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Evaluation of seedling age and nutrient sources on phenology, yield and agrometeorological indices for sweet corn (*Zea mays saccharata* L.)

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ABSTRACT

The field experiment was conducted during *Kharif* season of 2020 at Agronomy farm of Faculty of Agriculture, Wadura, SKUAST-K to study the influence of age of seedling and sources of nutrients on phenology, yield and agrometeorological indices for sweet corn. The experiment included two factors viz. age of seedlings (12, 22 and 32 days old seedling) and sources of nutrients (control, RDF, 50 percent RDF + FYM @ 12 t ha^{-1}, 50 percent RDF + vermi-compost @ 4 t ha^{-1} and 50 percent RDF + poultry manure @ 2 t ha^{-1}) tested in RCBD with three replications. Transplanting 12 days old seedlings required maximum number of days to attain different phenological stages, thereby accumulated maximum heat units followed by 22 days old seedlings. While as transplanting 22 days old seedling recorded significantly highest HUE, HTUE, PTUE and HyTUE and consequently resulted in the highest green cob and biological yield compared to other ages of seedlings. Among various sources of nutrients, application of 50 per cent RDF + poultry manure @ 2 t ha^{-1} took maximum number of days to attain various phenophases thereby accumulated maximum heat units and registered highest HUE, HTUE, PTUE and HyTUE followed by application of 100 per cent RDF.

1. Introduction

In order to maximize production potential of different crops including sweet corn, transplanting technique is potent approach. This technique lays emphasizes on the use of optimum age of seedlings which is an important determinant of various agronomic traits i.e., plant height, dry matter accumulation, growth period and yield. Transplanting of too younger age of seedling limits the expression of their potential whereas transplanting older seedlings results in greater transplanting shock. Therefore, for attaining maximum productivity of the crop transplanting at appropriate age of seedling is required (Adesina et al., 2014). Moreover, due to the intensive cultivation of exhaustive crops particularly in cereal-based cropping system, the gap between nutrient removal by the crops and nutrients added through fertilizers is widening. Apparently, nutrient depletion from the soil demands higher rate of nutrient replenishment to ensure that soil fertility is not a limiting factor in crop production and for maintaining the soil nutrient balance. Agronomic interest in use of combining organic with inorganic sources of crop nutrition provide a reliable alternative to chemical fertilization on long term basis and can act as a prominent effort to maintain soil health and boost up the crop production (Ghosh et al., 2020a,b).

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Agrometeorological variables such as maximum and minimum temperature, rainfall, relative humidity and sunshine hours assume a direct relationship with growth and development of the crop. The effect of these variables at different growth stages of the crop is accounted in terms of agrometeorological indices such as Growing degree Days, Heliothermal units, Photothermal units, Hydrothermal units *etc.* A plant requires a definite temperature for attaining different phenological stages. The time taken to reach a particular growth stage and duration of each phenophase depends upon the accumulation of heat units or growing degree days (Tauseef et al., 2015). Each phenophase have its own heat requirement and to attain certain phenological stage, required number of heat units are accumulated. Growing degree days are based on the idea that the amount of time it takes to reach a phenological stage is linearly related to temperature in the range between mean and base temperature. The heat unit concept assumes that a direct and linear relationship between growth and temperature is advantageous for assessing a crop's yield potential under various weather conditions. Agroclimatic models based on thermal indices can possibly meet these objectives (Mousumi and Ghosh, 2018). Heat use efficiency (HUE) i.e. competence of utilization of heat in relations of dry matter accumulation or grain yield depends on crop type, genetic factors and sowing time as well as has great practical application. Crop phenology can be used to specify the most suitable date and time of specific development process. The growing degree day (GDD), heliothermal unit (HTU), photothermal unit (PTU) and phenothermal index (PTI) are some simple tools to find out the relationship between plant growth, temperature, bright sunshine hours and day length (Tauseef et al., 2015). Despite similar agroclimatic conditions variation in seedling age modifies the phasic development of the crop, thus affecting the accumulation and partitioning of dry matter. Furthermore, availability of nutrients in sufficiency shows a pronounced effect on the crop growth and development, thereby lengthening the crop growth period. Whereas reduction in growth period of the crop due to attainment of forced maturity under reduced availability of nutrients affects the accumulation of heat units by the crop which ultimately determines the crop productivity.

2. Materials and methods

A field experiment was laid out at Agronomy Research Farm, Faculty of Agriculture, SKUAST-K, Wadura, Sopore, J&K during the *Kharif* season of 2020. Geographically, Wadura is located at an altitude of 1587 m AMSL, 34° 34́ N latitude and 74°40́ E longitude. The weather data recorded for the period of investigation during *Kharif* -2020 revealed that weekly minimum temperature ranged between 7.5 and 18.1 °C and maximum temperature ranged from 23.8 to 35 °C. A rainfall of 166 mm was noted during the period. The soil of experimental field was sandy loam in texture with sufficient available nitrogen (304.67 kg ha^{-1}), phosphorus (17.20 kg ha^{-1}) and potassium (181.50 kg ha^{-1}). The soil was neutral in reaction with pH of 6.67.

The experiment was tested in Randomized Complete Block Design. The treatments consisted of three ages of seedling (12-, 22- and 32-days old seedling) and five sources of nutrients (control, RDF, 50 percent RDF + FYM @ 12 t ha^{-1}, 50 percent RDF + vermicompost @ 4 t ha^{-1} and 50 percent RDF + poultry manure @ 2 t ha^{-1}) with three replications. The variety used was Sugar-75 transplanted at a spacing of 75 cm × 20 cm.

The seedlings were raised in poly bags by sowing seeds on different dates at an interval of 10 days to achieve 12-, 22- and 32-days old seedlings. The poly bags were kept in green house and regular cultural operation like watering and weeding were adopted.

The number of days taken to attain different phenological stages viz. knee high, 50 per cent tasseling, 50 per cent silking and maturity were recorded from the date of transplanting. Observations for yield parameters like number of cobs per plant, green cob yield and biological yield were recorded at harvest. The weather data recorded for daily maximum and minimum temperature, sunshine hours, day length and average relative humidity was used for the examination of agrometeorological indices viz. growing degree days (GDD), heliothermal units (HTU), photothermal units (PTU) and Hydrothermal units (HYTU) at different growth stages of crop using the given formulae:

$$GDD = \{\frac{T_{max} - T_{min}}{2} - T_b\} \tag{1}$$

where, T_{max} (°C) is the daily maximum temperature, T_{min} (°C) is the daily minimum temperature, T_b (°C) is the base temperature.

$$HTU = (GDD * SSH) \tag{2}$$

where, SSH (hour) is the daily duration of sunlight

$$PTU = (GDD * DL) \tag{3}$$

where, DL (hours) is the length of day

$$HYTU = (GDD * RH) \tag{4}$$

where, RH (%) is the daily mean value of relative humidity.

Thermal use efficiencies viz. HUE, HTUE, PTUE and HyTUE were calculated by dividing the biological yield of sweet corn with GDD, HUE, PTU and HyTU respectively.

The estimate of the association between green cob and biological yield with agrometeorological indices was worked out using correlation analysis. Regression analysis of green cob and biological yield against agrometeorological indices was computed and regression equations was fitted to estimate the response of green cob and biological yield explained by agrometeorological indices. The statistical analysis was performed using SPSS software.

3. Results and discussion

3.1. Crop phenology

Attainment of different phenological stages was significantly influenced by the age of seedlings (Table 1). The seedlings of young age took maximum number of days to reach to different phenological stages viz. knee high, 50 per cent tasseling and 50 per cent silking and maturity while as older seedlings reached different phenological stages faster. This could be attributed to the reason that senescence strikes older seedlings earlier than younger seedlings. Seedlings undergo transplanting shock while transplanting them into an open field and due to advanced growth of older seedlings a larger transpiring surface area leads to more transpiration losses, thereby reducing the performance of the crop. The results are supported by the findings of Adesina et al. (2014); Biswas et al. (2009) and Kumar et al. (2014).

Under different sources of nutrients, the number of days taken to attain different phenological stages varied significantly. The crop took maximum number of days to reach maturity under the application of 50 per cent RDF + poultry manure @ 2 t ha^{-1} followed by application 100 per cent RDF whereas minimum days were taken under control. Reduction in the number of days required to attain different phenological stages was possibly due to the limited availability of nutrients. Whereas application of 50 per cent RDF + poultry manure @ 2 t ha^{-1}resulted in adequate supply of nutrients throughout the crop growth period which lengthened the crop growth period. The maximum number of days taken by the crop

Table 1
Effect of age of seedling on days taken to attain various growth stages of sweet corn under different sources of nutrients.

Treatment	Days taken			
Age of seedling (days)	Knee high	Tasseling	Silking	Maturity
A_1: 12	37.29	65.93	71.70	102.43
A_2: 22	34.66	64.33	69.70	100.35
A_3: 32	32.38	62.20	67.10	95.69
SE(m)±	0.46	0.31	0.33	0.67
CD ($p \leq 0.05$)	1.35	0.90	0.96	1.94
Sources of nutrients				
F_0: Control	31.90	61.39	67.00	95.27
F_1: 100% RDF	36.10	65.39	70.69	101.18
F_2:50% RDF + FYM @ 12 t ha^{-1}	33.80	63.25	68.49	98.15
F_3: 50% RDF + VC @ 4 t ha^{-1}	34.25	63.69	69.10	98.62
F_4: 50% RDF + PM @ 2 t ha^{-1}	37.84	67.06	72.22	104.21
SE(m)±	0.60	0.40	0.43	0.86
CD ($p \leq 0.05$)	1.74	1.16	1.23	2.50

to attain different knee high, 50 per cent tasseling and 50 per cent silking and maturity were 37.84, 67.06, 72.22 and 104.21 days respectively. Application of 50 per cent RDF + vermicompost @ 4 t $ha^{-1}$was found at par with application of 50 per cent RDF + FYM @ 12 t $ha^{-1}$with respect of number of days taken to reach different phenophases. The easy and full availability of nutrients via chemical fertilization and organic manures (poultry and vermicompost) might had enhanced the growth at different phenophases which in turn increased the crop duration. The influence of organic and inorganic nutrients on the growth of maize was also reported by Ghosh et al. (2020a,b); Kartseva et al. (2021) and Sarkar et al (2020). Further the findings of Wajid et al. (2012) are also in close conformity with the present results.

3.2. Agrometeorological indices

3.2.1. Growing degree days

Data pertaining to growing degree days during different phenological phases of sweet corn is presented in Table 2. The attainment and duration of different phenological stages is determined by requirement of heat units which itself is influenced by the atmospheric ambient temperature. Accumulated GDDs at different phenophases of sweet corn varied significantly with age of seedlings which can be attributed to heat unit requirements to attain different phenological phases. The requirement of heat units decreased gradually with increase in the age of seedlings. The declining trend of GDD with increase in age of seedlings was attributed to the stress experienced by older seedlings resulting in forced maturity, thereby decreasing the growth period (Adesina et al., 2014). To attain knee height, tasseling, silking and maturity stage, transplanting 12 days old seedlings accumulated significantly highest GDDs of 421.82, 823.11, 922.45 and 1288.49 °C day respectively. Among sources of nutrients, application of 50 per cent RDF + poultry manure @ 2 t ha^{-1} accumulated maximum GDDs which can be attributed to the adequate availability of nutrients throughout the growth period that resulted in elongated crop period resulting in accumulation of more heat units. The agrometeorological indices in maize were also studied by Perves et al. (2020).

3.2.2. Helio-thermal units

The amount of heliothermal units accumulated by sweet corn to reach various phenological stages under different ages of seedlings ranged from 3456.52 to 4061.97 °C day hour for knee high stage, 6859.14 to 7355.63 °C day hour for tasseling stage, 7592.78 to 8288.21 °C day hour for silking stage and 10070.12 to 10705.09 °C day hour for maturity stage (Table 2). The maximum HTU accumulated by transplanting 12 days old seedling to attain knee high, tasseling, silking and maturity from transplanting was 4061.97, 7355.63 °C, 8288.21 and 10705.09 °C day hour respectively and crop growth period was ascribed as the most pertinent reason. The young age seedling being more vigorous in terms of growth and crop duration resulted in accumulation of more heat units compared to older age seedlings (Adesina et al., 2014). Among different source of nutrients, the accumulation of heliothermal units varied significantly. Application of 50 per cent RDF + poultry manure @ 2 t ha^{-1} accumulated higher HTUs as compared to rest of the sources followed by application of 100 per cent RDF. Application of 50 per cent RDF + vermicompost @ 4 t $ha^{-1}$was found at par with application of 50 per cent RDF + FYM @ 12 t ha^{-1}. Reduction in the accumulation of HTUs was due to reduced crop growth period. The findings of Perves et al. (2020) also support these results.

Table 2
Accumulated GDD and HTU at different growth stages of sweet corn.

Treatment	GDD				HTU			
Age of seedling (days)	Knee high	Tasseling	Silking	Maturity	Knee high	Tasseling	Silking	Maturity
A_1: 12	421.82	823.11	922.45	1288.49	4061.97	7355.63	8288.21	10705.09
A_2: 22	388.45	797.54	889.53	1266.96	3646.68	7020.05	7854.48	10167.78
A_3: 32	357.28	764.17	847.43	1218.12	3456.52	6859.14	7592.78	10070.12
SE(m)±	2.94	4.80	5.40	6.97	25.92	33.10	34.92	44.42
CD ($p \leq 0.05$)	8.51	13.92	15.66	20.19	75.11	95.93	101.20	128.71
Sources of nutrients								
F_0: Control	350.75	752.18	850.46	1213.68	3271.96	6558.27	7442.55	9854.80
F_1: 100% RDF	405.56	815.89	907.09	1276.92	3913.22	7292.87	8157.68	10586.82
F_2:50% RDF + FYM @ 12 t ha^{-1}	376.04	778.81	864.78	1244.84	3635.58	6954.84	7717.04	10308.61
F_3: 50% RDF + VC @ 4 t ha^{-1}	383.57	785.22	873.75	1247.72	3716.26	7033.70	7855.66	9976.27
F_4: 50% RDF + PM @ 2 t ha^{-1}	429.99	842.59	936.28	1306.12	4071.61	7551.71	8386.20	10845.15
SE(m)±	3.79	6.20	6.98	8.99	33.46	42.74	45.09	57.34
CD ($p \leq 0.05$)	10.99	17.97	20.22	26.06	96.96	123.84	130.64	166.16

3.2.3. Photothermal units

The PTUs accumulated from transplanting to various phenological stages furnished in Table 3 indicated that transplanting 12 days old seedlings recorded maximum values and decreased consistently with increase in age of seedlings which also was ascribed to longer duration of the younger age of seedlings. Transplanting 12 days old seedlings accumulated PTUs of 5775.30 °C day hour to attain knee high stage, 11157.26 °C day hour to attain tasseling stage, 12456.30 °C day hour to attain silking stage and 16997.88 °C day hour to attain maturity stage. This could be attributed to the fact that young age seedlings accumulated more heat units at different phenophases which resulted in higher values of PTU. For entire growing season, accumulation of PTUs varied significantly under varying sources of nutrients. Application of 50 per cent RDF + poultry manure @ 2 t ha^{-1} accumulated higher hydrothermal units followed by application of 100 per cent RDF. These results are supported by the findings of Patel et al. (1999).

3.2.4. Hydrothermal units

Age of seedlings brought about significant variation in the accumulation of hydrothermal units during the growth period of sweet corn at different phenological stages (Table 3). The amount of HyTUs accumulated to reach knee high, tasseling, silking and maturity stage ranged from 22683.49to 26805.30, 50764.04 to 54883.55, 56567.45 to61803.36 and 83779.75 to 88678.96 respectively. It was quite noticeable from the data that younger seedlings performed better than those of relatively older seedlings. Regarding sources of nutrients, application of 50 per cent RDF + poultry manure @ 2 t ha^{-1} accumulated highest HyTUs followed by application of 100 per cent RDF. The number of HyTUs accumulated at knee high, tasseling, silking and maturity stage ranged from 22270.42 to 27320.55 °C day %, 49915.84 to 56239.33 °C day %, 56542.11 to 62684.57 °C day %, and 83491.82 to 89815.01 °C day %. These results are supported by the findings of Perves et al. (2020) who also studied the agrometeorological indices in *rabi* maize.

3.2.5. Pheno-thermal index

PTI of sweet corn at different phenological stages is furnished in Table 4. PTI was significantly influenced by age of seedling at all the phenological stages however no significant difference was noticed at knee high stage. Phenothermal index being dependent upon the degree days consumed between the two phenophases per units of duration between the two phenophases (Tauseef et al., 2015). Among all the phenological stages highest values for PTI were observed at silking stage in all the seedling ages and showed a declining trend towards maturity. Concerning the age of seedlings higher values for PTI were observed under transplanting 12 days old seedling up to silking stage. At maturity transplanting 32 days old seedlings showed maximum value for PTI which was due to reduced number of days required to attain maturity. In regard of sources of nutrients PTI varied significantly at all the phenological stages except for knee height stage. Application of 50 per cent RDF + poultry manure @ 2 t ha^{-1} recorded maximum value of PTI at silking stage. However, at maturity maximum value for PTI was recorded under control which was due to minimum number of days taken to reach maturity. These results are supported by the findings of Perves et al. (2020)

3.3. Yield

Data in Table 5 indicates that yield of sweet corn varied significantly with age of seedlings. Transplanting 22 days old seedlings contributed to maximum green cob and biological yield of 138.35 q ha^{-1} and 331.98 q ha^{-1} respectively, followed by 12 days old seedlings with 133.07 q ha^{-1} and 310.91 q ha^{-1} of green cob and biological yield respectively. This possible reason could be that older seedlings have a shorter growth period indicating that maturity is attained earlier which reduces the grain filling period resulting in insufficient filling of grains. While as longer duration of crop growth period in young aged seedlings helped in accumulation of more dry matter and enhanced the grain development by proper filling of grains and subsequently enhanced the yield. The results are consistent with the finding Kumar et al. (2014) and Biswas (2015). Among different sources of nutrients, application of 50 per cent RDF + poultry manure @ 2 t ha^{-1} registered significantly higher green cob and biological yield of 163.76 q ha^{-1} and 391.43 q ha^{-1} followed by 100 per cent RDF. This might be due to combined application of organic and inorganic sources of nutrients that resulted in better availability of nutrients throughout the crop growth period which enhanced the leaf area index, dry matter accumulation and crop duration resulting in improved yield (Amusan et al., 2011).

3.4. Thermal use efficiencies

The heat energy available to the crop is not completely utilized by the crop or converted into dry matter. But the yield potential of the crop is governed by number of factors like genetic makeup, management practices *etc.* which can be assessed in terms of thermal use efficiency as depicted in Table 5. Transplanting 22 days old seedlings resulted in higher HUE, HTUE, PTUE and HyTUE for biological yield. The increased values for HUE, HTUE, PTUE and HyTUE were due to marked improvement in the yield of sweet corn under transplanting of 22 days old seedling which was more vigorous and produced more leaf are index and dry matter accumulation. Among, application of 50 per cent RDF + poultry manure @ 2 t ha^{-1} had significantly higher HUE, HTUE, PTUE and HyTUE for

Table 3
Accumulated PTU and HyTU at different growth stages of sweet corn.

Treatment	PTU				HyTU			
Age of seedling (days)	Knee high	Tasseling	Silking	Maturity	Knee high	Tasseling	Silking	Maturity
A_1: 12	5775.30	11157.26	12456.30	16997.88	26805.30	54883.55	61803.36	88678.96
A_2: 22	5336.37	10820.66	12026.95	16744.14	24676.91	53096.13	59515.49	87257.78
A_3: 32	4910.96	10380.02	11477.00	16158.26	22683.49	50764.04	56567.45	83779.75
SE(m)±	39.53	63.33	70.65	83.09	192.47	335.15	377.06	481.74
CD ($p \leq 0.05$)	114.55	183.52	204.73	240.76	557.73	971.17	1092.61	1395.92
Sources of nutrients								
F_0: Control	4822.34	10222.80	11456.54	16105.62	22270.42	49915.84	56542.11	83491.82
F_1: 100% RDF	5569.52	11061.32	12256.47	16862.34	25772.58	54387.18	60734.41	87933.54
F_2:50% RDF + FYM @ 12 t ha^{-1}	5166.99	10574.31	11744.15	16479.98	23877.58	51777.93	57981.89	85718.39
F_3: 50% RDF + VC @ 4 t ha $^{-1}$	5269.29	10658.72	11840.98	16513.17	24368.37	52252.59	58534.19	85902.06
F_4: 50% RDF + PM @ 2 t ha^{-1}	5876.26	11412.74	12635.62	17206.03	27320.55	56239.33	62684.57	89815.01
SE(m)±	51.03	81.76	91.21	107.27	248.48	432.68	486.78	621.92

Table 4
Effect of age of seedling on PTI during various growth stages of sweet corn under different sources of nutrients.

Treatment	PTI			
Age of seedling (days)	Knee high	Tasseling	Silking	Maturity
A_1: 12	11.31	12.48	12.86	12.58
A_2: 22	11.23	12.39	12.76	12.63
A_3: 32	11.04	12.28	12.63	12.74
SE(m)±	0.12	0.02	0.02	0.02
CD ($p \leq 0.05$)	N.S.	0.05	0.05	0.05
Sources of nutrients				
F_0: Control	11.00	12.25	12.69	12.74
F_1: 100% RDF	11.24	12.47	12.83	12.62
F_2:50% RDF + FYM @ 12 t ha^{-1}	11.16	12.31	12.63	12.69
F_3: 50% RDF + VC @ 4 t ha^{-1}	11.21	12.33	12.64	12.66
F_4: 50% RDF + PM @ 2 t ha^{-1}	11.36	12.56	12.96	12.53
SE(m)±	0.15	0.02	0.02	0.02
CD ($p \leq 0.05$)	N.S.	0.06	0.07	0.06

Table 5
Yield and thermal use efficiencies of sweet corn as influenced by age of seedling and sources of nutrients.

Treatment	Yield		Thermal use efficiencies			
Age of seedling (days)	Green cob yield (q ha^{-1})	Biological yield (q ha^{-1})	HUE	HTUE	PTUE	HyTUE
A_1: 12	133.07	310.91	24.05	2.89	1.82	0.35
A_2: 22	138.35	331.98	26.15	3.25	1.98	0.38
A_3: 32	120.50	290.50	23.74	2.87	1.79	0.35
SE(m)±	1.75	5.92	0.49	0.06	0.04	0.01
CD ($p \leq 0.05$)	5.09	17.14	1.42	0.16	0.11	0.02
Sources of nutrients						
F_0: Control	79.84	221.28	18.27	2.25	1.38	0.27
F_1: 100% RDF	149.35	346.35	27.12	3.27	2.05	0.39
F_2:50% RDF + FYM @ 12 t ha^{-1}	127.69	292.24	23.49	2.84	1.77	0.34
F_3: 50% RDF + VC @ 4 t ha^{-1}	132.57	304.35	24.39	3.06	1.84	0.35
F_4: 50% RDF + PM @ 2 t ha^{-1}	163.76	391.43	29.95	3.61	2.27	0.44
SE(m)±	2.27	7.64	0.63	0.07	0.05	0.01
CD ($p \leq 0.05$)	6.57	22.13	1.84	0.21	0.14	0.03

biological yield. Similarly, sufficiency and deficiency of nutrients showed a pronounced effect on the crop growth and development, thereby lengthening and shortening the crop growth period respectively. The reduction in crop growth period led to forced maturity thereby negatively influencing the crop productivity as indicated by relatively lower values for thermal use efficiencies. Application of 50 per cent RDF + poultry manure @ 2 t ha^{-1}recorded higher values of 29.95 kg/ha/°C day, 3.61 kg/ha/°Cday hour, 2.27 kg/ha/°Cday hour and 0.44 kg/ha/°Cday% for HUE, HTUE, PTUE and HyTUE respectively followed by application of 100 per cent RDF. These results are supported by the findings of Perves et al. (2020).

3.5. Correlation of yield with agrometeorological indices

The correlation coefficients of green cob and biological yield with agrometeorological indices are given in Table 6. Both green cob and biological yield of sweet corn was positively corelated with various agrometeorological indices. The correlation coefficients of GDD, HTU, PTU and HyTU ranged from and 0.29 to 0.69 and 0.28 to 0.65 with green cob and biological yield respectively. Both green cob and biological yield showed close association with GDD and PTU. Thermal use efficiencies viz. heat use efficiency, heliothermal efficiency, photothermal use efficiency and hydrothermal use efficiency showed strong correlation ranging from 0.91 to 0.93 and 0.97 to 0.99 with green cob and biological yield respectively. Green cob yield was best correlated (0.93) with photothermal use efficiency while as biological yield was best correlated with HUE, PTUE and HyTUE. Tauseef et al. (2015) also carried the correlation analysis between agrometeorological indices and yield attributes and found significant results.

Table 6
Correlation coefficients of agrometeorological indices at maturity against the green cob and biological yield of sweet corn.

Correlation coefficient		
Parameters	Green cob yield	Biological yield
GDD	0.69	0.65
HTU	0.29	0.28
PTU	0.69	0.65
HyTU	0.68	0.64
HUE	0.92	0.99
HTUE	0.91	0.97
PTUE	0.93	0.99
HyTUE	0.92	0.99

3.6. Regression analysis

The coefficient of determination ranged from 0.09 to 0.86 and 0.08 to 0.98 indicating the response of green cob and biological yield respectively to agrometeorological indices (Figs. 1 and 2). PTUE accounted for maximum variability of 86% in green cob yield. The GDD explained 47% of variability in green cob yield whereas HTU explained 9% variability in green cob yield. Similarly, for biological yield maximum variability was contributed by HUE, PTUE and HyTUE (98% each). While as HTU contributed up to 8% variability in biological yield. The variability up to 41% in biological yield was explained by GDD and further more HTU and PTU explained up to 42% variability in biological yield. Thermal use efficiencies showed maximum values for coefficient of determination against green cob and biological yield (Fig. 3). This clearly indicates the closeness of association between thermal use efficiency and green

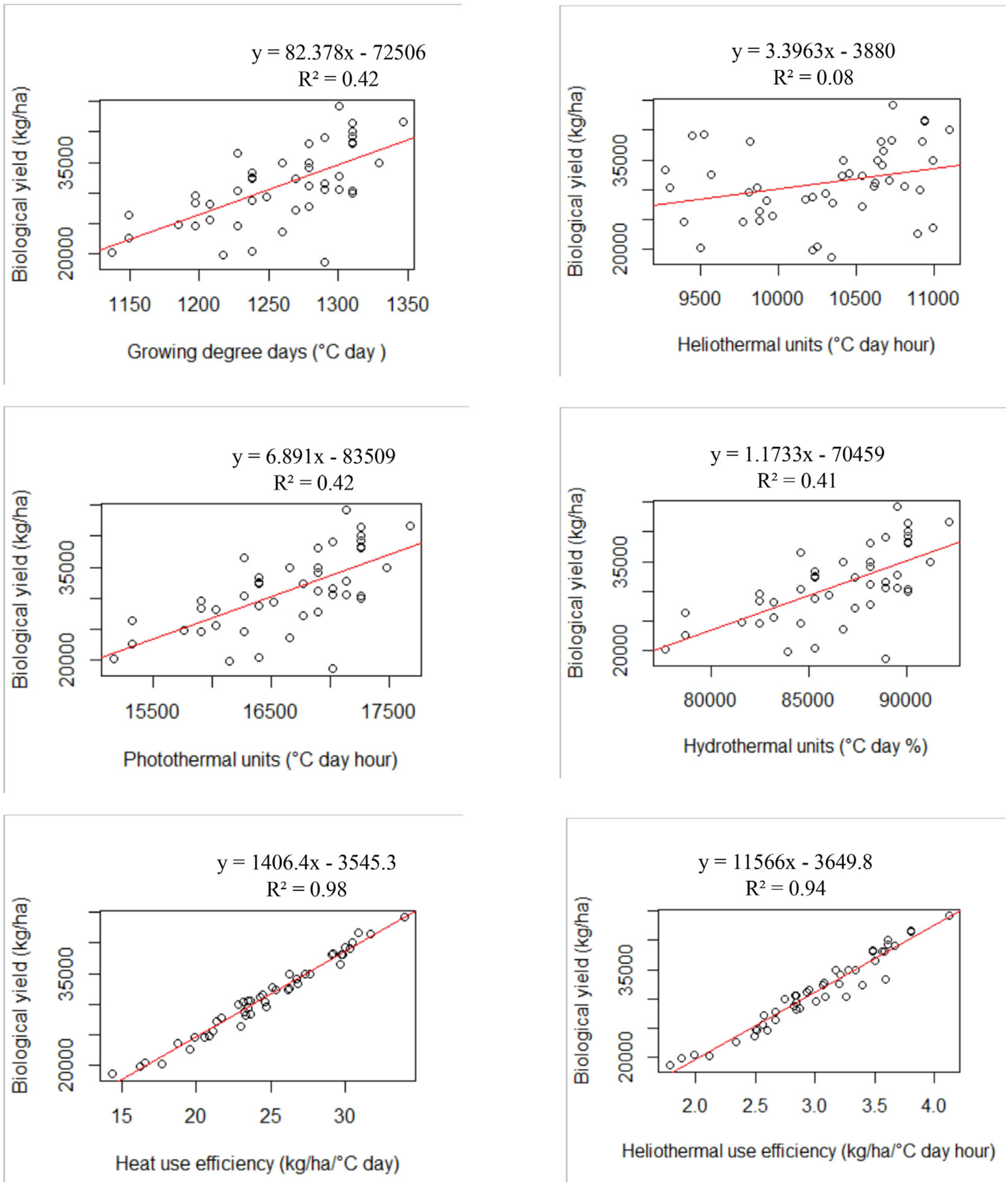

Fig. 1. Linear regression equations fitted to explain the effect of agrometeorological indices on green cob and biological yield of sweet corn.

cob and biological yield of sweet corn. Thus, it can be concluded that apart from heat requirement, heat utilization efficiency acts as a key determinant of crop yield. These results are supported by the findings of Amgain (2013) and Tauseef et al. (2015).

4. Conclusion

The results indicate that age of seedlings had significant effect on the phasic development and productivity of the crop. Duration of the growth period determines the extent of accumulation of assimilates by the crop. Besides determining the growth period of the crop, the heat utilization efficiency is also governed by the age of seedlings as explained by thermal use efficiencies, therefore transplanting at appropriate age of seedlings is recommended. Similarly, adequacy in nutrient availability lengthens the crop growth period, thus enabling the crop plant to utilize the prevailing weather conditions efficiently as indicated by thermal use efficiencies such as heat use efficiency, heliothermal use efficiency, photothermal use efficiency and hydrothermal use efficiency.

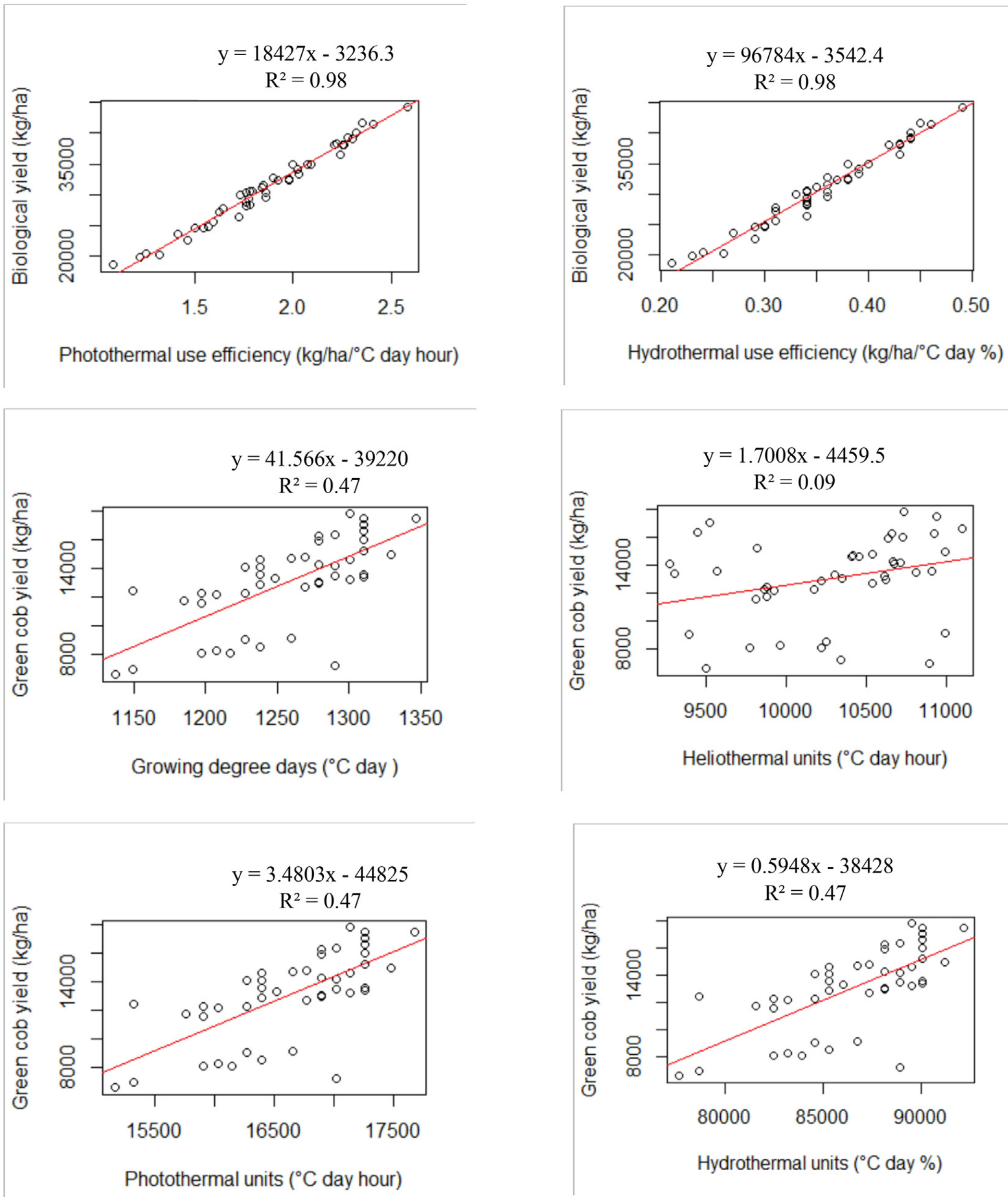

Fig. 2. Linear regression equations fitted to explain the effect of agrometeorological indices on green cob and biological yield of sweet corn.

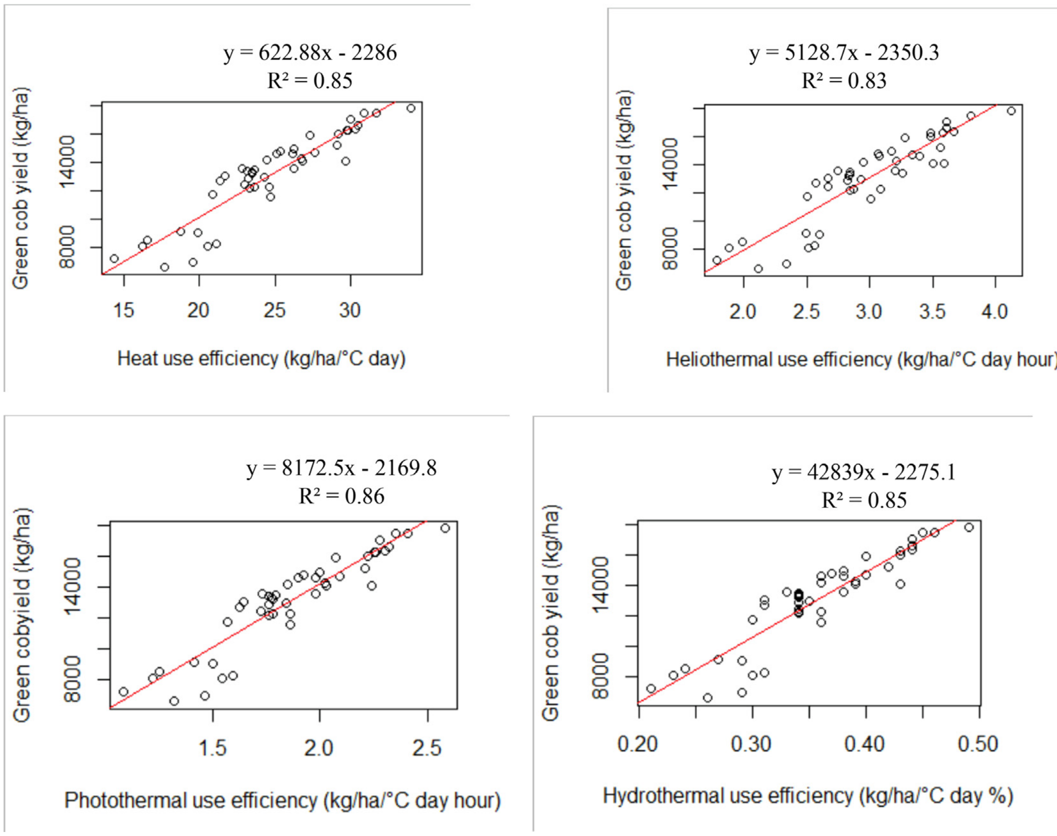

Fig. 3. Linear regression equations fitted to explain the effect of thermal use efficiencies on green cob and biological yield of sweet corn.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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