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Effect of Establishment methods, planting dates and Hybrids on phenology and yield of Sweet corn (*Zea mays saccharata* L) under temperate conditions

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Abstract
The field experiment was conducted for two sessions during Kharif 2020 and 2021 at the experimental farm of the Division of Agronomy at the Wadura campus of Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Wadura, Sopore, to study the "Effect of Establishment method and Planting date on phenology, yield, and agrometeorological indices for sweet corn." The experiment incorporated two factors: the technique of establishment (direct sowing and transplanting) and varied sowing dates with a 20-day interval. The first sowing date was (25th April, 2nd was 15th of May and third was 5th of June during both the year). In RCBD, three replications were tested. Direct sowing on the first day of sowing took the longest to achieve various phenological phases and accumulate the most heat units, followed by transplanting on the first day of sowing. Transplanting with the initial date of sowing yielded considerably greater HUE, HTUE, PTUE, and HyTUE, leading in the largest green cob and biological yield as compared to other dates of sowing and direct seeding. As a result, with Kashmir's temperate climate, transplanting with the first date of sowing was determined to be a cost-effective way to increase Sweet corn production.

Keywords: Sowing dates, transplanting hybrids and establishment methods

Introduction

Maize (*Zea mays* L.) is a wonder crop that has grown to become the world's third most important grain, behind rice and wheat, supplying food, feed, and raw materials for a variety of industrial products. Maize is grown in tropical, subtropical, temperate, and even frigid desert conditions all throughout the world. Because it contains 9.0 percent protein, 3.4 percent fat, 1.1 percent ash, 1.0 percent starch fibre, 0.30 percent thiamine, 0.08 percent riboflavin, and 1.9 percent niacin, it is nutritionally superior to most other cereals (Sahoo and Mahapatra 2007). Maize is grown on 197 million hectares around the world, yielding 1070 metric tonnes and 5.82 tonnes ha-1. Maize is grown in a variety of soils, climates, biodiversity, and management practises, accounting for 37% of global grain production (FAO, 2021) [3]. In 2020-21, India produced 30 million tonnes on 9.9 million hectares. Anonymous (Anonymous, 2021) [2]. Sweet corn (*Zea mays saccharata* L.) is a unique maize that can be consumed fresh or canned. Cobs collected during early-milk ripeness of seed are used in the "fresh produce" market, whereas those harvested at late-milk ripeness of seed are used in pickles and frozen items. Anemia and cholesterol levels are lower, which is good for pregnant women (Anonymous, 2018) [4], Sweet corn is a major player in the global sugar industry, particularly in North America. In the United States, sweet corn accounts for more than half of all sweeteners ingested. In the food and beverage industries, it has largely replaced cane and beet sugar. Sweet corn is one of the most popular vegetables in the United States and Canada. Sweet corn is grown in abundance in the United States, with the majority of the crop used in the frozen and canned food businesses (Ugur and Maden, 2015) [5]. Transplanting has several advantages over direct seeding, including a decreased death rate, the ability to select strong and healthy seedlings for a better plant stand, and a lower seed rate. The recent data suggest that using a transplant strategy rather than direct sowing could provide a similar or greater yield from sweet maize mutant plants under optimal conditions. The goal of this study was to look into the acceptance of poly bag transplant practises as an alternative to direct seeded sweet corns, as well as the impact of planting dates on different sweet corn varieties.

The growth responses of Sweet Corn hybrids vary continuously with planting dates and establishing practises, and a thorough understanding of the phenomena could lead to new crop management opportunities. Raising seedlings in poly bags under controlled conditions is one option to examine. Due to its perishable nature, the entire quantity of produce should be consumed within a short period of time. To extend the market window, sow Sweet Corn hybrids as direct seeded and transplant into (polybags) at different planting dates with a 20-day break. Weather variability is a major factor to inter-annual variability in crop growth and yield in all scenarios. Temperature and bright sunlight hours, relative humidity, and rainfall are agrometeorological parameters that have a direct relationship with crop growth and development. Growing degree days, Heliothermal units, Photothermal units, Hydrothermal units, and thermal usage efficiency are agrometeorological indicators that are used to account for the effect of these variables at various phases of crop growth. A plant requires a precise temperature to progress through the various phenological stages. The accumulation of heat units or increasing degree days determines how long it takes to attain a given growth stage and how long each phenophase lasts. Tauseef and Kotru (2015) [6] each phenophase has its own heat requirement, and in order to achieve a given phenological stage, a certain quantity of heat units must be accumulated. Growing degree days is based on the concept that the time it takes to achieve a phenological stage is related to temperature in the range between mean and base temperature. The influence of ambient temperature on phenological development and heat accumulation in Sweet corn hybrids established using two distinct establishment procedures and subjected to diverse microclimates by modifying their planting dates was investigated in this study. The objective of the study was.

1. To study the impact of sowing dates and establishment methods on various phenophase of Sweet corn.
2. To study the sowing dates and establishment methods on yield of sweet corn.

Methodology
The study was place at the Wadura campus of the Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir at Wadura, Sopore, which is located at 34o17' N latitude and 74o33' E longitude, at an elevation of 1524 metres above mean sea level. The experimental site was well-drained and had a homogeneous topography. The weekly minimum temperature ranged from 13.7 to 19.3 °C, while the maximum temperature ranged from 22.8 to 35.1 °C, according to meteorological data collected throughout the inquiry period, Kharif 2020 and 2021.

The soil in the experimental field was sandy loam with a medium nitrogen content (311.77 kg ha-1), phosphorus content (22.50 kg ha-1), and potassium content (350.61 kg ha-^{1}). The pH of the soil was 6.50, which indicated that it was neutral in reaction.

The formulae provided were used to examine agrometeorological indices such as growing degree days (GDD), heliothermal units (HTU), photothermal units (PTU), and hydrothermal units (HYTU) at different growth stages of the crop using weather data for daily maximum and minimum temperatures, sunshine hours, day length, and average relative humidity.

$\sum$ (Tmax + Tmin) /2 = − Tbase

Tbase is the crop's base temperature, also known as minimum threshold temperature, and Tmax and Tmin are the day's maximum and minimum temperatures, respectively. GDD was calculated on a daily basis for maize crops at a base temperature of 10°C.

$HTU = \Sigma(GDD * SSH)$ where, SSH (hour) is the daily duration of sunlight.

$PTU = \Sigma(GDD * DL)$ where, DL (hours) is the day length.

$HYTU = \Sigma(GDD * RH)$ where, RH (%) is the daily mean relative humidity.

The number of days required to achieve different Thermal use efficiencies, such as HUE, HTUE, PTUE, and HyTUE, was estimated by dividing the biological yield of sweet corn by GDD, HUE, PTU, and HyTU. The experiment was set up in a factorial randomised block design (RCBD) with three replications, and the statistical analysis was done in R.

Result
As mentioned in the Table-1. Hybrids Mithas in comparison to sugar-75, it required more days to reach Knee high, Tasseling, Silking, and Harvest. The number of days it took to attain distinct phonological stages was significantly affected by the establishment strategies used. When compared to direct planting, transplanted polybags achieved different phenophases sooner.

The date of sowing has a significant impact on the completion of several phenological stages. The first date of planting, whether transplanting or direct sowing, took the longest to reach various phenological stages because the plant had reached its full potential, i.e. Knee Heigh, 50% Tassling, 50% Silking, and Milking stages, whereas late planting reached various phenological stages faster. The thermal time required for reaching maturity, expressed in growing degree days (GDD), varied significantly between sowing to different phenological stages. Under direct sowing, the degree day accumulation from Knee heigh to physiological maturity (Milking stages) was found to be relatively higher, ranging from 359.97 to 498.48°C during knee high stages and 1264.12 to 1415.17 Milking stages respectively. However there is decrease in phenophase with the delay in sowing date where as 3rd dates which was sown on 5th June took. However, the first sowing, on April 25th, accumulated total heat units of GDD 1406.59 to reach the harvesting stage, whereas the second sowing, on May 15th, took a GDD of (1368.01) and the third sowing, on June 5th, took a GDD of (1368.01). (1280.17).

Heliothermal Units
are a type of unit that is used to measure the temperature of The amount of heliothermal units accumulated by sweet corn to reach various phenological stages in the years 2020 and 2021 ranged from 3520.51 to 4136.45°C day hour for knee high stage, 6692.61 to 7570.44°C day hour for tasseling stage, 7792.45 to 8680.50 °C day hour for silking stage, and 9150.93 to 11190.89 °C day hour for maturity stage during both years.

Table 1: Effect of establishment methods and sowing dates to reach various phenological stages of sweet corn hybrids

Treatment	Knee Height			Tasseling			Silking			Milking/ Harvest		
	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled
Hybrids												
Mithas	35.8	34.8	35.5	65.8	65.9	65.9	72.8	72.7	72.7	116.6	116.7	116.7
Sugar-75	36.2	34.9	35.3	65.5	65.5	65.5	72.3	72.5	72.4	116.2	116.4	116.4
Establishment Methods												
Direct Sowing	36.5	36.3	36.9	66.2	66.2	66.2	73.3	73.5	73.4	117.3	117.5	117.3
Transplanting	34.6	34.3	34.5	65.1	65.2	65.1	71.4	71.3	71.3	114.2	114.5	114.4
Date of Sowing												
25th April	38.3	36.7	37.3	68.1	68.2	68.2	75.1	75.2	75.1	116.1	116.8	117.8
15th May	36.4	34.8	35.4	66.3	66.7	66.4	72.3	72.5	72.4	108.2	107.1	107.6
5th June	34.1	33.66	33.5	63.5	63.4	63.2	69.6	69.4	69.5	101.3	100.8	101.1

Table 2: Effect of establishment methods and sowing dates on GDD of sweet corn hybrids

Treatment	knee High			50% Tasseling			50% Silking			Milking/ Harvesting			Green Cob Yield t/ha		
405.67	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled
Hybrids															
Mithas	390.08	410.33	407.63	851.87	857.84	853.87	940.01	947.93	944.04	1365.34	1366.48	1365.40	18.73	18.92	18.82
Sugar75	390.08	397.76	395.64	843.54	848.43	846.47	935.05	939.81	937.38	1350.47	1358.39	1354.42	17.23	17.21	17.22
S.E(m)±	3.877	4.07	3.79	10.60	11.07	10.78	12.85	13.11	1291	20.95	20.99	20.97	0.355	0.373	0.365
CD(P≤0.05)	11.63	12.22	11.39	31.81	32.98	31.89	38.56	39.21	38.39	62.868	63.894	62.812	1.138	1.161	1.144
Establishment Methods															
Direct Sowing	431.56	432.30	431.93	858.33	860.02	859.18	947.65	949.41	948.53	1365.81	1368.07	1366.94	14.72	14.94	14.82
Transplant	372.33	373.23	372.78	829.07	831.36	830.21	927.41	929.27	928.34	1340.13	1342.35	1341.24	20.02	20.25	20.11
S.E(m)±	3.877	4.07	3.79	10.60	11.07	10.78	12.85	13.11	1291	20.95	20.99	20.97	0.355	0.373	0.365
CD(P≤0.05)	11.63	12.22	11.39	31.81	32.98	31.89	38.56	39.21	38.39	62.868	63.894	62.812	1.138	1.161	1.144
Date of Sowing															
25th April	463.55	464.46	464.01	910.94	912.74	911.84	987.88	989.70	988.79	1405.49	1407.69	1406.59	21.78	22.39	21.53
15th May	403.14	403.92	403.53	841.55	843.89	842.72	936.71	938.38	937.54	1366.96	1369.05	1368.01	18.09	18.35	18.18
5th June	339.15	339.91	339.53	778.61	780.44	779.53	888.01	899.38	888.97	1278.95	1281.39	1280.17	14.61	14.92	14.78
SE(m)±	4.89	5.056	4.75	33.86	11.98	11.37	13.86	14.11	13.89	22.43	23.12	22.27	0.431	0.451	0.438
CD(P≤0.05)	14.11	15.25	14.36	11.08	34.21	33.56	41.324	42.594	41.451	67.29	68.12	67.23	1.214	1.242	1.227
CD(P≤0.05) (Year)	NS			NS			NS			NS			NS		

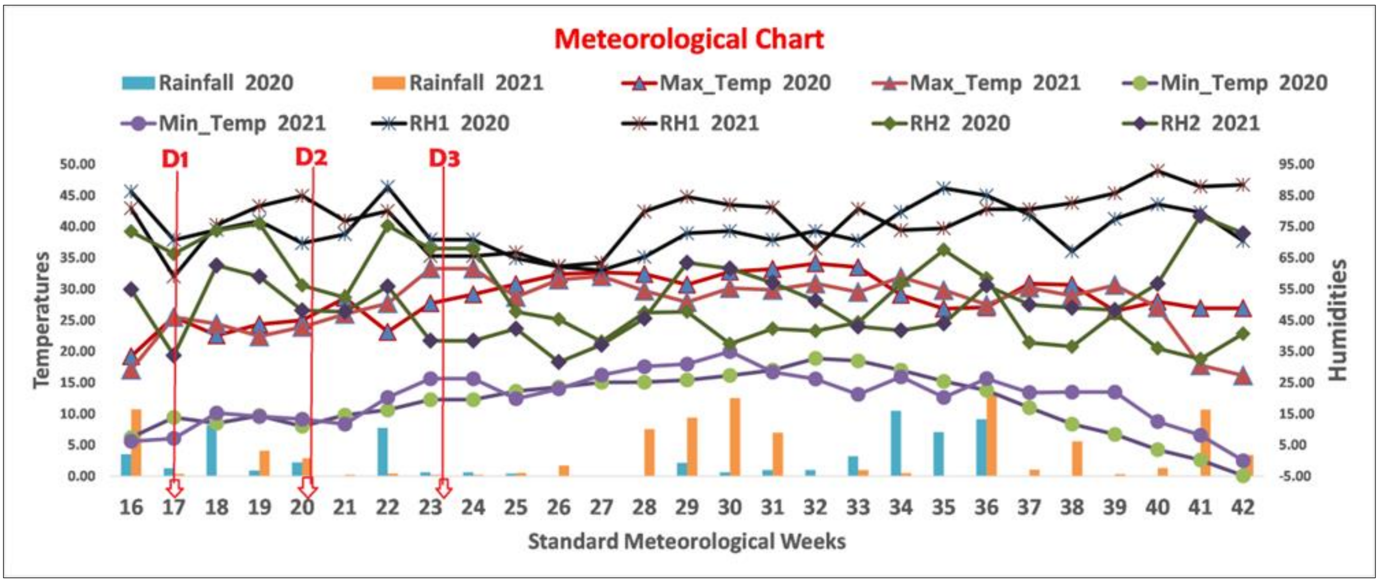

Fig 1: Standard Meteorological Week 2020 and 2021

Photothermal units

PTU accumulated during different phenological stages as mentioned in the Tabel 4. Direct seeding on April 25th (1st date of sowing) Knee high stage PTUs of 5961.50 °C per hour, tasseling stage PTUs of 12170.44 °C per hour, silking stage PTUs of 13681.51 °C per hour, and milking stage PTUs of 17870.46 °C per hour.

Hydro thermal units

The amount of Hy-TUs accumulated to reach knee high, tasseling, silking, and maturity stage ranged from 27617.99 to 27370.30, 56234.65 to 56570.51 °C day percent, 63043.17 to 63245.56-day percent, and 90876.17 to 91234.67 day percent, respectively, for both direct and transplanting methods with the same date of sowing.

Transplanting accumulates more dry matter than direct sowing because direct sowing results in poor germination, increased bird damage, and high cutworm infection. HUE, HTUE, PTUE, and HyTUE Green cob yields were higher when sweet corn was transplanted on the first day of planting.

Discussion

With direct seeding, the greatest GDD was accumulated on April 25th. The initial date of sowing, April 25th, provided the highest GDD when using the transplanting method. This could be due to the plant's ability to reach its maximum potential. The accumulated heat units for various phenological growth phases decreased as sowings were delayed (Khavse *et al* 2013) [1] Early planting with direct sowing resulted in more strong development and crop duration, resulting in a higher heat unit accumulation. PTU accumulation varied dramatically throughout the course of the growing season when alternative sowing dates and establishment procedures were used. The findings of similar studies back up these conclusions. (Bashir *et al*. 2022 and Khavse 2013) [7, 1]. The green cob yield was significantly influenced by the establishment procedures. Greater grain yield (green cob yield) might be explained by higher yield attributes, while higher leaf area index and dry matter accumulation could be explained by higher biological yield. Transplanting through polybags produces the maximum grain yields when compared to direct seeding because seedlings cultivated in a low tunnel and planted in the field during or after the optimum time grew quicker and yielded more grain than direct seeded maize, increasing the biological yield (Gonda *et al*. 2013) [8]. This could be because early seeding during a favourable season resulted in the accumulation of more heat units at various phenophases, resulting in greater PTU values. When alternative sowing dates and establishing procedures were used, PTU accumulation varied dramatically over the course of the growth season. These findings are validated by studies such as [Khavse *et al* 2013, and Jan 2020] [1][9].

Conclusion

The findings demonstrate that the establishing method and sowing date had a substantial impact on the crop's phasic growth and productivity. The length of the growing cycle determines the amount of assimilates accumulated by the crop. The first sowing date is advised because, in addition to determining the crop's growth phase, the date of sowing also influences the heat consumption efficiency, as stated by thermal use efficiencies. Similarly, as evidenced by thermal use efficiencies such as heat use efficiency, heliothermal use efficiency, photothermal use efficiency, and hydrothermal use efficiency, adequacy in the establishment method, namely transplanting the crop, allows the crop plant to make efficient use of the current weather conditions.

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