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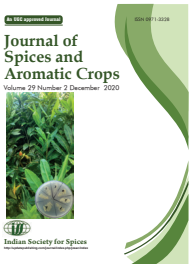

Impact of paddy straw mulch on germination and growth of celery (*Apium graveolens* L.) seedlings and associated weeds in nursery

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Abstract

A study was undertaken during three consecutive *rabi* seasons of 2014–15 to 2016–17 at the Research Farm, Department of Agronomy, Punjab Agricultural University, Ludhiana (Punjab) to determine the effect of paddy straw mulch load and retention time on the germination and growth of celery and associated weeds. The experiment was conducted in randomized complete block design (RCBD) with nine treatments *viz*., paddy straw mulch @ 4 and 6 t ha^{-1} with retention time of 15, 20, 25 days after sowing (DAS), full time retention (60 DAS), and control (without mulch). The results indicated that application of paddy straw mulch @ 4 or 6 t ha^{-1} significantly improved the germination of celery in nursery as compared to no mulch treatment but retention of paddy straw mulch beyond 20 days after sowing suppressed the celery seedlings adversely resulting in lowering seedling population as well as fresh and dry weight of celery seedlings. Application of paddy straw mulch @ 4 or 6 t ha^{-1} resulted in significantly lower density and dry weight of weeds as compared to control. Further, each successive increase in retention time of paddy straw mulch from 15 DAS to full time retention (60 DAS) through 20 and 25 DAS significantly reduced the weed population in celery nursery.

Keywords: Apiaceae, mulch retention time, oleoresin, seed spice, weed management

Celery (*Apium graveolens* L.) belonging to the family Apiaceae is an important foreign exchange earning spice of India. India is a major producer and exporter of celery seeds and its products in the world. In India, it was grown on an area of 4010 hectares with production of 5510 tonnes during 2017–18. Celery was first introduced in India around 1940 from France in Amritsar District of Punjab. Nowadays, it is cultivated as a commercial crop in Punjab contributing more than 90% of the total celery production in India (Anonymous 2020). In Punjab, it is mainly grown in the districts of Amritsar and Tarn Taran, and some areas of Gurdaspur and Patiala. Celery is grown mainly for its seeds which contain about 2 per cent essential oil and 17–18% fatty oil, which are used in medicines. It is also grown for vegetable, seed oil and oleoresin.

Celery is grown during winter (*rabi*) season as an annual crop in Punjab. It is mainly raised by nursery sowing followed by transplanting due to many advantages such as lesser seed requirement, uniform plant stand in definite geometry as well as ensuring crop establishment even after the late harvest of *kharif* crops. In Punjab, its nursery is sown during mid September to mid October and then transplanted in the field during mid November to December end. The crop gets ready for harvesting during early May. At the time of nursery raising, celery encounters germination problem due to existence of thermo dormancy in celery seeds (Desai *et al*. 1997) and germination is also hampered at temperatures higher than 25°C (Malhotra 2012). The germination of celery seeds is slow even under favourable conditions due to hard seed coat, miniature size and less food reserves, and it takes about 15 days for initiation of germination. The mean temperature during the month of September in Punjab remains comparatively high, in the range of about 25–30°C resulting in slow and less germination leading to poor nursery stand. However, temperature becomes favourable for celery germination during the month of October, particularly during second fortnight. Although delayed sowing during mid or October end results in good seed germination and nursery stand of celery but it results in delayed transplanting and consequently reduces the seed yield. To enhance seed germination during September, soil has to be kept moist to keep soil temperature relatively low. One method to keep the soil moist and soil temperature low is through frequent irrigations. Nevertheless, frequent irrigations, delayed germination of celery and congenial environment for the growth of weeds results in the occurrence of complex weed flora and ultimately poor vigour of celery transplants. Alternatively, application of paddy straw mulch is known to moderate soil temperature, conserve soil moisture and suppress weeds (Pramanik *et al*. 2015). However, the impact of paddy straw mulch on germination and growth of celery seedlings and associated weeds is not studied yet. Keeping these points in view, the present study was carried out to determine the effect of paddy straw mulch load and retention time on germination and growth of celery in the nursery and associated weeds.

The experiment was conducted during three consecutive winter (*rabi*) seasons of 2014–15, 2015–16 and 2016–17 at the Research Farm, Department of Agronomy, Punjab Agricultural University, Ludhiana, Punjab. The experimental site was located at 30° 54′ N latitude and 75° 48′ E longitude at an elevation of 247 metres above mean sea level falling in the central plain zone of Punjab. The climate of the area is semi-arid perceiving average annual rainfall of 759 mm of which 75–80% is received during the south-west monsoon period from July to September. During the month of September, the minimum temperature was 23.5, 20.0 and 24.6°C, whereas, the maximum temperature observed was 34.1, 32.8 and 34.3°C during 2014, 2015 and 2016, respectively. However, during the month of October, the minimum temperature recorded was 16.1, 14.9 and 15.2°C, whereas, the maximum temperature observed was 32.5, 33.5 and 33.5°C during 2014, 2015 and 2016, respectively (as per the data available from the Meteorological Observatory of PAU, Ludhiana). The experimental field soil was loamy sand in texture, low in organic carbon (0.36%) and available nitrogen (207.4 kg ha^{-1}), medium in available phosphorus (16.2 kg ha^{-1}) and potassium (194.1 kg ha^{-1}) with neutral soil reaction (pH 7.6). The experiment was conducted in a randomized complete block design (RCBD) with nine treatments; paddy straw mulch @ 4 t ha^{-1} with retention time of 15, 20, 25 days after sowing (DAS), full time retention (60 DAS), paddy straw mulch @ 6 t ha^{-1} with retention time of 15, 20, 25 days after sowing (DAS), full time retention (60 DAS) and control (without mulch) replicated four times.

For sowing seeds, beds of 1.25 m width and 4.0 m length were prepared to realize each bed of 5 m^2 per treatment. A shallow channel was provided around the beds to facilitate the irrigation. Beds were prepared in open field having no hindrance to sunlight. Urea @ 4 g m^{-2} and single super phosphate (SSP) @ 7.5 g m^{-2} were applied to beds. Seeds of celery variety, Punjab Celery 1 @ 5 g m^{-2} were sown on beds between 15-20

September during 2014, 2015 and 2016. Seeds were covered with a mixture of FYM and soil. After sowing, water was applied to beds with sprinkler without disturbing the upper layer of seed bed. Then paddy straw mulch was applied to beds as per the treatment. Urea @ 5.5 g m^{-2} was applied to nursery beds one month after sowing of seeds. Light and need based irrigations were applied to the nursery. All other recommended cultural practices were followed throughout the growing season. The observations on daily emergence count, from initiation till the plant population became constant were recorded with the help of a 25 × 25 cm quadrate from two fixed spots per plot to find out the days taken for initiation and completion of celery emergence. Plant population as well as fresh and dry weight of celery seedlings were recorded with the help of same quadrate from two randomly selected spots per plot at 30 and 60 days after sowing. The fresh weight of celery seedlings was recorded in the field immediately after sampling and thereafter, the same samples were first sun dried and then in oven at 60°C till the attainment of constant weight for observing dry weight. Fresh and dry weight of celery seedlings were expressed as g m^{-2}. Similarly, population and dry weight of weeds were also recorded with the help of quadrate from two randomly selected spots per plot at 60 days after sowing. Dry weight was calculated in a similar way as that of celery seedlings. Weed number and dry weight were expressed as number m^{-2} and g m^{-2}, respectively. Statistical analysis of all the recorded data were done as per randomized block design (Gomez & Gomez 1984) and treatment means were compared at 5% level of significance.

A perusal of data presented in Table 1 indicate that initiation of emergence was significantly advanced due to the application of paddy straw mulch over control (no mulch) and the effect was irrespective of load and retention time of paddy straw mulch. The same trend of improvement was observed in completion of germination at both the rice straw mulch loads of 4 and 6 t ha^{-1} during all the three years of experimentation. It is evident that in mulched plots, initiation and completion of emergence were early by 3.1 to 5.0 days and 5.0 to 7.0 days, respectively over control. The speedy emergence under mulch treatments may be ascribed to the role of mulch application in moderation of soil temperature, which might have favorably influenced the physiological process of seed germination. Lamia *et al.* (2014) also reported significant earliness of emergence in *Moringa oleifera* under shade as compared to no shade.

Application of paddy straw mulch @ 4 or 6 t ha^{-1} with retention time up to 15 as well as 20 days after sowing (DAS) resulted in significant enhancement in population of celery seedlings in nursery both at 30 and 60 DAS compared to control (Table 1). Data further brings out that irrespective of paddy straw mulch load of 4 or 6 t ha^{-1}, retention of mulch beyond 20 DAS i.e. up to 25 DAS as well as full time retention (60 DAS) caused significant drop in plant population of celery seedlings. Further, full time retention of mulch till 60 DAS recorded plant population significantly lower even than control (without mulch) plots at both the observational stages of 30 and 60 DAS. However, plant population in plots with retention of mulch up to 25 DAS was statistically at par with control at 30 DAS but significantly lesser than control at 60 DAS (Table 1) clearly indicating suppression of celery seedlings with prolonged time of paddy straw retention beyond 20 DAS. The trend was same during all the three years of investigation. It is documented that light is essential for vital physiological process i.e. photosynthesis. The retention of paddy straw mulch after 25 DAS caused mortality of seedlings on account of absence of light. Lamia *et al.* (2014) also reported less growth of *Moringa oleifera* plants under high shade as compared to medium and no shade.

Irrespective of the paddy straw mulch load of 4 and 6 t ha^{-1}, celery seedlings in the nursery gained significantly more fresh as well as dry weight with the retention of paddy straw mulch up to 15 and 20 days after sowing (DAS) than all other treatments during all the three years of study (pooled data of three years presented) (Table 1). Further, retention time of paddy straw mulch up to 25 DAS recorded fresh and

Table 1. Effect of paddy straw mulch load and retention time on growth of celery and associated weeds (Pooled data of three years)

Treatment (mulch load and retention time)	No. of days taken for		Population of celery seedlings (No.m^{-2})		Fresh weight of seedlings (gm^{-2}) at 60 DAS	Dry weight of seedlings (gm^{-2}) at 60 DAS	Weed density (No.m^{-2}) at 60 DAS	Dry weight of weeds (gm^{-2}) at 60 DAS
	Initiation of emergence	Completion of emergence	30 DAS	60 DAS				
T_1 4 t ha^{-1} up to 15 DAS	12.2	15.8	544.5	533.3	258.8	41.5	48.8	48.1
T_2 4 t ha^{-1} up to 20 DAS	12.1	15.6	547.2	531.0	263.1	42.2	33.3	33.2
T_3 4 t ha^{-1} up to 25 DAS	12.2	15.7	403.0	365.1	199.8	31.9	16.4	18.7
T_4 4 t ha^{-1} FT (60 DAS)	12.2	15.8	378.3	310.2	176.0	28.0	6.3	7.9
T_5 6 t ha^{-1} up to 15 DAS	11.2	14.6	559.9	547.7	267.7	42.3	43.3	43.4
T_6 6 t ha^{-1} up to 20 DAS	11.2	14.5	568.0	555.5	274.3	43.6	28.3	27.5
T_7 6 t ha^{-1} up to 25 DAS	11.1	14.4	388.1	340.5	188.4	30.4	14.7	15.3
T_8 6 t ha^{-1} FT (60 DAS)	11.1	14.3	355.2	263.3	157.7	26.0	5.4	6.6
T_9 Control (no mulch)	15.7	21.1	431.5	423.3	209.9	33.5	93.1	99.3
LSD (P=0.05)	1.5	2.1	48.2	51.4	26.1	4.0	7.8	7.5

DAS=Days after sowing; FT=Full time retention

dry weight of celery seedlings statistically at par with control (without mulch), however, full time retention (60 DAS) of paddy straw mulch recorded the least fresh weight as well as dry weight of celery seedlings which was significantly lower even than that of control, thus indicating the adverse effect of long time mulch retention on plant population and vigour of seedlings thereby reducing the fresh and dry weight accumulation by celery seedlings. Enhanced retention time of paddy straw mulch might have reduced the photosynthesis thereby reducing the photosynthates accumulation in the seedlings. Kumar *et al.* (2017) also observed beneficial effect of paddy straw mulch on growth of turmeric. Cui *et al.* (2013) and Lamia *et al.* (2014) also reported lesser accumulation of photosynthates with the interruption of sunlight.

Data presented in Table 1 indicate that application of paddy straw mulch @ 4 or 6 t ha^{-1} resulted in significantly lower density and dry matter accumulation by weeds as compared to control. Although the differences in weed density and dry matter accumulation due to paddy straw mulch load were inconspicuous during all the three years of investigation, but retention time of mulch had significant effect on weed growth. Data in Table 1 further reveal that irrespective of mulch quantity (4 or 6 t ha^{-1}), each successive increase in retention time from 15 DAS to full time retention (60 DAS) through retention up to 20 and 25 DAS caused significant reduction in weed density and dry matter accumulation by weeds during all the three years of study (Table 1). Brar & Walia (2010) also observed reduction in weed population with the application of paddy straw mulch as compared to no mulch in wheat.

It can be concluded that application of paddy straw mulch @ 4 to 6 t ha^{-1} with retention time from 15 to 20 days after sowing, can result in production of vigorous celery transplants due to favorable effect of mulch on hydro thermal regime of soil and lowering weed growth.

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