Plant Spacing and Time of Topping affects Growth and Yield of Roselle (*Hibiscus sabdariffa* L.) Cultivated in the Nyankpala Soil Series of Ghana

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ABSTRACT

Plant spacing/density and topping are two important agronomic practices that could effectively be applied to improve growth and increase the yields of horticultural crops. In this experiment, we investigated the effect of plant spacing at 30 x 15 cm, 30 x 30 cm, 30 x 45 cm and broadcasting combined with topping at 4, 6 and 8 weeks after planting (WAP) on the growth and yield of Roselle (*Hibiscus sabdariffa* L.). The experiment was a 4 x 4 factorial laid out in a Randomized Complete Block Design with three replications. The results showed that the 30 x 45 cm spacing combined with topping at 4, 6 and 8 WAP gave the best crop performance ($p<0.5$) in terms of increased number of leaves and branches, seeds per fruit, 1000 seed weight, shoot biomass at harvest and seed yield. Broadcasting and spacing at 30 x 15 cm or 30 x 30 cm combined with no topping enhanced plant height. Early flowering occurred when the plants were planted at 30 x 15 cm or sown by the broadcast method. Considering the most useful parts of the crop for commercial purposes, the 30 x 45 cm spacing, followed by topping at either 4, 6 or 8 WAP is recommended for increased leaf and seed yields.

Keywords: Roselle, *Hibiscus sabdariffa*, plant spacing, topping, leaf/seed yields

INTRODUCTION

Roselle (*Hibiscus sabdariffa* L.), is an annual plant that belongs to the family Malvaceae (Raemaekers, 2001). It is an annual crop with many benefits which is extensively grown in sub-tropical and tropical climates. There are many species of hibiscus in the world and more than 300 species have been documented in the world. Roselle (Hibiscus sabdariffa Linn) is one of the hibiscus species which has attracted many attention and it is cultivated in many parts of the world (Mahadevan *et al*., 2009). The food and feed benefits, medicinal and potential industrial value of the various parts (leaves, stems, calyces and seeds) of this multipurpose leafy vegetable have contributed to its extensive cultivation across the savannah zones of Burkina Faso, Ivory Coast and Ghana (Gibbon and Pain, 1986). Dalziel (1995) reported that the calyces and leaves have anti-scorbutic and diuretic effects whiles an infusion of the calyxes, referred to as roselle tea, cures bronchitis and cough. According to

Dupriez and De Leener (1989), the leaves and fruits also cure conditions such as hepatitis, constipation and round worm infestation. The protein content of the leaves and seeds is about 2.7% and the edible oil from the seeds is about 17% (Tindall, 1983; Gibbon and Pain, 1986).

It is noteworthy that the production of Roselle drink popularly called *Sobolo* in Ghana is an emerging beverage industry from which increasing number of resource poor women are deriving their cash income and livelihood. The plant also has potential as an important raw material for the pharmaceutical industry considering its phytotherapeutic potency for treating some tropical health conditions (Dalziel, 1995; Dupriez and De Leener, 1989). The extracts from Roselle have been found to contain medicinal properties that are used in the treatment of toothaches, urinary tract infections, hangovers and colds. Conjunctivitis is treated with juice from Roselle in Senegal (McClintock, 2004). It is envisaged that demand for Roselle products is likely to increase in the near future as a result of the rising interest of people for natural herbal products that are caffeine free like the tea and beverage.

In spite of the tremendous economic potential of Roselle, a plethora of cultivation constraints have seriously hampered its development into a major vegetable and industrial raw material. These constraints include use of poor quality seeds, as well as poor crop management practices, poor harvesting techniques, and post-harvest handling and storage challenges (Halimatul *et al*., 2007, Eslaminejad and Zakaria, 2011). Moreover, Norman (1992) indicated that improved growth and increased yields of the crop have not been achieved because of the lack of established standard for optimum plant population density. Forbes and Watson (1994), also pointed out that inter and intra specific competition among plants which occurs as a result of variation in plant density or spacing has great effect on yield components of the crop. In cucumber, different plant densities affected growth, yield and fruit quality differently (Boateng *et al*., 2003).

Meyer *et al*. (1996) reported herbaceous plants with aerial stems, growth in length takes place principally or entirely at the apex of the main axis of the plant. General plant morphology show that a lateral bud is present in the axil of every leaf, however, side branches do not develop from these buds so long as the apical bud retains its vigour and continues to grow. Berrie *et al.* (1993) observed that when the apical tip and its growth hormone are removed in a cultural practice termed topping, the lower dormant lateral buds develop to produce new shoots. Berrie *et al.* (1993) further explained that the removal of the growing tip of the shoot reduces significantly the level of auxin content and its suppressive effect on lateral growth which then enable auxiliary buds to start to develop afterwards. Norman and Shongwe, (1991) showed that topping or cutting terminal shoots 20 – 30 cm long-enhances the growth of branches and the production of leaves and floral development and thus increases overall yields. It is therefore, envisaged that combining optimal population density and appropriate time of topping could be a good strategy for increased vegetative growth and leaf/seed yields in Roselle.

Obviously, the importance in economic gain for the establishment of a standard of integrated optimal population density and topping practice system as a guide to farmers is tremendous. However, this important aspect of the agronomy of the crop has not been established in the West African growing regions including Ghana. Due to the scanty research data available on the agronomy of Roselle, farmers have difficulty in obtaining information on the best practices to enhance the yields of the crop. The level of production of the crop is currently simply based on farmers' indigenous knowledge. This study was therefore, conducted to determine the interaction effect of plant spacing and topping on the growth performance and yield of Roselle. The data obtained will enable the establishment of the good standard for combination of plant density and topping practices that could lead to increased yields in Roselle to enhance its economic potential.

MATERIALS AND METHODS

Site location, soil type, rainfall pattern and humidity

The experimental site was located in the interior Guinea savannah zone of Ghana at an altitude of 183m at latitude 9° 25''N and longitude 0°58''W of the equator. The soil type is sandy loam textured developed from the Voltaian sandstone known as the Nyankpala series. The area receives a unimodal rainfall pattern with mean annual amount of 1000-1200 mm which is usually fairly distributed from April through to November. Temperature distribution is uniform with mean monthly minimum of 23.4°C and maximum of 34.5°C. A minimum relative humidity of 46 % and maximum of 76.8 % is recorded for the area (SARI Annual Report, 2016).

Experimental Design and Treatments

The study was a 4 x 4 factorial experiment laid out in a Randomized Complete Block Design (RCBD) with three replications with spacing at 30 cm x 15 cm, 30 cm x 30 cm, 30 cm x 45 cm and broadcast control (Farmer method) combined with topping at 4, 6, 8 weeks after planting (WAP) and no topping.

Sowing and cultural practices

The experimental field was ploughed, harrowed and demarcated appropriately. Beds were made and seeds sown on beds. Seeds with a germination percent of 90% were sown at three seeds per hill at a depth of 5 cm in different spacing dimensions: 30 x 15 cm, 30 x 30 cm and 30 x 45 cm, and by broadcasting. Seedling emergence was observed 3 days after sowing and 80 – 87 % emergence was recorded at 6 days after sowing.

Weeds were cleared manually from the experimental field at 2, 5 and 8 WAP. Insect pests infestation occurred and the common pests found were Cotton stainers (*Dysdercus superstitiosus*), Flea beetle (*Podagrica spp*) and Spiny bollworm (*Earis biplaga*). Pests were controlled at 2, 4 and 6 WAP by applying DIZ – LAMBDA 2.5 E C pesticide at the rate of 10.8 ml per 12.96 litres of water. NPK (15:15:15) fertilizer was applied at 225 g per 9 m² plot.

Data Collection

Five plants were randomly selected and tagged in each plot for data collection at 4, 6, and 8 WAP.

Data on plant height was taken with a tape measure from the base of the plant to the apical part of the plant using measuring tape. The number of branches and number of leaves per plant were counted manually. The number of days after planting at which 50% of the Roselle plants produced flowers per plot was recorded. Five mature fruits were randomly selected and harvested from each treatment, dried and threshed and the seeds counted per fruit. Mature fruits from 7.2 m² area from each plot were harvested, sun dried and threshed for 1000 seed determination with an electronic scale. For seed yield, mature fruits from 7.2 m² area from each plot were harvested, sun dried, threshed and weighed with electronic scale and the weight was extrapolated to obtain seed yield in kg/ha. Shoots were harvested from 7.2 m² area from each plot at harvest and cut separately into pieces and stored in separate paper envelopes for fresh shoot weight and subsequently dry weight (biomass) determination after oven drying at 105°C for 24 hours.

Data analysis

Data collected was subjected to Analysis of Variance (ANOVA) using GENSTAT (Teaching edition) software and the treatment means were separated using the least significant difference (LSD) test at 5 % significant level.

RESULTS AND DISCUSSION

Plant height

Broadcasting without topping produced significantly ($p<0.05$) taller plants which were similar to plants at 30 x 15 cm and 30 x 30 cm without topping (Figure 1). High plant population enhances etiolation, most especially due to competition for sunlight (Schippers (2000). Light is supplied from above plants, individuals that situate their leaves above others benefit directly from increased photosynthetic rate accelerated growth and indirectly reduced growth of associated plants via shade (Craine, *et al.*, 2005). Plant also compete for nutrients by preventing nutrient supplies from coming into contact with nearby plants, which is required for maximizing root length. Although water is soil resource, competition for water is generally considered to occur by availability reduction, favoring plants that can withstand the lowest water potential.

There were no significant ($p<0.05$) differences in plant height among the 30 x 15 cm, 30 x 30 cm and 30 x 45 cm spacing at the topping timings at 4, 6 and 8WAP. This could probably be due to less competition for growth requirements among these entries compared with the broadcast plant population. Schippers (2000) reported that wider spacing results in shorter plants. Plants with topping were generally ($p<0.05$) shorter than plants without topping (Figure 1).

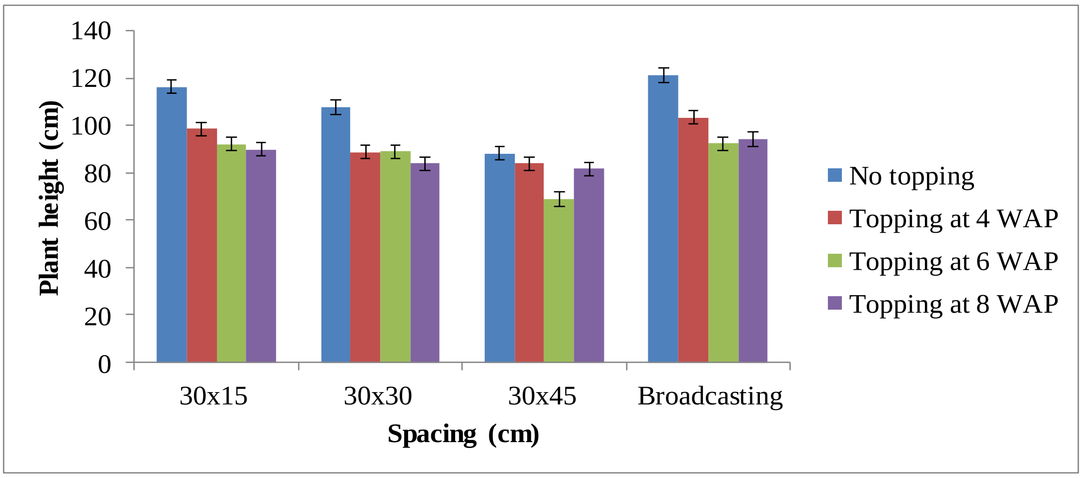

Figure 1. Effect of spacing and topping on plant height. Bars represent S.E.D.

Number of branches

Spacing plants at 30 x 45 cm with topping produced significantly ($p<0.05$) the highest number branches. However, comparing the effect of topping at 4, 6 or 8WAP for the 30 x 45 cm spacing gave similar number of branches (Figure 2). This suggests that the time for the removal of terminal buds could not be critical in enhancing branching. According to Berrie *et al.*, (1993), removal of the growing tip of the shoot cuts down the level of auxin, leading to more auxiliary buds developing into lead growth and eventually branches. Wider spacing results in shorter plants with more branches (Schippers, 2000). For all spacing with no topping practice, there were significantly ($p<0.05$) fewer branches compared to treatments where topping was carried out (Figure 2). The observed differences in number of branches between topping and no topping is the effect of presence of epical dominance in plant without topping and absence of apical dominance in topped plants respectively.

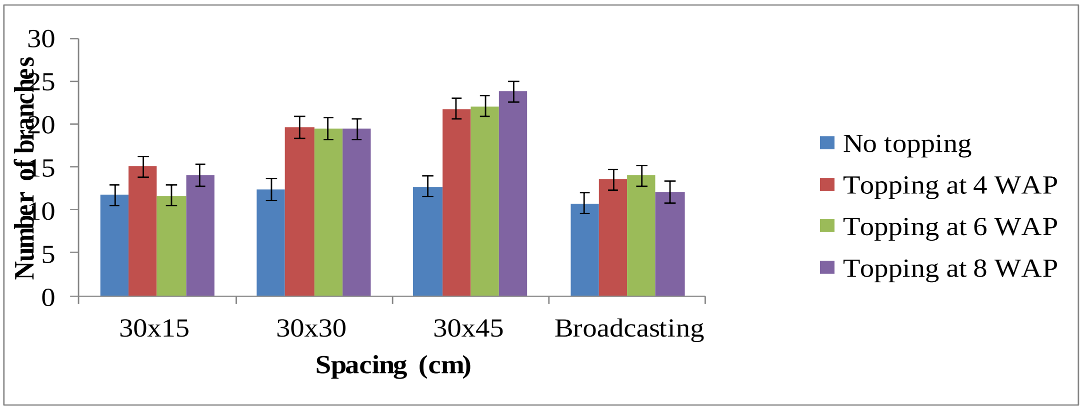

Figure 2. Effect of spacing and topping on number of branches. Bars represent S.E.D.

Number of leaves

The interaction effect of spacing and topping on number of leaves was highly significant ($p<0.001$) comparing spacing 30 x 30 cm and 30 x 45 cm to other plant spacing and no topping treatments (Figure 3). Plants at these two spacing with topping produced significantly ($p<0.001$) the most number of leaves. Further comparison of topped plants at spacing 30 x 30 cm and 30 x 45 cm showed that plants at spaced 30 x 45 cm produced significantly ($p<0.05$) the highest number of leaves. The effect of topping at 4, 6 or 8 weeks after planting for the plants at 30 x 45 cm spacing did not show any significant ($p<0.05$) difference in number of leaves (Figure 3). This might probably be due to the control of epical dominance and availability of adequate moisture, nutrients and sunlight for the production of more leaves by the widely spaced plants as earlier reported (Amaglo *et al.*, 2007).

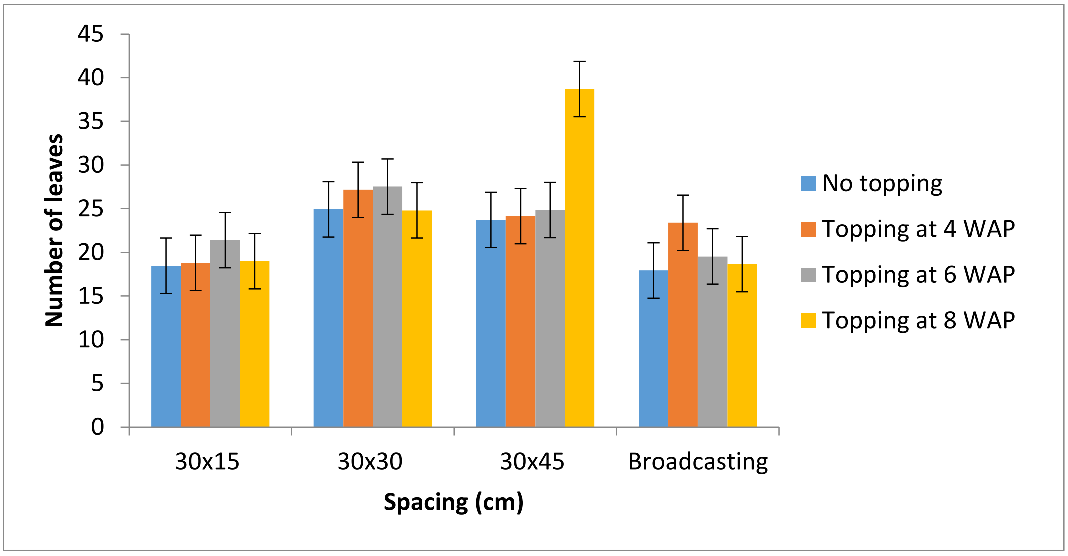

Figure 3. Effect of spacing and topping on number of leaves. Bars represent S.E.D.

Days to 50% flowering

Comparing spacing of plants without topping, plants spaced 30 x 15 cm and those sown by the broadcast method attained 50% flowering earlier at (91 days after sowing) whiles those that were at 30 x 30 cm and 30 x 45 cm attained 50% flowering at 95 days after sowing (Figure 4). This might probably be due to high competition for growth requirements in order to complete their growth period. It took the same duration of at least 95 days for plants to attain 50% flowering when planted at 30 x 30 cm and 30 x 45 cm spacing (Figure 4). This might be as a result of lack of competition among plants for growth requirements. However, no significant ($p<0.05$) differences were observed for all treatments where topping was carried out.

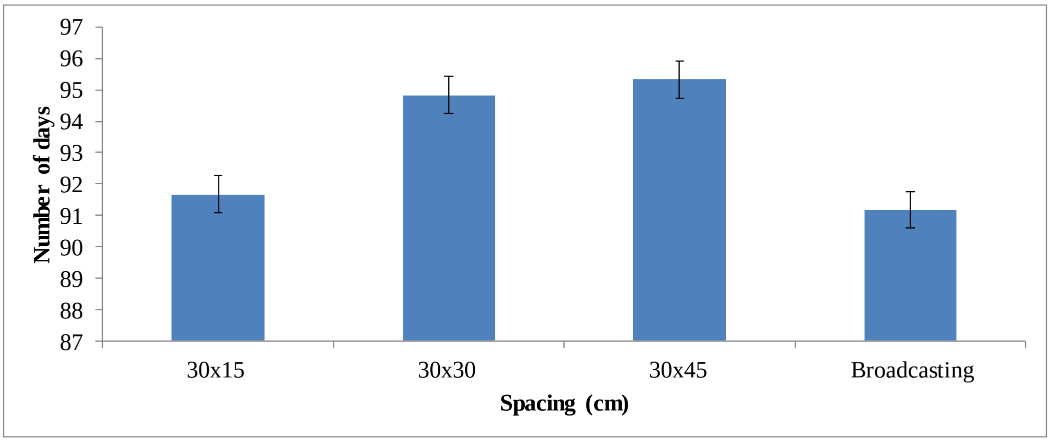

Figure 4. Effect of spacing on days to 50% flowering. Bars represent S.E.D.

Number of seeds per fruit

The highest number of seeds per fruit (26.27) was produced by plants at 30 x 45 cm spacing and topping at 6 weeks after planting. The 30 x 45 cm spacing combined with topping at 4 WAP gave similar results. The spacing at 30 x 30 cm with topping at 6 WAP and no topping also produced similar results (Fig. 5). This result falls within the range 22 - 34 seeds per fruit reported by Tindall (1983).

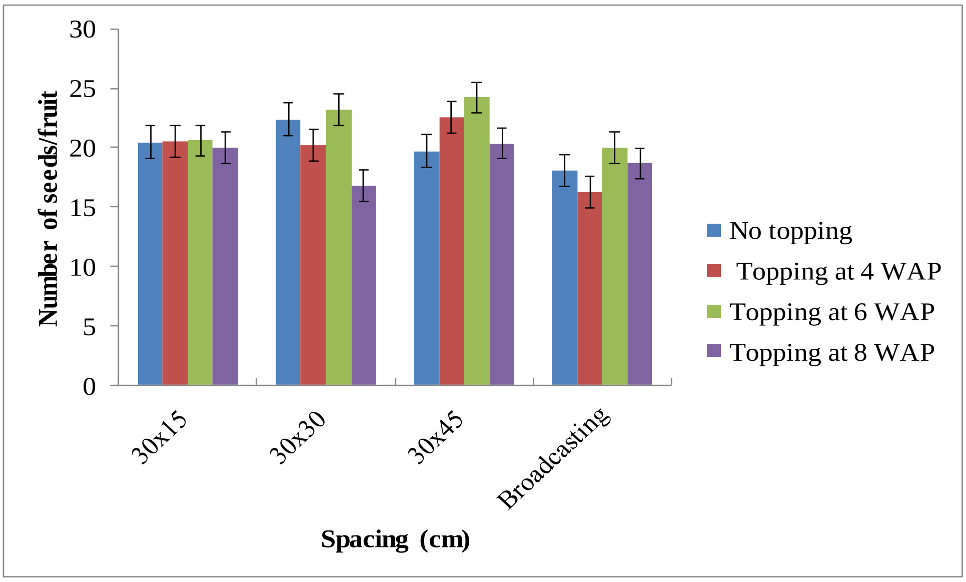

Fig. 5: Effect of spacing and topping on number of seeds per fruit. Bars represent S.E.D.

Thousand seed weight

The highest 1000 seed weight 35.67 g ($p>0.05$) was obtained at 30 x 45 cm spacing followed by topping at 8 WAP (Figure 6). This might be due to the availability of adequate nutrients, light and water for seed development and also adequate time allowed for crop growth. There was no significant difference among the other treatments in which the 1000 seed weight range was from 25 g to 30 g. Tindall (1983) obtained similar results for 1000 seed weigh .

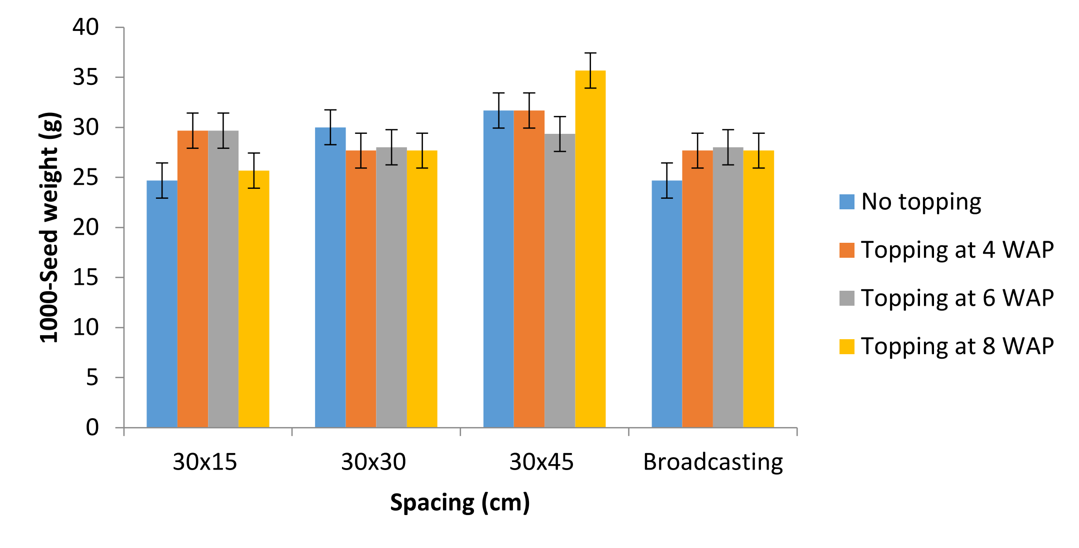

Fig. 6: Effect of spacing and topping on 1000 seed weight. Bars represent S.E.D.

Seed yield

Spacing at 30 x 45 cm combined with topping at 6 WAP gave the highest seed yield (197.6 kg/ha) (Fig.7). This yield is in line with about 200 kg/ha reported by Tindall (1983). This spacing combined with levels of topping also gave considerable yield. However, spacing at 30 x 30 cm combined with levels of topping and 30 x 15 cm combined with topping at 6 and 8 WAP also gave similar results. Broadcasting combined with levels of topping and spacing at 30 x 15 cm combined with no topping and topping at 4 WAP produced the least seed yield.

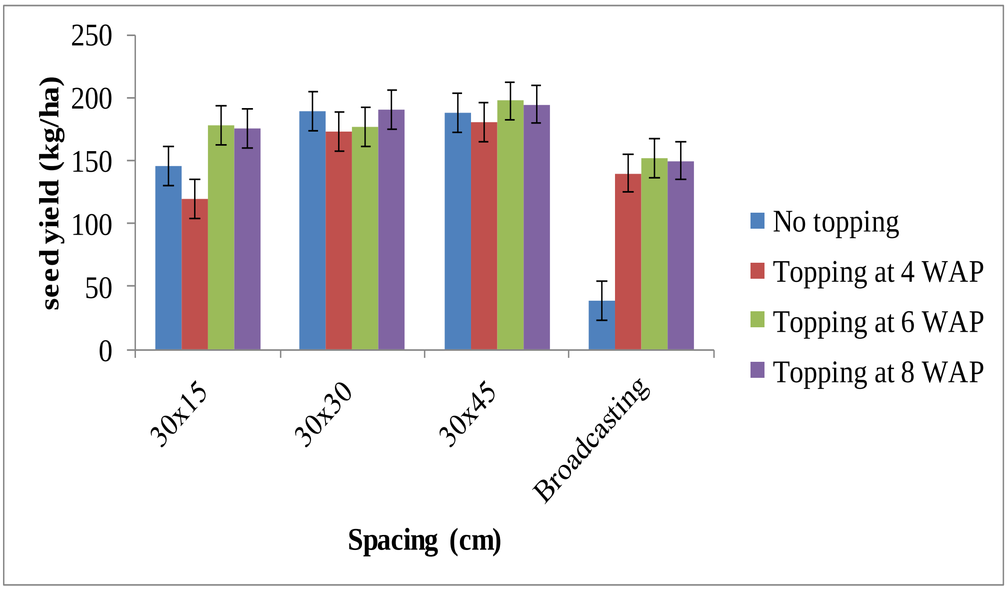

Fig. 7: Effect of spacing and topping on seed yield. Bars represent S.E.D.

Shoot biomass at harvest

Spacing at 30 x 45 cm combined with topping at 6 WAP produced the highest dry shoot

biomass at harvest (7,840 kg/ha). However, spacing at 30 x 45 cm combined with topping at 4 and 8 WAP gave similar shoot biomass at harvest (Fig. 8). Wider spacing produce higher shoot yield per plant than the medium and closer spacing (Amaglo *et al.*, 2007). This might be as a result of less competition for nutrients, water and sunlight and proper utilization of growth requirements.

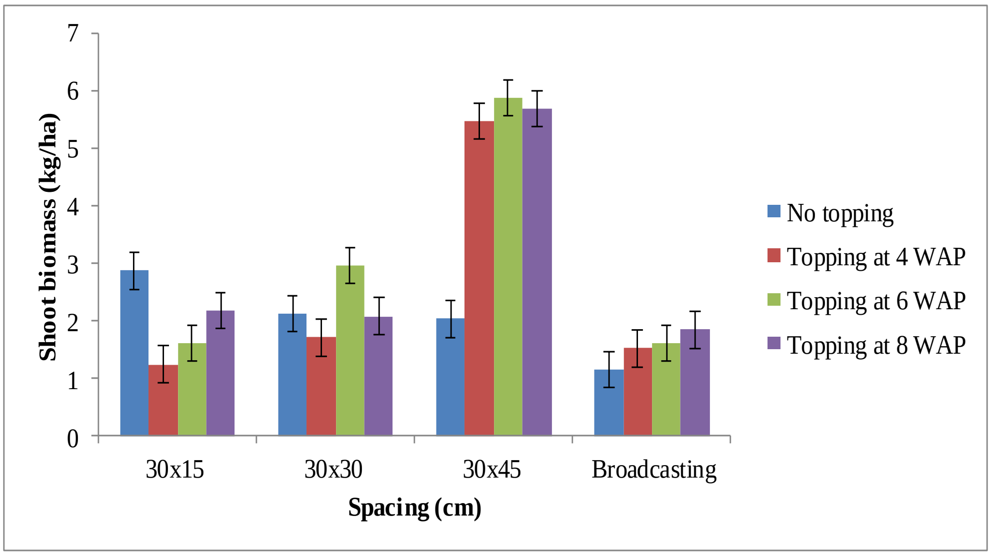

Fig. 8: Effect of spacing and topping on shoot biomass at harvest. Bars represent S.E.D.

CONCLUSION

The present study revealed that spacing at 30 cm x 45 cm combined with topping at 4, 6 and 8WAP gave the best crop performance with seeds per fruit, number of leaves and branches, shoot biomass at harvest, 1000 seed weight, and seed yield. Plant height was enhanced by broadcast, (Farmer seeding rate) and spacing at 30 cm x 15 cm or 30 cm x 30 cm combined with no topping. Planting at 30 cm x 15 cm and broadcast seeding promoted early flowering of the vegetable crop.

Disclosure of conflict of interest

The authors have not declared any conflict of interest that might have influenced the study.

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