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RESEARCH PAPER

Influence of temporal variation in sowing and organic mulch application on sweet corn (*Zea mays* L. var. *saccharata*) in spring season in sub-tropical North India

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Abstract: Field experiment was conducted at G.B.P.U.A. & T., Pantnagar during spring season 2017 to study the effect of different sowing dates and time of application of rice straw mulch on yield and economics of sweet corn (*Zea mays* L. var. saccharata). The experiment consisted of 12 treatments; having 4 sowing dates (8th, 18th, 28th February and 10th March) and 3 levels of mulch application (no mulch, mulch application after 2nd and 3rd irrigation) was conducted in SPD. Sowing dates were accommodated in main plots and mulch treatments in sub plots. Crop sown on the earliest date being at par with next date resulted in significantly more growth, dehusked cob yield (11427 kg/ha), net return (Rs. 110361 /ha) and B:C (1.80) than other sowing dates. Application of rice straw mulch after 2nd and 3rd irrigation being at par with other resulted into better growth and produced significantly more dehusked cob yield (11128 kg/ha) and production efficiency than no mulch. Mulch application after 2nd and 3rd irrigation were at par for net return and B:C and were significantly superior to no mulch.

Keywords: Cobs • Mulch • Sowing time • Sweet corn

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Introduction

Sweet corn (*Zea mays* L. var. saccharata) in spring season in north western plain of India is a profitable crop and fits well in the cropping system after harvest of vegetable pea, potato, ratoon sugarcane etc. The productivity of crop is primarily governed by environmental conditions and management factors. Time of sowing is one of the major concerns and it becomes more important in spring season. Temperature play significant role in growth and development and thus yield is significantly affected by sowing time (Cao *et al.*, 2024). Too early sowing in spring may affect emergence and initial vegetative growth due to low temperature. On the other hand, under late sowing reproductive phase faces high temperature which affect pollen viability and grain filling. Therefore, it is necessary to emphasize on sowing dates for securing a good economic harvest and for best utilization of growth factors such as moisture, nutrients and solar radiation.

Spring maize at reproductive stage encounters major two problems i.e. high temperature and high ET. High temperature affects the reproductive phase of maize crop and influences the capacity of grain filling and duration of crop (Lohani *et al*., 2020). High evapo-transpiration owing to high temperature during spring season enforces high irrigation frequency. It leads to high cost of cultivation and heavy pressure on irrigation resources. It is necessary to minimize the adverse effect of temperature on crop growth and ET. One of the solutions to this problem is use of mulches which influence crop growth by maintaining favourable moisture regime in soil and regulate soil temperature by covering soil surface. Organic mulches have been proved very effective in regulating soil temperature,

increasing soil moisture content and improving soil physical properties (Lin *et al*., 2016). Rice straw which is either burned or wasted can be effectively used as mulch. In north western plains of India, atmospheric temperature and evaporation remain low during start of spring season (February) and thereafter increases rapidly from March onwards. So, application of mulch at the start of season has only little advantages. Mulch application at the time of sowing of the crop has certain limitations, like hindrance in the top dressing of urea, as entire land surface is covered by mulch. Also, it does not remain intact during the entire life period of the crop, as decaying starts during later phase when evaporation is very high. Application of mulch at later stages of crop growth may overcome these problems as by that time splitting of nitrogen would be completed and the plants are large enough to restrict the movement of mulch with irrigation water. It is necessary to examine the usefulness of application of mulch at later stages of crop growth after 2nd and 3rd irrigation**.** Therefore, experiment was conducted to find out the impact of different sowing dates and differed mulch application on growth, productivity and economics of sweet corn in spring season.

Materials and methods

The field experiment was conducted at Govind Ballabh Pant University of Agriculture & Technology, Pantnagar, Uttarakhand during spring season, 2017. During the experiment, the maximum temperature ranged from 21.0°C (12th March) to 41°C (16th May) with average 32.9°C whereas the minimum temperature varied from 4.9°C (10th February) to 26.9°C (22nd May) with average 16.8°C. The mean maximum relative humidity was 74 per cent with fluctuation of 45 to 96 per cent. A range of 11.0 to 82.0 per cent was recorded for minimum relative humidity with average 36 per cent. The mean sun shine duration was 8.4 hours which ranged from 0.9 to 11.7 hours per day. During the crop growing period, a total 40.6 mm rainfall was received in 5 rainy days and total evaporation was 634.2 mm. The soil of experiment field was silty clay loam in texture, neutral in reaction (pH 6.9), medium in organic carbon (0.65%), low in available N (269 kg/ha), medium in available P (19.1 kg/ha) and medium in available K (245.3 kg/ha). The experiment was conducted in split plot design having 4 dates of sowing at 10 days interval (8th February, 18th February, 28th February and 10th March) in main plot and application of rice straw mulch (no mulch, after 2nd irrigation and after 3rd irrigation) was in sub plot with three replications. Between two rows of maize rice straw mulch was applied @ 5 t/ha. Rice straw mulch was applied after 2nd irrigation and this treatment was executed 36, 35, 34 and 31days after sowing (DAS) in first, second, third and fourth date of sowing, respectively. Another mulch treatment was imposed after 3rd irrigation and was started 54, 53, 52 and 44 DAS in first, second, third and fourth date of sowing, respectively. The field was prepared by three harrowing with tractor mounted disc harrow. Thereafter, the field was levelled with leveller. Sweet corn variety 'Sugar-75' was sown at 60 cm × 25 cm. Fertilizers were applied through NPK mixture (12:32:16), urea and muriate of potash. The 25 per cent of nitrogen and full dose of phosphorous and potassium was applied as basal. Remaining nitrogen was applied in 3 equal splits at 4-5 leaf- stage, knee height stage and at initiation of tasseling. Weeds were managed manually. One hoeing was done in different treatment before mulch application at different date. During the crop growing period 6, 6, 5 and 5 number of irrigations were applied in first, second, third and fourth date of sowing, respectively and the irrigation depth was 5 cm. One spray of chlorantraniliprole @ 0.3 ml/litre water was made to save the crop from infestation of insects. Plant height was measured at cob harvesting stage. At milk stage, the green cobs from the plants were harvested manually and the plants were cut close to the ground with the help of sickle. Dehusked cob yield was obtained after removing husk. Harvesting dates were 17th May, 20th May, 26th May and 3rd June, respectively. Production efficiency was calculated by dividing dehusked cob yield by duration of crop in respective treatment. Gross returns (Rs./ha) were worked out on the basis of market selling price of dehusked cobs @ Rs. 15/kg. The data obtained from various observations were statistically analysed at 5% level of significance as per procedure of split plot design by using the standard techniques of Analysis of Variance (Gomez and Gomez, 1984).

Results and discussion

Growth parameter

Data presented in Table 1 indicated that both sowing dates and mulch application did not influence plant population

and number of cobs/ha significantly. In present study the crop geometry (60 cm × 25 cm) in all treatments was same so plant population remained at par. Since number of cobs per unit area depends on plant population, non-significant variation in plant population led to at par difference in number of cobs. Shrestha *et al.* (2016) also reported at par differences in number of cobs due to different sowing dates.

Crop sown on the earliest date (8th February) attained significantly higher plant height (135.6 cm) than rest of the dates but it remained at par with that of 18th February. Moreover, plant height in 18th February sowing was also significantly superior to that of 28th February and 10th March. Significantly lowest plant height (123.0 cm) was noted in the last sowing date. Crop sown on first and second sowing dates continued their higher growth rate and acquired more plant height. Temperature is to be known to influence plant growth. Maize growth is greatly affected by temperature. In this study average maximum temperature between 60 DAS to 50% tasseling stage was 36.4, 37.2, 37.6 and 37.9°C and average minimum temperature was 20.4, 21.4, 20.7 and 23.8°C in I, II, III and IV sowing dates, respectively. Less plant height under delayed sowing dates was due to high temperature. These results corroborate the findings of Amajadin *et al.* (2015) who reported reduction in plant height due to high temperature. Mulch application after 2nd irrigation resulted into significantly higher plant height (133.1 cm) than without mulch treatment but it remained at par with another mulch application. Significant effect of mulch on plant height may be attributed to better soil moisture and soil temperature regimes due to covering of soil surface by rice straw during the period of high temperature and high evaporation. Rice straw mulch reduced evaporation from soil and maintained lower soil temperature as compared to non-mulched plots. The beneficial effect of mulch on maize due to soil moisture conservation has also been reported by several researchers (Xiangxiang, *et al.*, 2022)

Yield attributes

The results showed that cob length and cob girth decreased significantly with delay in sowing (Table 1). Early sowing on 8th February and 18th February being at par each other recorded significantly higher cob length (19.0 cm) and cob girth (16.2 cm) than other dates. The minimum cob length and girth were recorded in last sowing date. Owing to favourable temperature regime vegetative growth was better in early sowing as evident from plant height and it helped in making proper reproductive development. Therefore, longer and broader cobs were obtained in early sowing. The average daily temperature between 60 DAS to 50% tasseling in first, second, third and fourth sowing was 28.4, 29.3, 29.2 and 30.9°C, respectively. High average daily temperature in late sowing might depressed cob length and girth (Cao *et al.*, 2024). Heat stress reduces the viability and amount of pollens (Lizaso *et al*., 2018).

Table 1. Effect of sowing dates and rice straw mulch application on growth and cob characteristics of sweet corn in spring season

Treatment	Plant population/ha	No. of cobs/ha	Plant height (cm)	Cob length (cm)	Cob girth (cm)	No. of grain rows/cob	No. of grains/row	No. of grains/cob
Sowing date								
8th February	63413	61067	135.6	19.0	16.2	14.3	36.6	526
18th February	64735	60847	134.7	18.7	16.3	14.4	36.0	518
28th February	62090	60185	128.9	17.6	15.8	14.1	35.6	501
10th March	63756	60672	123.0	17.2	15.6	14.1	35.1	496
SEm±	727	1378	1.1	0.4	0.1	0.1	0.6	13
CD (p = 0.05)	NS	NS	3.7	1.2	0.2	NS	NS	NS
Mulch (rice straw @ 5 t/ha)								
No mulch	63761	60603	126.7	17.7	15.5	14.2	35.4	501
After 2nd irrigation	62449	60638	133.1	18.5	16.2	14.3	36.1	519
After 3rd irrigation	64285	60838	131.9	18.2	16.1	14.2	36.0	512
SEm±	1129	1071	1.1	0.2	0.1	0.1	0.4	6
CD (p = 0.05)	NS	NS	3.3	0.6	0.4	NS	NS	NS

Mulch application after 2nd irrigation being at par with another mulch treatment resulted into significantly higher cob length (18.5 cm) and cob girth (16.2 cm) than no mulch treatment. Inferiority of cob length in no mulch treatment might be due to poor growth. Further, mulching helped in keeping soil temperature relatively lower and had low evaporation during hot months (April to May) which favoured growth of plants (Agber *et al.*, 2017).

Data revealed that different sowing dates and mulch treatments failed to produce significant effect on number of grain rows/cob, number of grains/ row and number of grains/cobs. However, numerically the maximum number of these attributes were noticed in early sowing and in mulch treatment. Number of rows is strongly related to the genetic trait and it only affected by serious environmental stress (Ljubicic *et al.,* 2023). Genetic constitution of the plant for number of grain rows and grains per row may be reasoned for no alteration in this character. Number of grains per cob is obtained by multiplying number of grain rows per cob with number of grains per row therefore, non-significant difference in these characters caused statistical similar number of grains per cob. Crop sown on February 8th attained significantly higher single cob weight without husk (188 g) as compared to that of 28th February and 10th March sowing but remained at par with 18th February sowing. Significantly higher cob weight in early sowing may be reasoned to more cob length and cob girth under these treatments. Better translocation of photosynthates from source to sink at reproductive stage and proper grain filling in early sowing treatment due to favourable weather conditions (relatively low temperature at reproductive stage) might have contributed towards heavier weight of cobs. Kettler *et al.* (2022) also of opinion that high night temperature results in loss of more sugar for respiration and reduces kernel filling in maize. Shrestha *et al*. (2018) also observed that low temperature during anthesis is favourable for higher yield.

Among different mulch treatment, significantly higher single cob weight was observed with mulch application after 2nd irrigation (184 g) as compared to without mulch but was at with another mulch treatment. Longer and broader cobs in mulch treatments may be assigned responsible factors for more cob weight. The positive effect of rice straw mulch on cob weight of spring maize was also reported by Singh *et al.* (2016).

Yield

Data in Table 2 showed that dehusked cob yield was statistically higher in February 8th sowing (11427 kg/ha) as compared to 28th February and 10th March but it remained at par with 18th February. Significantly lowest dehusked cob yield was recorded with March 10th sowing (9148 kg/ha). Delay in sowing from 8th February caused 12.8 and 19.9 per cent reduction in yield under 28th February and 10th March, respectively. Significantly higher cob yield in 8th February sowing was due to more cob weight. A reduction in the values of yield attributes with delay in sowing resulted into poor cob yield (Hai-dong *et*

Table 2. Effect of sowing dates and rice straw mulch on yield, production efficiency and B:C ratio of sweet corn in spring season

Treatment	Single cob weight (g)	Dehusked cob yield (kg/ha)	Green fodder yield (kg/ha)	Production efficiency (kg/ha/day)	B:C
Sowing date					
8th February	188	11427	21987	116.7	1.80
18th February	184	11117	21807	122.1	1.73
28th February	165	9963	19930	114.4	1.48
10th March	151	9148	18555	107.5	1.37
SEm±	4	178	439	2.1	0.04
CD (p = 0.05)	15	618	1517	7.2	0.16
Mulch (rice straw @ 5 t/ha)					
No mulch	152	91927	18158	101.6	1.35
After 2nd irrigation	184	11128	21925	123.2	1.71
After 3rd irrigation	179	10921	21626	120.7	1.66
SEm±	7	379	882	4.1	0.09
CD (p = 0.05)	22	1138	2644	12.4	0.28

al., 2017). Yield of sweet corn in spring season was higher in early sowing due to more values of yield attributes (Shrestha *et al.*, 2018). Temperature during anthesis is very important which affect yield (Patel *et al*., 2024). Crop sown on first, second, third and fourth date of sowing faced average daily temperature 28.8, 29.2, 30.1 and 30.7°C, respectively during 50% tasseling to harvest stage. High temperature during reproductive stage in late sown crops was responsible for lower cob yield (Koca and Canavar, 2014). High temperature during reproductive phase adversely affected pollen viability, receptivity of silk, cell division in endosperm, duration in grain filling, kernel development and enzyme activities.

Mulch application after 2nd and 3rd irrigation being at par with each other resulted into statistically higher dehusked cob yield (11128 and 10921 kg/ha, respectively) as compared to without mulch treatment. In comparison to no mulch, dehusked cob yield increased 21.1 per cent when mulch was applied after 2nd irrigation and 18.8 per cent in case of mulch application after 3rd irrigation. The higher dehusked cob yield in mulch treatment was because favourable soil moisture and temperature which enhanced yield attributes (Patel *et al*., 2024). Ranu *et al.* (2022) also concluded that rice straw mulch in maize enhanced yield due to conservation of soil moisture. Higher yield of maize due to mulching was also reported by Xing *et al.* (2024).

It is apparent from data that delay in sowing led to significant reduction in biological yield. The 8th February sowing recorded statistically higher green fodder yield (21987 kg/ha) than 28th February and 10th March sowing, which was higher by 2057 and 3432 kg/ha, respectively but it was statistically at par with 18th February. Moreover, crop sown on 18th February produced significantly more green fodder yield than 28th February and 10th March. Reduction in green fodder yield under late sowing was due to reduced vegetative growth (Shrestha *et al.*, 2016). The significant difference was also recorded in green fodder yield due to different mulch treatments. Mulch application after 2nd and 3rd irrigation being at par with each other resulted into significantly higher green fodder yield over no mulch by an increase of 20.7 and 19.1 per cent, respectively. More green fodder yield under mulch treatments may be ascribed to higher plant growth as evident by plant height. Shashikanth *et al.* (2022) also reported more production of biomass of maize due to application of straw mulch.

Production efficiency

Production efficiency decreased continuously after 18th February. Significantly higher value of production efficiency (122.1 kg/ha/day) was obtained in crop sown on 18th February as compared to other sowing dates but it was statistically at par with 8th February sowing. The significant difference was also recorded in different mulch treatments. Significantly higher production efficiency (123.2 kg/ha/day) was recorded when mulch was applied after 2nd irrigation in comparison to no mulch treatment however, it was statistically at par with mulch application after 3rd irrigation. Both the mulch treatments on an average exhibited 20% higher production efficiency over no mulch treatment. Production efficiency is directly related to yield and inversely with crop duration. Although crop duration reduced with delay in sowing but cob yield also decreased in higher proportion which ultimately led to low production efficiency in later sowing dates. Mulch treatment recorded more production efficiency mainly because of higher cob yield.

Economics

Economics varied due to both date of sowing and mulching (Figure 1). Same level and number of inputs were used in all sowing date treatments except number of irrigations. Crop sown on first and second dates were irrigated 6 times whereas irrigation was given 5 times in crop sown on later two dates. This difference in frequency of irrigation caused variation in cost of cultivation. Among different mulch treatments, crop grown without mulch had less cost of cultivation than mulch treatment. Mulch treatments had more cost which was incurred on application of rice straw between the rows. Gross return from sweet corn sown on 8th February and 18th February was significantly superior to that of later sowings. Gross return in first sowing date (Rs. 171406/ha) was higher by Rs. 21949 and Rs. 34173/ ha than third and fourth sowing date, respectively. Mulch applied after 2nd irrigation fetched highest gross return (Rs. 166932/ha) which was at par with mulch applied after 3rd irrigation but showed significantly superiority over no mulch treatment. On an average, mulch application gave 19.9 per cent higher gross return as compared to no mulch treatment. The difference in gross return under different sowing dates and mulch treatments were simply because of variation in economic

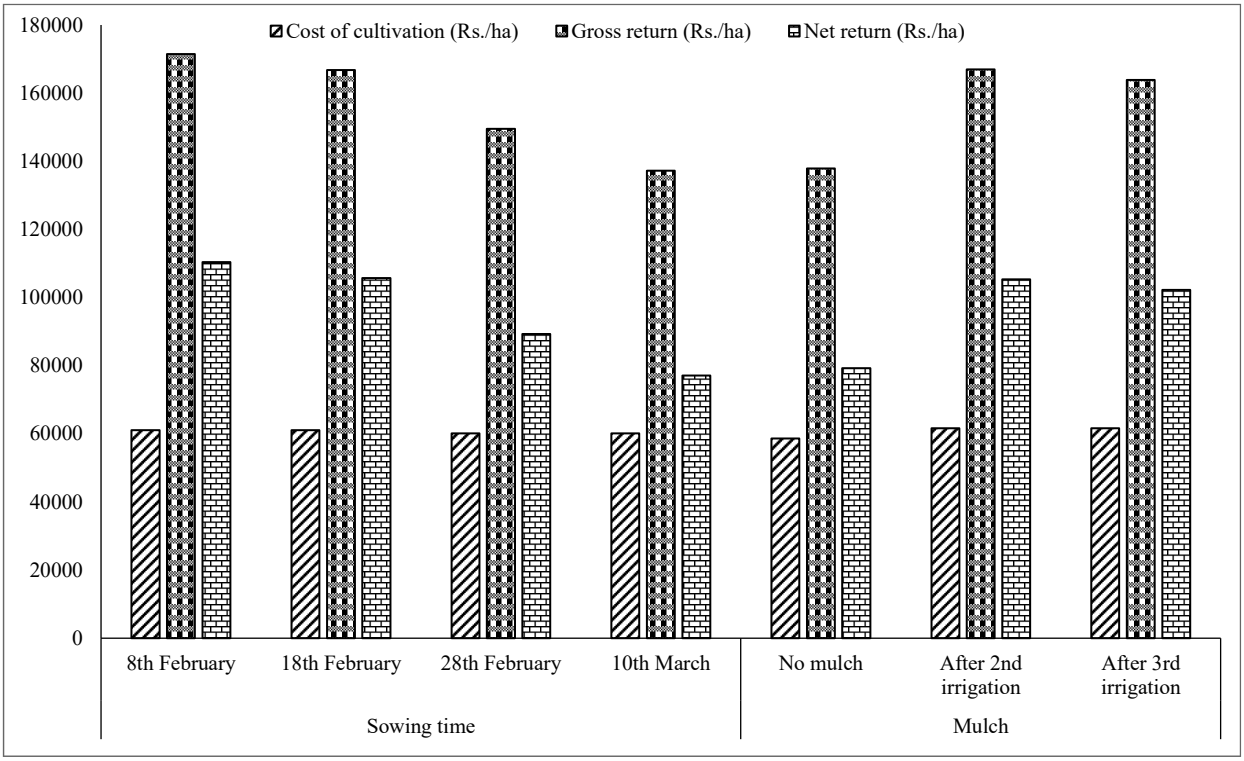

Figure 1. Economics of sweet corn in spring season as affected by date of sowing and mulching

yield (dehusked cob) under respective treatments. Therefore, treatments with higher dehusked cob yield had higher gross return. Maize sown on 8th sowing gained significantly higher net returns (Rs. 110361/ha) than that of 28th February and 10th March but it was at par to the 18th February sowing date. Early sowing of sweet corn on 8th February resulted into 23.6 and 43.2 per cent more net return over 28th February and 10th March sowing. Since, gross return in early sowing was higher, hence, net return in this treatment was more compared to other sowing dates. Mulch application after 2nd irrigation being at par with after 3rd irrigation recorded significantly higher net return than no mulch treatment. On an average mulch application acquired 30.9 per cent more net return as compared to no mulch. Cost of cultivation in mulch treatment was higher but produced more gross return which resulted into higher net return.

A reduction in benefit to cost ratio was observed with postponement of sowing dates (Table 2). The B:C of 8th February sowing was significantly superior (1.80) to late sowing treatments but it was at par with 18th February sowing. Moreover, 18th February was also statistically superior to 28th February and 10th March sowing. Mulch application significantly improved B:C where the highest value (1.71) was in mulch application after 2nd irrigation followed by mulch application after 3rd irrigation (1.66). Crop grown without mulch had significantly lowest B:C (1.35). Variations in B:C among different sowing dates and mulch treatment were because of difference in cost of cultivation and net return (Singh *et al.*, 2016).

Conclusion

From present study it can be inferred that optimum sowing time of sweet corn during spring season in north western plains of India is the first fortnight of February. Mulching of rice straw @ 5 t/ha after 2nd irrigation or 3rd irrigation is effective in increasing productivity and profit.

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