Effect of mulching materials and plant spacing on growth, sex expression and yield of bitter gourd (*Momordica charantia*) cv. Paalee in Chitwan, Nepal

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**Article Info**

**ABSTRACT**

The field experiment was carried out in bitter gourd cv. Paalee in Chitwan during the cropping season of March-May, 2019. 4 × 2 Factorial Randomized Complete Block Design (RCBD) was conducted with three replications. Four different mulching materials viz. silver plastic mulch, black plastic mulch, straw mulch and a control with no mulch were assigned as first factor whereas second factor consisted of two plant spacing of 1.5m and 1m (plant-to-plant). The analysis revealed that silver plastic mulch recorded highest vine length (468.71 cm), maximum number of nodes per main vine (44.47) and maximum number of branches per main vine (31.57). Days to first male and female flowering, and sex ratio were found significantly (p<0.05) lower in silver plastic mulch as compared to other mulches. Similarly, silver plastic much had highest average fruit length (26.9cm), average fruit diameter (6.95cm), fruit number per plant (16.23), individual fruit weight (285.14g) and fruit yield (61.5 tons ha⁻¹), soil moisture percentage (47.45) and Benefit-cost Ratio (BCR) (3.08). The control treatment with no mulch had the lowest of all these parameters. The plant spacing did not significantly (p<0.05) differ for all the characters, except average individual fruit weight, average fruit yield and BCR, which were found higher (265.07g, 50.91 tons/ha and 1.9 respectively in wider spacing. The interaction effects of plant spacing and mulching materials were observed only for average fruit length and average fruit diameter. This study suggests silver plastic mulch as an effective mulching material for better growth and yield of bitter gourd cv. Paalee.

**Keywords:** Bitter gourd, Mulching materials, Plant spacing, Sex ratio, Benefit-cost Ratio

**INTRODUCTION**

Bitter gourd (*Momordica charantia* L.) is one of the important summer vegetable crops (family: Cucurbitaceae). The chromosome no. of bitter gourd is 24 (2n=2x=24) and, it was originated in Indo-Burma region. Several cultivars of bitter gourd are grown extensively in many tropical and sub-tropical countries throughout the world. Bitter gourd is an annual to perennial, monoecious, herbaceous vine that measures up to six meters in length. It has a climbing habit with well branched, slender, green stems that carry unbranched tendrils in the leaf axils. Leaves are 5-13 cm long, simple, alternate, rounded in outline with 4-6 deeply distinguished lobes (Gupta et. al 2011).

Bitter gourd has been found useful in maintaining blood sugar levels, lowering cholesterol levels and it is widely used to cure asthma, cough, diabetes, skin diseases, ulcers and wounds as a traditional medicine (Panday et. al 2014). Bitter gourd is grown up to the elevation of 1500 meters in warm and rainy season i.e. during April–July. The crop duration is about three to four months. Plant requires the temperature in a range of 24–27°C for the optimum growth whereas optimum soil temperature for seed germination is 18°C. It prefers a well-drained sandy loam soil rich in organic matter. The optimum soil pH should be 6-7, but plants can tolerate up to pH 8 in alkaline soil. First harvest of fruit is made 20-25 days after fruit setting. The average yield of bitter gourd in Nepal is 13.1 tons per hectare, which is comparatively low to the production potential of bitter gourd varieties.

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cultivated in Nepal. Different package of practices can be adopted to foster the yield of bitter gourd.

Mulching is one of the efficient management practices for increasing water use efficiency (WUE). The word mulch has been probably derived from the German word “molsch” which means to decay, which apparently referred to the use of straw and leaves by gardeners as a spread over the ground as mulch to protect it from solar radiation and evaporation (Jacks et. al 1955). Different types of materials like wheat straw, rice straw, plastic film, grass, wood, sand, etc. are used as mulches to moderate soil temperature and increase water infiltration during intensive rain (Gajri et. al 1994). This is also supported by (Farias-Larios et. al 1993) who concluded that mulching can be used to increase soil temperature, conserve water, enhance flowering period, reduce days to first harvest, and increase the yield of bitter gourd in dry-tropical regions. Soil surface mulching decreased water consumption which was reduced by 22.5% and 16.2% through the use of plastic film and wheat straw mulch (Zhen-dong et. al 2009). In our study, drip irrigation was used along with different mulching materials aiming at optimum water use efficiency. The use of drip irrigation along with plastic mulches enhanced vegetative growth and resulted in increased productivity of cucumber in an experiment conducted in Syria during 2009-2010 (Yaghi et. al 2013).

Plant density is an important agricultural factor that manipulates the above micro-climate of the field and affects growth, development and yield of crops. The interception of radiant energy largely depends on the plant density and plant arrangement (Hossain et. al 2011). The optimum plant density for attaining highest yield may vary with variety and geographical location. Higher plant density increases both canopy closure and interception of photosynthesis assimilation rate needed for carbohydrate production in the plants (McKenzie et. al 1992). Appropriate spacing of crops contributes in efficient space utilization and reduction of competition among plants with the same cultural requirements, enriches nutrient content of soil, repels pests and provides shade, improves the micro climate with reference to wind and moisture (Tuan and Mao 1989).

MATERIALS AND METHODS

Experimental Site

The field experiment was carried out at Jagatpur, Chitwan. It is situated at 27° 34’ N latitude and 84° 30’ E longitude at an elevation of 250m from mean sea level. The soil texture was sandy loam to sandy clay. The daily maximum and minimum temperature varied from 29°C to 35°C and 18°C to 22°C respectively during the cropping period.

Experimental Design

Factorial RCBD Experiment (4*2) was conducted using mulching materials and plant density as factor A and factor B respectively. Factor A comprised four treatments of mulching materials viz. silver plastic mulch, black plastic mulch, straw mulch and a control with no mulching. Factor B consisted two treatments of plant spacing viz. 1.5m and 1m plant-to-plant distances. Altogether eight treatment combinations were obtained. Three replications were maintained for each treatment combination. Each plot contained single bed with 10 plants in paired row planting design. Adjacent beds were spaced at 1.5m distance. Eight treatments were randomly allocated in each plot of all three replications. The total field size was 26.5 × 20.5 m².

‘Paalee’ cultivar of bitter gourd was shown directly on the field. Drip irrigation system was installed for optimizing water supply. Twenty tons of FYM along with recommended dose (140:40:100) kg of NPK/ha were applied at the time of sowing. Staking was provided in inverted U-shaped rope supported by vertical and horizontal wooden bars. Two plants from two adjacent rows were trailed for support. Appropriate management techniques were adopted to control disease and pest incidence. Harvesting was done manually at 90 DAS (Days After Sowing).

Data collection and analysis

Vegetative, floral and metrical measurements were taken in five randomly selected plants from each plot. Vegetative measurements included vine length (cm), number of primary branches per main vine and number of nodes per main vine, all measured at 90 DAS. Floral measurements comprised days to first male and female flowering and total number of flowers to calculate the sex ratio, all measured at 90 DAS. Number of fruit per plant, individual average fruit weight (g), average fruit length (cm), average fruit diameter (cm), average fruit yield per ha (tons/ha) were measured under the metrical measurements, all measured at 90 DAS.

To determine soil moisture content, soil sample from each plot were composited for the analysis of each replication. From composite sample 50 gram soil was taken, and dried in oven for 24 hours at 100°C. The soil samples were taken for four times viz. first before sowing, second during vegetative phase, third during flower initiation and final before first harvesting.

\[
\text{Soil moisture percentage} = \left( \frac{\text{Fresh weight} - \text{Oven dried weight}}{\text{Oven dried weight}} \right) \times 100
\]
For the economic analysis, cost of cultivation, gross return and net return were calculated, and Benefit-cost Ratio (BCR) was estimated by the following formula:

$$BCR = \frac{\text{Gross return}}{\text{Cost of cultivation}}$$

All the collected data were entered into MS-Excel version 2013 and, were later analysed using R studio version 3.5.3. DMRT (Duncan’s Multiple Range Test) was conducted at 5% level of significance for the separation of means using the package agricolae. Correlation table was constructed (Himsec package in R studio) to study the correlations between variable parameters of bitter gourd.

**RESULTS AND DISCUSSION**

**Effect of mulching materials on growth parameters of bitter gourd**

Mulching materials significantly (p<0.05) influenced the growth parameters of bitter gourd, all measured at 90 DAS as shown in Table 1. Vine length was found significantly higher in silver plastic mulch (468.71 cm) and black plastic mulch (465.28 cm), and it was recorded least in control with no mulch (242.29 cm). Number of primary branches was recorded maximum in silver plastic mulch (31.57) whereas the control treatment had minimum number of them (16.34).

Similarly, number of nodes per main vine were found to be highest in silver plastic mulch and, they were recorded lowest in control with no mulch (33.97). These results were similar to the findings of Parmar et. al (2013) in their experiment conducted in watermelon. Coolong (2010) also recorded the similar results in vegetative growth parameters in summer squash.

Similarly, Bosland and Votava (2000) stated that one of the main objectives of using plastic mulch is to increase soil temperature in the rootzone. The favourable root-zone temperature promotes the uptake of water and mineral nutrients, which in turn promotes better growth of plants (Tindall et. al 1991). The vegetative growth of plants is largely affected as the alternation of light microenvironment leads to greater branching in plant grown on reflective mulches as compared to black plastic mulch (Decoteau et. al 1988).

**Effect of plant spacing on growth parameters of bitter gourd**

Plant spacing did not significantly (p<0.05) influence all the growth parameters of bitter gourd except no. of nodes per main vine with the highest no. of nodes (44.47) recorded in the widest spacing (1.5m × 1m). No significant effects were seen in vine length and no. of primary branches per main vine, all measured at 90 DAS as shown in Table 2.

No significant results were obtained for mulching materials and plant spacing interaction effect on growth parameters of bitter gourd cv. Paalee.

**Effect of mulching materials on yield parameters of bitter gourd**

Mulching materials significantly (p<0.05) influenced the yield parameters of bitter gourd, all measured at 90 DAS as shown in Table 3. Days to first male and female flowering were found highest i.e. 45.67 and 47.78 respectively in control with no mulch whereas silver plastic mulch had lowest of them as 32.93 and 35.65 respectively. Sex ratio was recorded least (2.66) in silver plastic mulch with no significant difference with black plastic mulch (2.92), whereas no mulch had the highest sex ratio of 5.03. Similarly, the major yield attributing parameters viz. average fruit length, average fruit diameter, no. of fruits per plant, average individual fruit weight and average fruit yield were found maximum in silver plastic mulch followed by black plastic mulch and straw mulch. All these parameters were recorded lowest in the control with no mulch.

The above results are in consonance with those of (Hallidri 2001) in cucumber and (Suresh and Kumar 2006) in pointed gourd. Increased weight of fruit and yield under drip irrigation and polythene mulch resulted due to better water utilization, higher uptake of nutrients and excellent soil-water-air relationship with higher oxygen concentration in root zone (Bhujbal et. al 2015). Similar findings were elucidated by (Hanna 2000) in his experiment in cucumber double cropped with tomatoes. Diaz-Perez (2010) also found significant results on yield of cucumber under different mulching treatment showing that the surface color of plastic mulch can

### Table 1. Effect of mulching materials on growth parameters of bitter gourd

| Mulching materials          | Vine length (cm) | No. of primary branches per main vine | No. of nodes per main vine |
|-----------------------------|------------------|--------------------------------------|--------------------------|
| Silver plastic mulch        | 468.71           | 31.57b                               | 53.18b                   |
| Black plastic mulch         | 465.28           | 29.23b                               | 50.57b                   |
| Straw mulch                 | 302.27           | 21.1c                                | 38.34c                   |
| No mulch (control)          | 1729c            | 16.34c                               | 33.97c                   |
| S.Em (±)                    | 4.40             | 0.65                                 | 0.36                     |
| LSD (0.05)                  | 13.33            | 1.97                                 | 1.1                      |

Means with same letter within column do not differ significantly at p=0.05 by DMRT.
change the quantity of light and spectral balance reaching plants, with consequent effects on growth and fruit production. Similar variation was recorded by (Sylvestre et. al 2014) in their experiment conducted in water melon. Birbal et. al (2014) elucidated congruous observations in yield parameters of squash melon.

Effect of plant spacing on yield parameters of bitter gourd

Plant spacing did not significantly (p<0.05) influence all the yield parameters of bitter gourd except average individual fruit weight and average fruit yield with maximum of them recorded in widest spacing (1.5m × 1.5m) as 265.07 g and 50.91 tons ha⁻¹ respectively as shown in Table 4. Catedral and Mamipic (1976) reported the increment in fruit size reaching plants, with consequent effects on growth and fruit production. Similar variation was recorded in water melon. Birbal et. al (2014) in their experiment conducted in water melon elucidated congruous observations in yield parameters of squash melon.

Effect of mulching materials × plant spacing interactions on yield parameters of bitter gourd

The interaction effect of mulching materials and plant spacing significantly (p<0.05) improved the average fruit length and average fruit diameter as shown in Table 5. The optimum result was obtained from the interaction of silver plastic mulch and widest spacing (1.5m × 1.5m) whereas no mulch and narrow spacing (1.5m × 1.0m) showed least values in both the parameters. Other yield parameters did not significantly (p<0.05) differ for the interaction effect. This result is supported by the findings of (Ekwu et. al 2012), who, in their experiment in okra found no interaction between mulching and plant spacing.

Effect of mulching materials on soil moisture percentage and Benefit-cost ratio (BCR)

Mulching materials significantly (p<0.05) influenced the soil moisture percentage and Benefit-cost ratio (BCR) of bitter gourd as shown in Table 6. Silver plastic mulch recorded the highest soil moisture percentage (47.45) and maximum Benefit-cost ratio (3.08). Both of these parameters were recorded least in no mulch as 40.28 and 0.55 for soil moisture percentage and

| Table 2. Effect of plant spacing on growth parameters of bitter gourd |
|-------------------------|-----------------|-----------------|------------------------|------------------------|
| Plant spacing            | Vine length (cm) | No. of primary branches per main vine | No. of nodes per main vine |
| 1.5m × 1.5m              | 373.62          | 24.89           | 44.47b                 |
| 1.5m × 1.0m              | 365.7           | 24.22           | 43.55b                 |
| S.Em (±)                 | 3.11            | 0.46            | 0.25                   |
| LSD (0.05)               | Ns              | Ns              | 0.783                  |

Means with same letter within column do not differ significantly at p=0.05 by DMRT.

| Table 3. Effect of mulching materials on yield parameters of bitter gourd |
|-------------------------|-----------------|-----------------|------------------------|------------------------|
| Mulching materials      | Days to first male flowering | Days to first female flowering | Male : Female flowers (Sex ratio) | Average fruit length (cm) | Average fruit diameter (cm) | No. of fruits per plant | Average individual fruit weight (g) | Average fruit yield (ton ha⁻¹) |
| Silver plastic mulch    | 32.93d          | 35.65d          | 2.66c                  | 26.9c                   | 6.95c                   | 16.23c                  | 285.14c                   | 61.5c                   |
| Black plastic mulch     | 35.78c          | 37.75c          | 2.92c                  | 24.33b                  | 6.52b                   | 15.27b                  | 275.20b                   | 55.86b                  |
| Straw mulch             | 44.78b          | 43.68b          | 3.43b                  | 15.42c                  | 3.8b                    | 13.53c                  | 247.28c                   | 44.51c                  |
| No mulch (control)      | 45.67a          | 47.78a          | 5.03c                  | 14.02d                  | 3.58c                   | 12.18d                  | 244.62c                   | 39.63d                  |
| S.Em (±)                | 0.25            | 0.17            | 0.14                   | 0.20                    | 0.07                    | 0.07                    | 1.72                      | 0.24                    |
| LSD (0.05)              | 0.75            | 0.53            | 0.43                   | 0.64                    | 0.22                    | 0.21                    | 5.24                      | 0.78                    |

Means with same letter within column do not differ significantly at p=0.05 by DMRT.

| Table 4. Effect of plant spacing on yield parameters of bitter gourd |
|-------------------------|-----------------|-----------------|------------------------|------------------------|
| Plant spacing            | Days to first male flowering | Days to first female flowering | Male : Female flowers (Sex ratio) | Average fruit length (cm) | Average fruit diameter (cm) | No. of fruits per plant | Average individual fruit weight (g) | Average fruit yield (ton ha⁻¹) |
| 1.5m × 1.5m              | 39.64           | 41.3            | 3.42                   | 20.28                   | 5.28                    | 14.35                   | 265.07c                   | 50.91c                  |
| 1.5m × 1.0m              | 39.92           | 41.13           | 3.59                   | 19.96                   | 5.14                    | 14.25                   | 261.07b                   | 49.86b                  |
| S.Em (±)                 | 0.18            | 0.12            | 0.10                   | 0.15                    | 0.05                    | 0.05                    | 1.22                      | 0.17                    |
| LSD (0.05)               | Ns              | Ns              | Ns                     | Ns                     | Ns                     | Ns                     | 3.7                      | 0.55                    |

Means with same letter within column do not differ significantly at p=0.05 by DMRT, Ns=Non- significant.
Benefit-cost Ratio respectively. The above results are in correspondence with the observations made by Awasthi et al (2006) and Schonbeck (1999) in brinjal.

**Effect of plant spacing on Benefit-cost Ratio (BCR) of bitter gourd**

Plant spacing significantly (p<0.05) influenced Benefit-cost Ratio (BCR) as shown in Table 7. Wider spacing (1.5m × 1.5m) had significantly higher (1.9) Benefit-cost Ratio (BCR) as compared to the BCR (1.87) of narrow spacing (1.5m × 1.0m).

**Study of relationship between variable parameters of bitter gourd using correlation table**

The correlation table revealed very high and significant (p<0.01) correlations between variable morphological and yield parameters of bitter gourd cv. Paalee as shown in Table 8. All the parameters except for days to first male flowering and days to first female flowering possessed high positive correlations. In contrast, days to first male flowering and days to first female flowering had high negative correlations with other parameters. This is true in an aspect that the achievement of optimum vigor at vegetative phase contribute to the decrease first flowering period. Similarly, the high positive correlation between other parameters is justifiable. Khan et al (2015) demonstrated the similar results between vegetative parameters and yield attributing parameters in sponge gourd.

The increment in vine length results in greater no. of leaves (larger photosynthetic area), increase in no. of primary branches and no. of nodes (more no. of flowers). Subsequently, the increased fruit length, fruit diameter, fruit number and individual fruit weight positively contribute to the overall yield and seed parameters of bitter gourd (Catedral and Mamipic 1976).

**CONCLUSIONS**

The results of this experiment revealed that silver plastic mulch was beneficiary for optimizing the production of bitter gourd in Chitwan district. Similarly, black plastic mulch followed it with good effects on vegetative growth, reproductive characters and yield attributing parameters. Plant spacing did not significantly influence all the characters of bitter gourd cv. Paalee, however it had shown the effects on few yield attributing parameters. Interaction effects of mulching materials and plant spacing were observed only for fruit length and diameter in this cultivar of bitter gourd. Hence, the farmers in Chitwan opting for medium scale production of bitter gourd cv. Paalee are recommended to use mulching materials (preferably silver plastic mulch) with wider spacing (1.5m × 1.5m) for optimum returns.

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**Table 5. Effect of mulching materials × plant spacing interactions on yield parameters of bitter gourd**

| Treatments                      | Average fruit length (cm) | Average fruit diameter (cm) |
|---------------------------------|---------------------------|-----------------------------|
| SPM × (1.5m × 1.5m)             | 27.15a                    | 7.1a                        |
| BPM × (1.5m × 1.5m)             | 24.83b                    | 6.7b                        |
| SM × (1.5m × 1.5m)              | 15.58c                    | 3.87c                       |
| No mulch × (1.5m × 1.5m)        | 13.55e                    | 3.47e                       |
| SPM × (1.0m × 1.0m)             | 26.24b                    | 6.8b                        |
| BPM × (1.0m × 1.0m)             | 23.84d                    | 6.33c                       |
| SM × (1.0m × 1.0m)              | 15.26ef                   | 3.73de                      |
| No mulch × (1.0m × 1.0m)        | 14.49f                    | 3.70e                       |
| S.Em (+)                       | 0.30                      | 0.10                        |
| LSD (0.05)                     | 0.90                      | 0.30                        |

Means with same letter within column do not differ significantly at p=0.05 by DMRT.

**Table 6. Effect of mulching materials on soil moisture percentage and Benefit-cost ratio (BCR)**

| Mulching materials | Soil moisture (%) | Benefit-cost Ratio (BCR) |
|--------------------|-------------------|--------------------------|
| Silver plastic mulch | 47.45a            | 3.08a                    |
| Black plastic mulch | 44.65b            | 2.18b                    |
| Straw mulch         | 42.7c             | 1.72d                    |
| No mulch (control)  | 40.28d            | 0.55e                    |
| S.Em (+)            | 0.30              | 0.01                     |
| LSD (0.05)          | 0.67              | 0.039                    |

Means with same letter within column do not differ significantly at p=0.05 by DMRT.

**Table 7. Effect of plant spacing on Benefit-cost Ratio (BCR) ratio of bitter gourd**

| Plant spacing | Benefit-Cost Ratio (BCR) |
|---------------|---------------------------|
| 1.5m × 1.5m   | 1.9b                      |
| 1.5m × 1.0m   | 1.87b                     |
| S.Em (+)      | 0.007                     |
| LSD (0.05)    | 0.027                     |

Means with same letter within column do not differ significantly at p=0.05 by DMRT.
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CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

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