing in the transparent mulch showed the tallest plants (34.9 cm) of the California Wonder variety with the control showing similar results as the long rain season.

Table-1. The plant height of green pepper as influenced by the interaction between spacing and mulching materials during the short rain season of September – December 2015 and long rain season of March – August 2015 in Busia, Kenya

		Long Rains			**Short Rains**		
Variety	Mulch	30by40cm	40by40cm	50by40cm	30by40cm	40by40cm	50by40cm
California Wonder	Black Plastic	23.1b	22.7b	11.2c	30.5a	27.3ab	23.4b
	Control	11.2c	23.3b	11.4c	22.6b	20.5b	26.6ab
	Straw Mulch	12.1c	13.6c	35.4a	30.7a	30.8a	19.8b
	Transparent Plastic	23.1b	34a	24.0b	34.9a	27.7ab	29.5a
Yolo Wonder	Black Plastic	21.5b	21.0b	27.9ab	28.1ab	28.9ab	28.2ab
	Control	11.7c	23.6b	12.1c	32.2a	28.1ab	24.5b
	Straw Mulch	36.4a	24.8b	25.7b	29.4a	34.2a	30.9a
	Transparent Plastic	37.3a	33.2a	24.1b	29.2a	25.4b	30.2a
	LSD (0.05)	8.16			7.72		

Means followed by the same letter do not differ significantly at the P=0.05 significance level

3.3. Fruit Length

The fruit diameter differed significantly for both seasons due to the spacing and mulching materials in the two varieties. The longest fruits were observed in the 40 by 40 cm spacing with a mean of 15.7 cm under the black plastic mulch in the California Wonder variety during the long rain season. During the short rain season, the 30 by 40 cm spacing elicited the longest fruits under the black plastic mulch of the California Wonder variety. For both seasons, the 40 by 40 cm spacing showed the shortest fruits under the mulch control for both varieties.

Table-2. Fruit length of green pepper under different mulch materials and spacing in two varieties during the short rain season of September – December 2015 and long rain season of March – August 2015 in Busia, Kenya

		Long Rains			**Short Rains**		
Variety	Mulch Material	30by40cm	40by40cm	50by40cm	30by40cm	40by40cm	50by40cm
California Wonder	Black Plastic	11.4ab	15.7a	10.7b	16.17a	3.0b	11.33ab
	Control	7.4b	5.2b	12.0ab	5.0b	3.67b	6.3b
	Straw Mulch	10.1b	10.6b	11.8ab	9.83b	10.33b	7.1b
	Transparent Plastic	14.8a	12.3ab	10b	9.77b	10.2b	12.33ab
Yolo Wonder	Black Plastic	13.6a	14.1a	12.5ab	12.3ab	9.83b	6.67b
	Control	9.1b	4.9b	10.5b	4.33b	9.57b	8.0b
	Straw Mulch	11.8ab	8.9b	11.4ab	4.63b	6.8b	10.2b
	Transparent Plastic	12.8ab	17.4a	9.9b	10.37b	11.2ab	11.17ab
	LSD (0.05)	6.222			6.97		

Means followed by the same letter do not differ significantly at the P=.05 significance level

3.4. Number of Fruits per Plant

The average number of fruits per plant were significantly influenced by the spacing and mulching materials for both seasons. The highest number of fruits in a plant (8) was recorded in the widest spacing of the black plastic mulch under the California Wonder variety during the long rain season while the lowest number of fruits in a plant (2) was recorded in the narrowest spacing in the mulch control. A mean of 7.37 fruits per plant was recorded in the same treatment combination as that observed in the long rain season with the lowest (1) shown in the 30 by 40 cm in the mulch control of California Wonder.

Table-3. The number of fruits per plant as influenced by spacing and mulch materials of green pepper during the short rain season of September – December 2015 and long rain season of March – August 2015 in Busia, Kenya

		Long Rains			**Short Rains**		
Variety	Mulch Material	30by40cm	40by40cm	50by40cm	30by40cm	40by40cm	50by40cm
California Wonder	Black Plastic	4.3c	6.0b	8.0a	4.7b	6.3a	7.4a
	Control	3.0d	3.0d	2.3d	3.9c	3.6c	3.5c
	Straw Mulch	3.8c	4.7c	5.3b	4.1b	4.7b	5.2b
	Transparent Plastic	5.7b	5.3b	6.7b	4.7b	5.2b	5.3b
Yolo Wonder	Black Plastic	4.0c	4.5c	5.2b	4.1b	5.7b	6.7a
	Control	2.0d	2.3d	3.7c	1.0d	2.1d	3.6c
	Straw Mulch	3.3d	4.0c	4.7c	3.7c	3.7c	5.7b
	Transparent Plastic	4.0c	4.3c	6.0b	4.3b	5.0b	5.9b
	LSD (0.05)	0.903			1.285		

Means followed by the same letter do not differ significantly at the P=0.05 significance level

3.5. Fruit Mass Yield Per Plant

The fruit mass per plant elicited in the spacing and mulching materials treatments was significantly different for both seasons. The maximum fruit mass yield per plant was 1556 g per plant per harvest during the long rain season in the 50 by 40 cm spacing under the black plastic mulch of California Wonder variety. The lowest fruit mass yield per plant was 330 g recorded in the mulch control at the narrowest spacing (30 by 40 cm) spacing in California Wonder variety. During the short rain season, the same trend as that of the long rain season was observed but with the widest spacing in the mulch control showing the lowest fruit yield mass per plant under California Wonder.

Table 4. The fruit mass yield per plant of green pepper under the different spacing and mulch materials during the short rain season of September – December 2015 and long rain season of March – August 2015 in Busia, Kenya

		Long Rains			**Short Rains**		
Variety	Mulch Material	30by40cm	40by40cm	50by40cm	30by40cm	40by40cm	50by40cm
California Wonder	Black Plastic	1238b	1514a	1556a	1380b	1440a	1533a
	Control	330f	640e	810d	900d	680e	627e
	Straw Mulch	1272b	970d	1117c	1187c	1160c	1173c
	Transparent Plastic	1050c	1343b	1183c	1317b	1033c	1273b
Yolo Wonder	Black Plastic	1054c	1075c	1106c	1310b	1130c	1207b
	Control	540e	750d	830d	700e	780d	867d
	Straw Mulch	1118c	1001c	1024c	1040c	1077c	1113c
	Transparent Plastic	1132c	1049c	1032c	1033c	1373b	1200c
	LSD (0.05)	180.9			168.49		

Means followed by the same letter do not differ significantly at the P=0.05 significance level

4. Discussion

The results showed that as spacing increased and the number of lateral branches increased, due to low competition for essential nutrients, light and water between crops and this finding is support by Dean, *et al.* [9] and Mangala and Mausia [10] who found that number of branches linearly increased with increase in spacing under mulched plots of triploid watermelon.

The results showed that as spacing increased and green pepper height increased due to high competition for water, nutrient and light between crops. These findings are in accord with that of Ahmad, *et al.* [11] who found that the use of transparent polyethylene mulch was increased the plant height in chilli than organic mulch and control. This might be due to the availability of moisture since mulching conserves moisture as well as due to better regulated temperature since mulching reduces extremes of temperatures. Plastic mulch is effective in promoting rapid plant growth and increases plant height because it creates favorable conditions of soil temperature, moisture, and nutrient availability, thereby resulting in better uptake of nutrients for enhanced plant growth.

Alam, *et al.* [12] reported that the tallest sweet pepper plants were obtained from the closest spacing and the shortest ones were obtained from the wider spacing. Maya, *et al.* [13] also reported similar results that plant height of sweet pepper was significantly increased with closer spacing. Under higher density i.e. closer spacing there might be

comparatively low solar interception through crop canopy and under increased spacing probably the increased competition for light might have resulted in such variation in plant height. Taj, *et al.* [14] found competition for light in narrow spacing resulted in taller plants while at wider spacing light distribution was normal.

Manchanda, *et al.* [15] reported that the number of fruits per plant and fruit length increased with decreasing plant density, which disagrees with the present study. The variations were most probably being attributed to their inherited traits or the growing environment.

Similar results on fruit yield were also recorded by Hamide, *et al.* [16] who reported that the significant color mulch (plastic mulch) and plant spacing interaction effect was observed on yield. This results are in tandem with those of earlier researchers who reported that significantly higher yield were attained under the black plastic mulch because of effective soil temperature, weed control and conservation of soil moisture [17, 18]. Alabi [19] had earlier reported that the moisture and temperature levels of the soil during reproduction influences the yield of green pepper fruits.

5. Conclusion

Among all the mulch materials, the plastic performed better than the straw mulch and bare soil under the wider spacing of 50 by 40 cm basing majorly on the fruit yield. This might be due the fast evaporation from the organic and control mulches, less suppression of weeds and low temperature under organic mulches. Therefore this practice is recommended for increased and profitable production of green pepper in the region of study.

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