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Research Article

Effect of different spacing and mulching on growth and yield of Okra (*Abelmoschus esculentus* L.) in Chitwan, Nepal

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ABSTRACT

Okra (*Abelmoschus esculentus* L.) is one of the most important vegetable crop of Nepal. Its yield and growth parameters are affected by different cultural practices. This study was conducted at Olericulture Farm of Agriculture and Forestry University, Rampur, Chitwan, Nepal during April 29 to July 9 of 2018. The field experiment was carried out in split plot design using three replications. The treatments consisted of three intra row spacing (30, 45 and 60 cm) and four different mulching materials (Silver plastic, *Panicum repens, Lantana camara* and bare soil). The objective of this experiment was to assess the effects of various intra-row spacings and mulching materials on growth and yield of okra. The effect of mulching materials on okra yield was found significant. The okra yield was highest (8104 kg/ha) under silver plastic mulch followed by control (5161kg/ha), *Panicum repens* (3901kg/ha) and *Lantana camera* (3701kg/ha), respectively. Silver plastic mulch enhanced the growth parameters like canopy length, plant height, leaf number, leaf length, girth and yield of okra. The spacings provided non significant effect on okra yield, however the yield of okra was highest (7295 kg/ha) under 30×30 cm spacing followed by 45×30 cm (4660 kg/ha) and 60 cm × 30 cm spacing (3703 kg/ha), respectively. Combination of silver plastic mulch along with 30 cm × 30 cm spacing provided the highest okra yield. This study suggests that farmers of the Chitwan should grow okra at spacing of 30 cm × 30 cm and under silver plastic mulch to produce higher yield.

Keywords: Mulching, Okra, Spacing

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INTRODUCTION

Okra (*Abelmoschus esculentus* (L).Moench) is one of the well known vegetable crop of the family *Malvaceae* and originated from tropical America and was first cultivated in Egypt in 12th century (Maurya *et al.,* 2013). Okra is cultivated mostly in tropics, subtropics and some warmer temperate region (Farinde *et al.,* 2007)**.** The fruits are used in making soup, salad and consumed as vegetables. Okra mucilage has medicinal value it expands blood volume, it binds cholesterol and bile acids carrying toxins and deposit into liver (Gemede *et al.,* 2015).Okra seed is source of protein, oil and can be use as non caffeinated substitute for coffee (Calisir *et al.,* 2005). Okra is one of the most important vegetable crop of Nepal widely cultivated in Jhapa, Morang, Saptari, Bara, chitwan, Rautahat, kailali and Dhanusa. Total production of okra across the country was 122,101.6 metric tons under the area of 10,781.4ha with the productivity of 11.3t/ha (MoAD, 2015-2016).

Growth, Yield and quality of okra are hampered by lack of knowledge about the best management practices, low awareness on nutritional and health benefits (Bake *et al.,* 2017). Mulching conserve soil moisture, reduce infiltration rate, reduce fertilizer leaching, prevent from extremes of temperature, reduce weed growth and ultimately increase yield of crop (Bhardwaj, 2013). The growers and researchers use different colored mulches in vegetable production. The use of silver plastic mulch has resulted in less insect-transmitted disease (Csizinszky *et al.,* 1995; Lamont *et al.,* 1990) in certain vegetable crops.

Adequate plant density achieved by maintaining narrow spacing resulted into efficient light interception which increases organic matter and yield of Okra (Asiegbu, 1997). For obtaining optimum growth and yield, Okra should be cultivated maintaining plant population of 55,555 okra plant/ha (Agba *et al.,* 2011). *Lantana camara* is source of microbiocide, nematocide, fungicides and insecticides. Chemical extract from lantana is used to kill weeds (Jimenez-Arellanes *et al.,* 2003). Thus the objective of this experiment is to find out the different types of mulching along with efficacy of *Lantana camara* and appropriate spacing for the higher yield of the okra crop.

MATERIALS AND METHODS

Experimental detail

Experiment was carried out in Agriculture and Forestry University, Bharatpur Metropolitan city, Rampur Chitwan from April 28 to July 9 of 2018. Geographic location is $27^0 38' 50.92'' N$, $84^0 20' 49.43'' E$ with the elevation of 228 meters above sea level (Marahatta *et al.,* 2017). The area is characterized subtropical climate with unimodal rainfall pattern. Soil type is sandy loam and acidic with grayish white color.

Experimental Design

The experiment was carried to find out the effect of different types of mulching and also the appropriate spacing for the higher yield of the okra crop. As two different factors affecting the yield were examined, split plot design with three replications was used to examine the effects of both the factors.

Factor 1: Different types of mulch application as subplot factor
M_1 = Silver plastic mulch plastic, M_2 = *Panicum repens* mulch, M_3= *Lantana camara* mulch,
M_4= Control
Factor 2: Different spacing as main plot factor
S_1 = 30 cm × 30 cm, S_2 = 45 cm × 30 cm, S_3 = 60 cm × 30 cm
For spacing there were three replication and these replicated plots accommodate all the treatments. The size of individual plot was 3×1.8 m^2, the distance between subplots was 50 cm and that of main plot was 1 meter.

Plant Material
Venus variety of okra was collected from local agro vet under the periphery of Agriculture and Forestry University. This variety was selected under the recommendations of subject matter specialist because of its special features which are as follows:

- Fruit remain tender for long time after picking and good for delayed pickings
- Tolerance to yellow vein mosaic vein

Climatic condition during experimental observation
The meteorological data for cropping season was recorded from meteorological station of National Maize Research Program (NMRP), Rampur, Chitwan, Nepal about 200 meter from research site (figure 1). The total rainfall of 349.9 mm was received during the entire period of experimentation. The highest rainfall was recorded during June (212.2 mm). The maximum temperature during the experimental period range from 31.85 ^{0}C to 38.10^{0}C. It was highest during June at the stage of fruiting and lowest during May at vegetative stage. Similarly the minimum temperature during experimentation period ranges from 21.5^{0}C to 26.55^{0}C. It was highest during June and lowest during April.

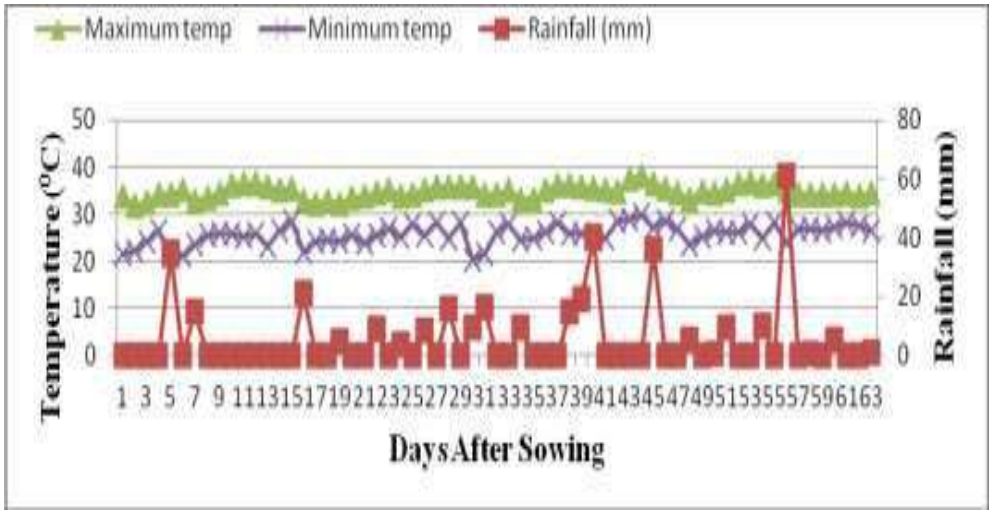

Figure 1. Weather condition during the experimentation period at Rampur, Chitwan, Nepal from April 29 to July 2

Crop management

Before sowing seeds were soaked overnight. One deep plowing and three light plowing was done followed by planking was done for field preparation.

Measurement of data

To measure growth and yield parameters, five plants excluding border plants were selected to study the following plant parameters.

Plant height: It was measured from base of the plant to its tip. It was measured from 15 DAS and continued at fortnight interval.

Stem base diameter*:*The vernier caliper was used for the measurement of stem base diameter. It was measured from 15 DAS and continued at fortnight interval.

Canopy length: It was measured by using meter scale and measured by taking diameter of canopy across two axes, after which mean was taken.

Leaf number**:** fully opened leaves were counted across whole height of plant.

Leaf length**:**

Three leaf lengths were taken from different plant height. Leaf length was measured from the base of the petiole to apex of leaf.

Yield:

Yield was taken at four days interval after 45 DAS till 5 pickings.

Statistical analysis

The collected data was processed by MS Excel and analyzed by using Genstat 13.2 (Baral *et al.,* 2016). All the recorded data were subjected to analysis of variance and Duncan's multiple range test (DMRT) for mean separation. The significance differences among the means were tested using least significance difference (LSD) at 5% level of significance (Gomez and Gomez, 1984).

RESULTS

The experiment was conducted to study two different factors spacing and mulching on the production of okra. The result of each parameter have been discussed and interpreted in this section. The average canopy length for all the three spacing at 15 DAS, 30DAS and 60 DAS was found to be statistically non significant whereas it was significant at 45 DAS. Longer canopy length at 45 DAS was found to be at wider (60×30) and medium (45×30) spacing shown in table 1.Canopy length of 73.5 and 74.5cm was found at 45 DAS at wider and medium spacing whereas 58.8cm is found at narrow spacing.

Effect of mulching was found to be statically significant at 15 DAS ($P<0.05$) 45 DAS ($P<0.05$) and significant at 60 DAS ($P<0.05$) but it was non-significant at 30DAS. At 15 DAS longer canopy length (25.15cm) was found in silver plastic mulch whereas smallest is found in *Panicum repens* mulch (18.49cm) and control (19.58).At 45 DAS longest canopy length (73.9cm) was found in silver plastic mulch but at 60 DAS longest canopy length was found to be on control (82.4cm).Lantana camara gave poor result in 45 DAS and 60 DAS. There was no any significant difference in interaction of spacing and mulching for canopy length.

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Table 1. Effect of spacing and mulching on canopy length of okra

Treatments	Canopy Length			
	15 DAS	30 DAS	45 DAS	60 DAS
Spacing				
30×30	18.29	40.1	58.8[b]	71.1
45×30	23.9	46.3	73.5[a]	79.9
60×30	21.05	38	74.4[a]	80.7
SEm(±)	7.58	9.88	3.33	4.09
CV%	62.3	41.3	8.4	9.2
LSD (0.05)	29.762	38.79	13.06	16.077
F test	NS	NS	*	NS
Mulching				
Silver plastic	25.15[a]	47.5	73.9[a]	81.6[ab]
Panicum repens	18.49[b]	37.2	69.4[ab]	75.2[bc]
Lantana camara	21.10[ab]	38.4	62.2[b]	69.8[c]
Control	19.58[b]	42.7	70.1[ab]	82.4[a]
SEm(±)	1.46	2.74	2.61	2.23
CV%	20.8	19.9	11.4	8.7
LSD (0.05)	4.33	8.15	7.76	6.63
F test	*	NS	*	*
Spacing × Mulching				
Grand Mean	21.08	41.5	68.9	77.3
CV%	20.8	19.9	11.4	8.7
LSD (0.05)	7.511	14.12	13.456	11.492
F test	NS	NS	NS	NS

*NS=non significant, *=Significant at 5% probability level.*

Table 2. Effect of spacing and mulching on plant height of okra

Treatments	Plant Height (cm)			
	15 DAS	30 DAS	45 DAS	60 DAS
Spacing (cm × cm)				
30×30	12.48	31.5	104	121.1
45×30	13.67	30.8	101.7	118.5
60×30	10.25	24.4	93.4	112.9
SEm(±)	2.410	8.93	5.38	3.80
CV%	34.4	53.5	9.4	5.6
LSD (0.05)	9.464	35.079	21.142	14.92
F test	NS	NS	NS	NS
Mulching				
Silver plastic	12.67	34.6	116.2	134.9
Panicum repens	12.37	26.9	100.2	113.4
Lantana camara	12.98	27.2	81.8	98.3
Control	10.52	26.9	100.5	123.4
SEm(±)	1.002	2.58	5.36	4.77
LSD (0.05)	2.976	7.658	15.918	14.175
F test	NS	NS	*	*
Spacing × Mulching				
Mean	12.14	28.9	99.7	117.5
CV%	24.8	26.7	16.1	12.2
LSD (0.05)	5.154	13.265	27.57	24.55
F test	NS	NS	NS	NS

**=Significant at 5% probability level.*

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Plant spacing did not have significant effect on the plant height as shown in Table 2 but mulching had significant effect on plant height at 45 DAS (P<0.05) and 60 DAS**.** Greater plant height was obtained in plastic mulch at 45 DAS (116.20cm) and 60 DAS (134.9) whereas plant cultivated under *Lantana camara* mulch gave the poor result. There was no any significant difference in interaction of spacing and mulching for plant height. Spacing did not have significant effect on leaf length. At 15 DAS mulching had no significant effect on leaf length but it provided significant result at 30 DAS (P<0.05), 45 DAS (P<0.05), and 60 DAS (P<0.05). Plastic mulching was found to be superior to other mulch in 30DAS but silver plastic mulch and control gave superior results at 45 DAS and 60 DAS as shown in table no. 3.There was no any significant difference in interaction of spacing and mulching for leaf length.

Table 3. Effect of spacing and mulching on leaf length of okra

Treatments	**Leaf Length (cm)**			
	15 DAS	30 DAS	45 DAS	60 DAS
Spacing (cm)				
30×30	11.68	26.9	36.13	38.49
45×30	15.04	32.2	37.25	39.69
60×30	10.73	23.1	40.17	40.03
SEm (±)	3.731	7.08	1.646	1.231
CV%	51.8	44.8	7.5	5.4
LSD (0.05)	14.647	27.79	6.461	4.835
Mulching				
Silver Plastic	14.86	32.9	40.67	40.98
Panicum repens	11.08	27.3	36.72	38.86
Lantana camara	12.53	22.2	33.76	36.36
Control	11.47	27.2	40.24	41.42
SEm (±)	1.27	2.3	1.441	1.007
CV%	30.5	25.2	11.4	7.7
LSD (0.05)	3.774	6.824	4.281	2.991
F test	NS	*	*	*
Spacing × Mulching				
Mean	12.48	27.4	37.85	39.41
CV%	30.5	25.2	11.4	7.7
LSD (0.05)	6.53	11.821	7.415	5.181
Grand Mean	12.48	27.4	37.85	39.41
F test	NS	NS	NS	NS

*NS=non significant, *=Significant at 5% probability level.*

Table 4. Effect of mulching and spacing on leaf number of okra

Treatments	Leaf number			
Spacing (cm × cm)	15 DAS	30 DAS	45 DAS	60 DAS
30×30	5.12	5.12	8.40	21.15
45×30	5.68	5.68	10.85	25.65
60×30	4.75	4.75	9.05	25.75
SEm (±)	0.991	0.991	1.679	1.705
CV%	33.1	30.8	12.2	13.2
LSD (0.05)	3.891	3.891	6.593	6.693
F test	NS	NS	NS	NS

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Mulching				
Silver Plastic	5.96	10.71	25.66	26.33
Panicum repens	4.64	8.89	23.87	23.78
Lantana camara	5.20	8.09	20.53	20.42
Control	4.94	10.04	26.67	26.31
SEm (±)	0.396	0.697	1.480	1.536
CV%	22.9	22.2	18.4	31.9
LSD (0.05)	1.176	2.070	4.396	4.562
F Test	NS	NS	NS	NS
Spacing × Mulching				
CV%	22.9	22.2	18.4	31.9
Mean	5.18	9.43	24.18	19
LSD (0.05)	2.0377	3.585	7.615	7.90
F test	NS	NS	NS	NS

Table 5. Effect of mulching on spacing and mulching on stem girth of okra

Treatments	**Stem Girth (cm)**			
	15 DAS	30 DAS	45 DAS	60 DAS
Spacing (cm × cm)				
30×30	0.515	1.273	1.936	2.019
45×30	0.699	1.362	2.216	2.364
60×30	0.455	1.147	2.158	2.336
SEm (±)	0.1092	0.2621	0.2117	0.1493
CV%	34	36	17.4	11.5
LSD (0.05)	0.4288	1.0291	0.8312	0.5862
Mulching				
Silver Plastic	0.646	1.47	2.345	2.497
Panicum repens	0.572	1.199	2.074	2.086
Lantana camara	0.444	1.076	1.833	1.975
Control	0.565	1.298	2.163	2.400
SEm (±)	0.0701	0.0707	0.1068	0.1003
CV%	37.8	16.8	15.2	13.4
LSD (0.05)	0.2083	0.2101	0.3172	0.2981
F test	NS	*	*	*
Spacing × Mulching				
Mean	0.556	1.261	2.103	2.240
CV%	37.8	16.8	15.2	13.4
LSD (0.05)	0.360	0.3638	0.5494	0.5162
F test	NS	NS	NS	NS

*NS=non significant, *=Significant at 5% probability level.*

Table 6. Effect of spacing and mulching on yield of okra

Treatments	**Yield (kg/ha)**
Spacing (cm × cm)	
30×30	7295
45×30	4660
60×30	3703
SEm (±)	1189.7
CV%	39.5
LSD (0.05)	4671.46
F test	NS

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Mulching	
Silver Plastic	8104
Panicum repens	3901
Lantana camara	3701
Control	5161
SEm (±)	715.5
CV%	41.1
LSD (0.05)	2125.99
F test	*
Spacing x Mulching	
Mean	5219
CV,%	41.1
F test	NS

*NS=non significant, *=Significant at 5% probability level.*

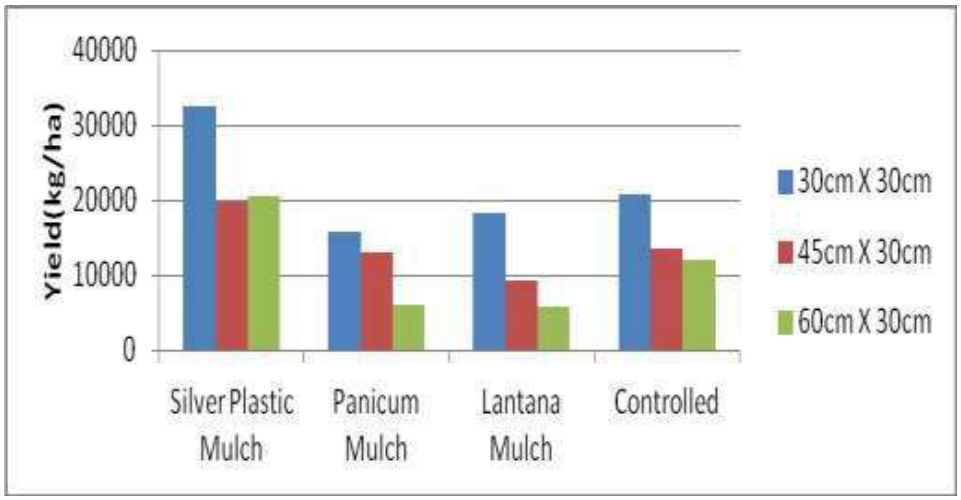

Figure 2. Effect of interactions of spacing and mulching on yield of okra

The effect of spacing on leaf number of okra was non significant at 15, 30, 45 and 60 DAS (Table 4). There was no significant difference on leaf number for spacing but silver plastic mulch and control gave superior results on 30DAS, 45 DAS and 60 DAS (Table 4). There was no any significant difference in interaction of spacing and mulching for leaf number. Initially mulching did not have significant effect on stem girth whereas at 30DAS, 45 DAS and 60 DAS mulching had significant effect. Silver plastic mulch was superior to other mulch at 45 DAS but silver plastic mulch and control gave superior results at 30DAS and 60 DAS as shown in table no 5. Spacing did not have significant effect on stem girth. There was no any significant difference in interaction of spacing and mulching for stem girth. Spacing did not have significant effect on yield of okra but in case of mulching it showed significant effect. Silver plastic mulch gave highest yield (8104kg/ha) followed by control (5161kg/ha), *Panicum repens* (3901kg/ha) and *Lantana camera* (3701kg/ha). There was no any significant difference in interaction of spacing and mulching on yield. However, the closer spacing of 30cm×30cm in combination with silver plastic mulch gave higher yield as comparison to the wider spacing (Figure 2).

DISCUSSION

Organic mulches can suppress annual weeds and offer other important benefits, such as organic matter, nutrients, moisture conservation, soil protection, and moderation of soil temperature. *Lantana camara*, an erect shrub, which grows widely in the tropics, exhibits insecticidal activity against several insects. The use of *Lantana camara* as mulch was beneficial in ginger reported by Thankamani *et al.* (2016). In our experiment mulching materials provided significant effect on okra yield and plant height at 15 DAS but non significant effect on plant height at 30 DAS; this result corroborates with the findings of Bhutia *et al.* (2017). Maximum plant height in chilli was observed at 45 DAT, 90 DAT, 135 DAT in silver polythene mulch (Dattatraya, 2014). Darker plastic mulches had higher yield on okra as compared to bare plot which is in accordance with (Gordon *et al.*, 2010). Similarly, Black plastic mulch gives higher yield as compared to organic mulches and control condition (Bhaduria & Kumar, 2006). Black plastic mulch had higher yield due to better weed control (Awodoyin *et al.*, 2007). Average yield of chilli was observed higherin silver polythene mulch (Dattatraya, 2014), similarly silver plastic mulch have highest yield in potato when compared to red, black or bare ground (Lamont jr, 2012). Tomato grown with silver plastic mulch has less number of whitefly infestation, higher leaf number and yield (Khanal, 2018). Bell pepper gave significantly higher yield under silver plastic mulch than other colored mulch (Hutton & Handley, 2007). Moisture retention, increased temperature, enhanced soil microorganism which ultimately increase availability of nutrients (Vanker & Sinde, 2007). All the growth parameters were significantly increased by silver plastic mulch which was found in agreement i.e. vegetative growth parameters of summer vegetable crops in semi-arid condition were higher in plastic mulch (Mahadeen, 2014). This increment was due to moisture conservation and availability (Albu-Goukh & El-Balla, 2003). Spacing had no significant effect on okra yield an dplant height of okra; similar experiment was conducted at Botswana College of Agriculture under Department of Crop Science and Production which concludes that plant height of okra was no significant till 6 weeks and then after again it was insignificant in 12th week (Madisa *et al.*, 2015). The close spacing of 30 cm did not give rise to taller plant significantly which is in contrast to the experiment conducted in sweet pepper by Maya *et al.* (1997) at cited in Islam *et al.* (2011). There is no significant difference in stem girth of okra during whole crop period which contradicts with the experiment conducted by Islam *et al.* (2011). But our result was similar with the study performed by Madisa *et al.* (2015) for stem girth in okra. No significant difference in result was obtained for leaf number and leaf length of okra under different spacing which deviates from the result obtained by Ijoyah *et al.* (2010) at cited in Maurya *et al.* (2013).

CONCLUSION

Based on the result of this experiment, it would be better to use silver plastic mulch in combination with intra-row spacing of (30×30) cm for optimum growth and yield of okra in Chitwan condition.

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Author Contributions

R.K.J., A.K., S.P. conceived and planned the experiments. R.K.J., A.K., S.P., B.R.D carried out the experiments. R.B.N. was involved in planning and supervised the work. A.K., B.R.D., processed the experimental data. R.K.J. performed the analysis. S.P., B.R.D., contributed to the interpretation of the results. A.K. designed the figures. R.K.J. worked on the manuscript. All authors provided critical feedback and helped shape the research, analysis and manuscript.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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