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Effect of sowing time and mulching type on growth, yield, and quality of *Abelmoschus esculentus* L.

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Abstract
The experiment "Effect of sowing time and type of mulching on the growth, yield and quality of okra" was conducted at Agriculture Research Institute Tarnab, Peshawar during 2016. The experiment was designed in Randomized Complete Block with split plot arrangements, replicated thrice. Sowing dates were assigned to main plots, while mulching materials were kept in sub-plot. The seeds of okra cultivar "Sabz-Pari" were sown at three different dates i.e. 15thApril, 30th April and 15th May. Three different types of mulch materials (Black plastic, Transparent plastic and Alsy straw (Organic mulch) were used and compared with control (no mulch). Higher germination percentage (79.6), more pods plant^{-1} (24.2), seeds pod^{-1} (72), 1000 seed weight (92 g), pod yield plot^{-1} (10.2 kg) and yield tones ha^{-1} (11.3) were recorded in plants sown on 30th April. Maximum plant height (143.7 cm) was observed in plants sown on 15th April while the 15th May plantation showed early emergence (6.1 days) of seedlings, early flowering (42.3 days) and maximum leaves plant^{-1} (32). In response to mulching, early emergence of seedlings (5 days), maximum plant height (138.9 cm), leaves plant^{-1} (39.3), number of pods plant^{-1} (25.3), yield plot^{-1} (10.8 kg) and yield tones ha^{-1} (12) were recorded in plants mulched with Transparent plastic. Higher germination percentage (87.96), seeds pod^{-1} (68.3), 1000 seeds weight (88.3 g) and early flowering (44.4 days) were recorded in plants mulched with Black plastic. It can be concluded that when the seeds of okra were sown on 30th April and mulched with Transparent plastic, it gave good response regarding growth, yield and quality.

Keywords: *Abelmoschus esculentus* L. moench, mulching, sowing dates

1. Introduction

Okra *(Abelmoschus esculentus* L. Moench*)* belongs to the Malvaceae family. It is among the oldest cultivated crops of the world. Its origin is believed to be from the Indian sub-continent [1] and Africa [2]. Its special taste and nutritional value has attracted more attention of the people of the tropical and subtropical areas of the world [3]. It is a nutritious vegetable and plays an important role in meeting the demand for vegetables in Pakistan.

Okra is one amongst the most economically important vegetables, which is grown in tropical and subtropical regions of the world [4, 5]. It is appropriate to grow this plant in a garden for home consumption and commercially on large farms [6].

People use it in different ways, such as its immature fruits (pods) are usually used as fresh vegetable, as stews, and in thicken soups [7]. It is also sliced, dried and stored for use in the off-season. It is a good source of calcium derived from fruits and leaves (90 and 70 mg/100g) respectively, while its secondary use is the oil from its seeds. The oil content is about 20% in okra seeds [8]. Its green pods are rich source of calcium, vitamins, potassium and other minerals [9].

Seeds can only geminate in relatively warm soils with minimum temperature of 16°C. Average monthly temperature range of 21 to 30°C is said to be appropriate for growth, flowering and pod development [10, 11].

In Pakistan okra is cultivated on an area of 14855 hectares with a total production of 112983 tons, while in Khyber Pakhtunkhwa it is cultivated on an area of 1957 hectares and its total production is 15630 tons annually [12].

For obtaining optimum yield, it is very important to determine optimum sowing date. Both quantitative and qualitative traits of different crops depend on sowing time in the proper growing season [13]. It is reported that okra plants sown in March showed significant difference in height and leaf number as compared to May sowings [14]. It is also foundthat plants sown in July had higher pod and seed yield compared to late August and October sowings [15] [16].

Changing the planting date of okra is one of the main reasons for the difference in seedling emergence, survival, and vigor [17]. It is reported that pod yield of okra was reduced due to late planting date [9]. Sowing time also has great impact on seed production and quality of okra [8] [18] [19] [20].

In addition to sowing time, mulching is an effective technique by which the plant growth environment can be changed. It helps in controlling weed growth, modify soil temperature, conserve soil moisture content, improve structure of the soil, increase organic matter, and reduce soil erosion [21, 22, 23]. For many centuries, natural mulches like leaves, straw, and compost etc. have been used. During the last seven decades, the trend changed the use of synthetic mulch. The synthetic mulch like plastic materials prevents direct evaporation from the soil surface and thus conserves soil moisture. This also prevents the rise of salt in the water which is very important in saline soils areas. The plastic mulch has many benefits, such as it increases soil temperature, eradicate weeds to certain level, and conserve soil moisture, which ultimately increase crop yield and efficiently use soil nutrients. Due to these benefits its usage is increasing worldwide [24, 25, 26, 27, 28, 29, 30].

However, there is very little research information available on response of okra to different mulch materials in Pakistan. Therefore, the present research was designed to find out the

best sowing time and the effects of different mulching types on growth, yield and quality of okra under the agro-climatic conditions of Peshawar Valley.

2. Materials and methods

The experiment was conducted at Agriculture Research Institute Tarnab, Peshawar, during 2016. Randomized complete block (RCB) design was used with split plot arrangements, replicated thrice. There were two factors in the experiment viz. sowing dates and mulching types. Three sowing dates (SD) with 15 days intervals i.e. SD1 = 15th April, SD2 = 30th April, and SD3 = 15th May were assigned to main plots, and four different types of mulching i.e. M0 = Control, M1 = Black plastic, M2 = Transparent plastic and M3 = Alsy Straw were assigned to sub-plots. There were 12 treatments of different sowing dates and mulching type's combinations and each treatment was replicated three times. Each plot was 3×3 meter, having row to row distance 60 cm and plant to plant distance was kept 20 cm. Okra cultivar 'SabzPari' seeds provided by the Oilseed department of Agriculture Research Institute Tarnab, Peshawar, were used in the current study.

Before sowing, the field was prepared thoroughly. The basal fertilizer dose NPK (nitrogen, phosphorus, and potash) at the rate 90–60–30 kg ha^{-1} [31] were applied, in the form of urea, DAP and potassium sulphate. Seeds (2 seeds per pit) were sown on ridges at different dates and mulching materials were applied according to the experimental design. When the seedlings were 6 cm tall, the thinning was done to maintain the required plants population. All the recommended cultural practices were practiced uniformly in all the treatments.

The data were recorded on days to emergence, seed germination percentage, days to 1st flower, number of pods plant^{1}, pod length (cm), pod diameter (cm), pod weight (gm), plant height (cm), number of leaves plant^{-1}, number of seeds pod^{-1}, 1000 seed weight (g), yield plot^{-1} (kg) and pod yield (tons ha^{-1}).

Data were statistically analyzed using analysis of variance technique, Least Significant Difference (LSD) test was used to compare the treatment means at 5% level of significance.

3. Results and discussion

Mean values of the recorded data of various parameters are presented in tables 1-4. The data analysis shows that the sowing dates and mulching has significant effect on growth and yield parameters, while their interaction was observed non-significant.

4. Days to emergence, Seed germination percentage and Days to flowering

The data in table-1 show that Days to emergence, Seed germination percentage, and Days to flowering were significantly affected by both sowing time and mulching type. The seeds sown on 15th May took the least days (6.1) to emergence and showed early flowering (42.3 days), while the 30th April sowings showed the highest percentage of germination (79.6 %) as compared to other sowing times.

The variation in the parameters might be due to the different soil and environmental conditions of the different months. The soil and air temperature, rainfall as well as humidity are different at the different sowing times, which might have affected the germination of seeds as well as days to flowering. El-Waraky [32] also observed that the late sowing of okra increased the emergence of the seedlings as compared to early sowing. Similarly, Amjid *et al.* [33] also found that okra seeds sown at different times had different germination percentage. Several other studies also showed that sowing date significantly affected crop growth and flowering, which was mainly attributed to influences of temperature [34, 35].

The seeds mulched with Transparent plastic emerged early (5 days after sowing), while the black plastic mulched seeds showed the highest germination percentage (88 %) and early flowering (44 days) as compared to the other types of mulching and control(bare soil). Furthermore, less number of days to flowing was observed in response to late sowing and mulching.

The soil surface with plastic mulch had more noticeable effects on the emergence of seedlings. The difference in emergence time in response to different mulching materials might be due to their capacity of increasing soil temperature and conserve soil moisture, which affect the seedlings emergence. These results are in line with Mamkagh *et al.* [26] who observed that seeds planted in soil with mulching took less time to emergence as compared to seeds sown in bare land. Atif [36] also observed that 50% okra plants mulched with black plastic reached flowering about 4-6 days earlier. Similarly, Lamont *et al.* [37] also documented that plastic culture caused early and high percentage of germination.

Table 1: Effect of different sowing dates and mulching on growth, yield and quality of okra

Treatments	Days to Emergence	Seed Germination Percentage	Days to Flowering
Sowing Dates			
S1=15 April	8.8 a	73.3 b	50.7 a
S2=30 April	6.6 b	79.6 a	45 b
S3= 15 May	6.1 b	71.1 b	42.3 b
LSD at 5%	1.55	3.98	5.6
Mulching			
M0=control	8.7 a	63.3 c	49.6 a
M1=Black plastic	6.7 b	88 a	44.4 b
M2=Transparent	5 c	80.4 b	44.6 b
M3=Alsy straw	8.2 a	67 c	45.3 b
LSD at 5%	0.74	4.1	1.42

5. Number of Pods plant^{-1}, leaves plant^{-1} and plant height

The maximum number of pods plant^{-1} (24.2) were observed in the plants sown on 30th April, while maximum plant height (143.7 cm) was recorded in 15th April seeds sowing (Table-2).

The variation might be due to the different climatic conditions at different times of the year. The results are in line with Incalcaterra *et al.* [38], who observed different number of pods plant^{-1} at different seed sowing dates. Similarly, Naz *et al.* [39] recorded the highest plant height in plants sown on 19th April as compared to those sown on 4th May.

On the other hand, the plants mulched with Transparent plastic gave better results having higher number of pods plant^{-1} (25.3), leaves plant^{-1} (39.3) and the tallest plant (138.9 cm).

These differences regarding mulch materials might be due to the more moisture retention and better soil temperature by plastic mulch, which enhance vegetative and reproductive growth of the plants. The results agree with that of Dalorima *et al.* [40] who concluded that plastic mulch results better

growth performance compared to other mulching materials. Aminu-Taiwo *et al.* [41] also observed that number of leaves and leaf area were significantly influenced by mulching. Similarly, Mamkagh *et al.* [26] found that the height of okra plants after 45 days of planting was higher when they were covered with plastic mulch as compared to other treatments.

Table 2: Effect of different sowing dates and mulching on growth, yield and quality of okra

Treatments	Pods Per Plant	Leaves per plant	Plant height
Sowing Dates			
S1=15 April	21.4 b	31.5 a	143.7 a
S2=30 April	24.2 a	30.5 a	125.5 b
S3= 15 May	20.8 b	32 a	106.1 c
LSD at 5%	2.16	NS	17.53
Mulching			
M0=control	20 c	23.7 c	116 b
M1=Black plastic	22.9 b	29.8bc	123.3 b
M2=Transparent Plastic	25.3 a	39.3 a	138.9 a
M3=Alsy straw	20.3 c	32.6 b	122.2 b
LSD at 5%	1.86	6.18	10.79

6. Number of seeds pod^{-1}, 1000 seed weight, yield plot^{-1} and yield ha^{-1}

The data presented in table-3 showed that the 30th April sowings gave better results having more number of seeds pod^{-1}(72), 1000 seed weight (92 g), more yield plot^{-1} (10.2 kg) and more yield tons ha^{-1} (11.3).

These results might be due to the variation in the prevailing soil and environmental conditions like temperature, relative humidity and soil moisture content etc. during the growing period of okra. These results correlate to the findings of Kortse *et al.* [42] who observed more number of seeds per pod in plants sown in June as compared to July sowings. Shahid *et al.* [43] found that okra plants sown on 30th March had higher 1000 seed weight as compared to those sown on 15th March. Dilburba *et al.* [44] reported that okra respond differently to various sowing times and observed higher pod yield when sown on 1st April as compared to 15th April. Differences in yield in response to different sowing times were also found by many other workers [45, 46].

The table-3 showed that the plants mulched with black plastic had more seed pod^{-1} (68.3) and 1000 seed weight (88.3 g) while the highest yield plot^{-1} (10.8 kg) and yield ha^{-1} (12 tons) were observed in plants mulched with transparent plastic.

The differences in the parameters might be due to the fact that mulch materials decrease evaporation from soil surface hence more water is retained and is available to the plants due to which they grow better as compared to non-mulched plants. The mulching also suppresses weeds growth, which compete with the crop plants. The results agree with Hamma *et al.* [47] who observed significantly increased number of seeds per pod in mulched plants as compared to plants without mulching. Mamkagh *et al.* [26] also found an increase in fruit yield ha^{-1} when mulched with plastic. Similarly, Nagalakshmi *et al.* [48] observed maximum number of fruits per plant, length of fresh fruit, circumference of fruit and yield of chili with the application of plastic mulch compared to organic mulch and no mulch.

Table 3: Effect of different sowing dates and mulching on growth, yield and quality of okra

Treatments	Seeds per pod	1000 seed weight	Yield per plot	Yield per ha
Sowing Dates				
S1=15 April	54.1 b	74.1 b	7.9 b	8.7 b
S2=30 April	72 a	92 a	10.2 a	11.3 a
S3= 15 May	59.4 b	79.4 b	7.3 b	8.2 b
LSD at 5%	5.99	5.99	1.27	1.41
Mulching				
M0=Control	56.2 b	76.2 b	7 c	7.8 c
M1=Black plastic	68.3 a	88.3 a	8.9 b	9.9 b
M2=Transparent Plastic	58.9 b	78.9 b	10.8 a	12 a
M3=Alsy straw	63.9 ab	83.9 ab	7.1 c	7.9 c
LSD at 5%	7.99	7.99	1.61	1.8

7. Pod length and pod diameter

The data in the table-4 presented that the parameters of pod length and pod diameter were non-significantly affected by either different sowing dates or mulching material. This might be due to the fact that all the pods were harvested at the stage of edible maturityhaving the same length, diameter and weight.

Table 4: Effect of different sowing dates and mulching on growth, yield and quality of okra

Treatments	Pod length	Pod diameter
Sowing Dates		
S1=15 April	12.5	1.3
S2=30 April	12.2	1.4
S3= 15 May	10.8	1.4
LSD at 5%	NS	NS
Mulching		
M0=Control	12.7	1.3
M1=Black plastic	11.1	1.4
M2=Transparent Plastic	11.8	1.4
M3=Alsy straw	11.2	1.4
LSD at 5%	NS	NS

8. Conclusion

It is concluded based on above results that okra cultivar 'SabzPari' may be sown on 30th April at Peshawar Valley, while transparent plastic may be used for better growth, yield and quality of okra.

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