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Seasonal Influence on Phenology and Accumulated Heat Units in Relation to Yield of Baby Corn

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Abstract: Analytical study was carried out to study the influence of phenology and accumulated heat units of baby corn in different seasons. Baby corn crop was raised during late rabi 2002, kharif 2002, late rabi 2002-03 and summer 2003 seasons. The observations on days required for attainment of different phenophases viz., seedling, peak vegetative, tasseling, silking, first harvest and last harvest were recorded. Heat units such as Growing Degree Days (GDD), Photo Thermal Units (PTU), Helio Thermal Units (HTU), Relative Temperature Disparity (RTD), Heat Unit Efficiency (HUE), Photo Thermal Index (PTI) and Seasonal efficiency were worked for different seasons of baby corn. The yield obtained during four seasons of baby corn crop was related with the different heat units calculated during crop growth seasons. The results revealed that among the different indices GDD, HTU, PTU and RTD had negative relationship whereas HUE, PTI and Seasonal efficiency had positive relationship with yield of baby corn. Thus, the indices such as HUE, PTI and Seasonal efficiency are seem to be effective in taking into account and expressing the effect of varying ambient temperature on the duration between the phenological events for comparing the crop response to the ambient temperature between different phenological stages.

Key words: Baby corn, heat units, phenology, seasonal influence, cob yield

INTRODUCTION

Temperature plays a vital role in almost all biological processes of crop plants. It is one of the most important climatic events affecting the growth, phenology, development and yield of crops (Adam *et al*., 1994) as well as the third world food security. Baby corn is a newly evolved vegetable crop has great potential in Indian and International market. Though there are ample evidences that maize yields are better when the crop is sown during late rabi season (Karthikeyan, 2002), there is no such clear evidence for baby corn. Influence of different time of sowing as well as temperature on phenology and yield of crop plants can be studied under field conditions through the accumulated heat units system (Chakravarty and Sastry, 1983; Rajput *et al*., 1987; Bishnoi *et al*., 1995). Crop model can be developed for large areas to forecast the phenology and crop production attributes (Doraiswamy and Thopmson, 1982). The accuracy in prediction depends on the assessment of rate of plant development at each growth stage during the growing season. The influence of high temperature stress on the heat unit requirement of crops should be assessed in a larger area as the temperature of farms in a zone varies considerably. The relationship of phenological development of baby corn with thermal units under different seasons was studied in the present investigation.

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MATERIALS AND METHODS

The field experiments were conducted at Eastern Block Farm, Tamil Nadu Agricultural University, Coimbatore during late rabi (January-March) 2002, kharif (July-September) 2002, late rabi (December-March) 2002-03 and summer (February-May) 2003 seasons. The experimental site is located at 11°N latitude, 77° E longitude with an altitude of 426.7 m above MSL. The soil of the experimental area was sandy clay loam (*Typic Ustropept*) with alkaline pH, low in organic carbon and available N, medium in available P and high in available K during all four seasons.

The date of occurrences of different phenological events viz., seedling, peak vegetative, tasseling, silking, first harvest and last harvest were recorded when 50% of the plants in each replication reached the respective stages. The daily data on temperature (maximum and minimum) and bright sunshine hours during the crop season were obtained from Department of Agricultural Meteorology, TNAU, Coimbatore. The day length details were obtained from Rastriya Panchang (Anon., 2002-03 and 2003-04) Published by Positional Astronomy Centre, IMD, Kolkata. Baby corn yield recorded during four seasons were used for calculations.

Various heat units were calculated as follows:

$$GDD = \sum_{i=1}^{n} \frac{[T\max + T\min]}{2} - Tb \qquad \text{(Iwata,1984)}$$

$$HTU = \sum_{i+1}^{n} GDD \times SSH \qquad \text{(Rajput,1980)}$$

$$PTU = \sum_{i=1}^{n} GDD \times Daylength \qquad \text{(Major } \textit{et al}\text{., 1975)}$$

$$RTD = \sum_{i=1}^{n} \frac{Tmax - Tmin}{Tmax} \times 100 \qquad \text{(Rajput,1980)}$$

HUE = Yield ÷ GDD (Haider *et al*., 2003)
PTI = GDD ÷ Growingdays (Haider *et al*., 2003
Seasonal Efficiency = (Yield of a season ÷ Mean yield of all season)×100

Where,

GDD - Growing Degree Days
HTU - Helio Thermal Units
PTU - Photo Thermal Units
RTD - Relative Temperature Disparity
HUE - Heat Use Efficiency
PTI - Photo Thermal Index
Tmax - Maximum temperature (°C)
Tmin - Minimum temperature (°C)
Tb - Base temperature (°C) = 10°C
SSH - Bright sunshine hours

Correlation between the heat units and baby corn yield was worked out as suggested by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Days Required for Phenophases Development

Quick attainment of phenophases was noticed during summer season whereas it was delayed during late rabi 2002-2003 season (Table 1). Higher amount of solar radiation and higher daily mean temperature recorded during summer season might have induced the early attainment of phenophases of baby corn. On the other hand, during late rabi 2002-03 season, the crop was sown during December month, the days were short during most of its crop growth and the minimum temperature was very low (gone up to 14°C) which reduced the mean daily temperature. Both low mean temperature and short day length delayed all phenophases development including germination. Variation of phenophases during different time of sowing was reported earlier (Rajput *et al*., 1987; Haider *et al*., 2003). During late rabi 2002 and kharif 2002 seasons, the phenophases difference is marginal.

Growing Degree Days (GDD)

Heat units required to attain individual stages are varied with different seasons (Table 2). During kharif 2002 season, required degree days was higher to attain seedling and peak vegetative stages whereas during late rabi 2002-03 season GDD values were higher to attain the rest of later stages. However, during late rabi 2002 season, all the stages required only minimum heat units to attain the stages. High temperature during early stags of kharif season and later stages of late rabi 2002-03 seasons might have influenced for higher GDD in these stages. Whereas, during late rabi 2002 season, the climatic requirements might be optimum and hence GDD requirements was low. Correlation analysis between baby corn yield and GDD also shown negative relationship (-0.62) which indicated that GDD values under tropical climate had negative influence on baby corn yield.

Helio Thermal Units (HTU)

The HTU required to attain different phenophases are the highest during late rabi 2002-03 season (Table 3). The crop required more days to pass each phenological stage, increased the day hours and in turn HTU. The HTU requirement was lower to attain different stages during late rabi 2002 and kharif 2002 seasons. The days taken to complete each stage is minimum and lower values of degree days which in turn reduced the HTU. However, the yield levels are shown negative trend i.e., during kharif 2002 and late rabi 2002-03 seasons, baby corn yields were higher and minimum during late rabi 2002-03 season. Correlation was also negative and significant (-0.92**) between baby corn yield and HTU indicated negative relationship.

Table 1: Days taken for different phenological stages as influenced by different seasons

Season	Seedling	Peak vegetative	Tasseling	Silking	First harvest	Last harvest
Late rabi 2002	20.8	41.3	52.0	54.1	60.3	74.0
kharif 2002	20.3	42.0	52.8	54.9	61.3	76.0
Late rabi 2002-03	23.0	48.6	62.3	65.9	72.0	86.0
Summer 2003	18.4	36.9	47.6	51.3	55.7	66.0

Table 2: Accumulated growing degree days (GDD) of baby corn as influenced by different seasons at different phenological stages

Phenological stage	Late rabi 2002	Kharif 2002	Late rabi 2002-03	Summer 2003
Seedling	289.75	363.25	319.20	327.50
Peak vegetative	614.75	749.30	694.20	653.45
Tasseling	789.65	916.00	940.70	863.15
Silking	818.55	948.00	993.50	902.80
First harvest	921.05	1066.65	1117.80	1023.25
Last harvest	1171.20	1325.00	1372.05	1235.95

Table 3: Accumulated Helio thermal units (HTU) of baby corn as influenced by different seasons at different phenological stages

Phenological stage	Late rabi 2002	Kharif 2002	Late rabi 2002-03	Summer 2003
Seedling	2184.39	1992.71	2357.84	3239.84
Peak vegetative	4118.42	4280.12	6719.50	5965.60
Tasseling	5668.23	4948.15	8908.03	7414.85
Silking	5947.04	5117.90	9436.15	7809.33
First harvest	6923.06	5943.85	10615.47	8785.47
Last harvest	8047.80	7573.62	13145.02	10406.57

Table 4: Accumulated Photo thermal units (PTU) of baby corn as influenced by different seasons at different phenological stages

Phenological stage	Late rabi 2002	Kharif 2002	Late rabi 2002-03	Summer 2003
Seedling	3261.74	4550.25	3581.47	3817.44
Peak vegetative	5195.76	9364.77	7817.79	7759.50
Tasseling	7199.10	11430.88	10628.71	10317.13
Silking	7531.45	11826.40	11233.45	10802.45
First harvest	8712.90	13289.57	12661.31	12280.38
Last harvest	10432.95	16456.42	15602.69	14902.47

Photo Thermal Units (PTU)

Heat units in terms of bright sunshine hours varied to complete each phenophase of baby corn over seasons (Table 4). The PTU values were maximum to attain each stage of the crop during kharif 2002 season and minimum during late rabi 2002 season. The kharif season crop completed its life cycle early, the bright sunshine hours during July-September months were higher which increased the PTU. Whereas during late rabi 2002 season, lower duration coupled with less sunshine hours ultimately reduced the PTU values. The relationship between baby corn yield and PTU by correlation analysis was negative (-0.23) but not significant which gives an indication of negative relationship of PTU with yield under high light available tropical conditions.

Photo Thermal Index (PTI)

Heat units required to pass from one stage to another varied among the seasons (Table 5). The PTI values were higher during summer season except between last stage and the values are the lowest during late rabi 2002 season. Days required to attain the phenophases are lower in summer season and also relatively higher GDD values influenced higher PTI values. However, during late rabi 2002 season the higher growing days between the seasons in addition to lower degree days in turn reduced the PTI values. The positive relationship between PTI and baby corn yield (0.55) noticed by correlation and indicated its positive relationship.

Relative Temperature Disparity (RTD)

Late rabi 2002-03 season accumulated higher RTD values to attain each phenophase of crop whereas lower values during kharif 2002 season (Table 6). Since the RTD values are dependant on maximum and minimum temperatures during different phenophases, the late rabi 2002-03 season crop took more days to pass every phenophase in turn made more RTD values and during kharif 2002 season the results are different. Correlation results were also showing negative relationship.

Heat Use Efficiency (HUE)

The HUE-values (grain yield per degree day) were calculated and presented in Fig. 1. Higher HUE values were recorded in late rabi 2002 season. Higher HUE in this season could be attributed to the highest baby corn yield. As the temperature was optimum throughout the growing period, it utilized heat more efficiently and increased biological activity that confirms higher yield. Optimum mean temperature and short day length during late rabi 2002 season resulted in higher baby corn yield via optimum metabolic activities thereby higher HUE. In contrast, low temperature and higher duration

Table 5: Photo thermal index (PTU) of baby corn as influenced by different seasons at different phenological stages

Phenological stage	Late rabi 2002	Kharif 2002	Late rabi 2002-03	Summer 2003
Seedling	14.49	18.16	13.88	18.19
Peak vegetative	14.99	17.84	14.46	18.15
Tasseling	15.19	17.62	15.17	18.36
Silking	15.16	17.56	15.28	17.70
First harvest	15.35	17.49	15.53	18.60
Last harvest	15.83	21.72	16.33	18.73

Table 6: Relative temperature disparity (RTD) of baby corn as influenced by different seasons at different phenological stages

Phenological stage	Late rabi 2002	Kharif 2002	Late rabi 2002-03	Summer 2003
Seedling	7.36	5.51	10.03	6.78
Peak vegetative	14.13	12.33	19.94	13.09
Tasseling	18.80	14.79	24.56	16.60
Silking	19.86	15.24	25.75	17.31
First harvest	22.52	16.72	28.40	19.37
Last harvest	28.32	21.61	33.82	22.93

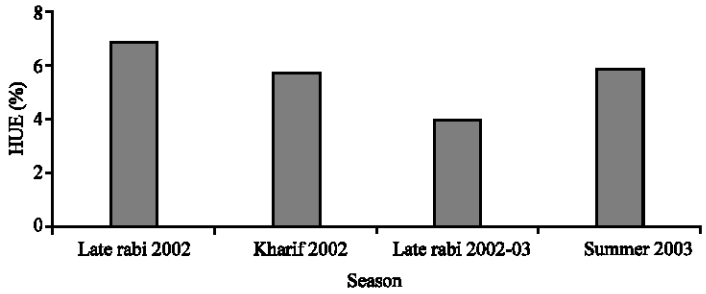

Fig. 1: Effect of HUE of different seasons

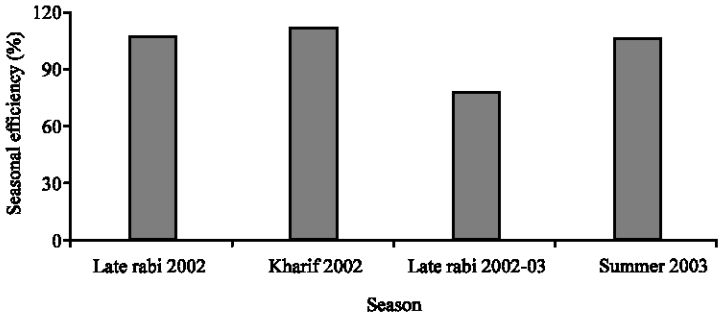

Fig. 2: Effect of seasonal efficiency of different seasons

to attain phenophases during late rabi 2002-03 season hampered normal biological activities resulted lower yield as well as lower HUE. Similar relationship was also expressed by Rajput *et al.* (1987), Paul and Sarkar (2000) and Haider *et al.* (2003) in different dates of sowing of crops. This positive relationship between HUE and baby corn yield also confirmed by correlation analysis which shown positive and significant (0.88**).

Seasonal Efficiency

Efficiency of different seasons was worked out and given in Fig. 2. The seasonal efficiency values were the highest in kharif 2002 season followed by summer 2003 and late rabi 2002 seasons. All these

seasons had efficiency values of more than 100 and hence suitable for raising baby corn crop. However, during late rabi 2002-03 season, the seasonal efficiency value was <100 which expressed the non suitability of the season.

The result of the present investigation indicates that changes in the ambient temperature for a short period reflected in all growth stages. Among the different indices, GDD, HTU, PTU and RTD had negative relationship whereas HUE, PTI and Seasonal efficiency had positive relationship with the yield of baby corn. Thus, the indices such as HUE, PTI and Seasonal efficiency are seems to be effective in taking into account and expressing the effect of varying ambient temperature on the duration between the phenological events for comparing the crop response to the ambient temperature between different phenological stages. The differences in phenothermal indices for different growth stages indicated that the accumulated temperature could be utilized for studying biomass accumulation pattern at different phenological stages which ultimately influence the crop productivity.

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