

Original Research Article

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Phenology and Yield of Baby Corn (*Zea mays* var. *rugosa*) as Influenced by Thermal Regime

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ABSTRACT

Baby corn is the ear and diversified product of maize plant harvested young, especially when the silks have either not emerged or just emerged, and no fertilization has taken place. Field experiments were conducted during October-March, 2012-13 and 2013-14 to study the impacts of thermal regime on phenology and yield of baby corn. Thermal environment during reproductive phase of baby corn contributed more towards the yield formation process, as compared to that during vegetative phases. Among yield components, ear diameter showed consistently negative correlation with thermal environment whereas cob and fodder yield showed consistently positive correlation with the thermal environment. Among weather variables during vegetative stage, maximum temperature was found to be best indicator of cob yield. The difference in heat use efficiency (HUE) values among the dates of sowing was statistically significant. Baby corn sown at 15th February recorded highest HUE vis-a-vis baby corn yield, which might be associated with the exposure of average maximum temperature beyond 35°C that favoured the crop yield level to its maximum. The growth and yield parameters of baby corn are clearly indicative that they are thermo- sensitive and the crop performs better at higher thermal regimes.

Keywords

Baby corn, Thermal regime, Phenology, Yield

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Introduction

Baby corn is the ear and diversified product of maize plant harvested young, especially when the silks have either not emerged or just emerged, and no fertilization has taken place. The dehusked young ears of baby corn are eaten as a vegetable. The important attributes relevant to baby corn are early maturity,

prolificacy (ability to produce multiple ears), synchronized ear emergence and yellow kernels (Kumar and Kallo, 1998). Ear quality, not quantity is the primary criterion of baby corn and ears should be 2–4 inches long and 1/3–2/3 inch in diameter at the base (Chutkaew and Paroda, 1994). Cultural requirement is same as that of maize but topping or detusseling is important to baby

corn for its quality ears. If topping or detusseling is not done properly, fertilization will occur which reduce the quality of corn. Baby corn can be grown throughout the year but its growth and yield potential vary across the growing season. Thermal environment during reproductive phase of baby corn contributed more towards the yield formation process, as compared to that during vegetative phases. Among yield components, ear diameter showed consistently negative correlation with thermal environment whereas cob and fodder yield showed consistently positive correlation with the thermal environment. The total accumulated heat at maturity is called Summation Constant or Remainder Index, which may predict on a long term basis the probable maturity time of a crop (Shanmugavelu, 1989).

Materials and Methods

Field experiments were conducted at the AB Block Seed Farm of Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia, West Bengal (Lat 22.99°N, Long 88.43°E) during October-March, 2012-13 and 2013-14. The present experiment was conducted with variety G-5414 in a split plot design with five levels of date of planting viz. 15th October (D1), 15th November (D2), 15th December (D3), 15th January (D4) and 15th February (D5), and three levels of plant population having three replications. Five levels of date of planting were allotted in the main plots and three levels of plant population were allotted randomly in the subplots. So, the treatment combinations are 5x3 i.e. 15, replicated thrice. Therefore, the total number of plots was 5x3x3=45. Each sub plot size was 3 X 2.25m = 6.75 sq.m, accommodating 50, 75 and 150 plants per plot for 30, 20, and 10 cm plant to plant distance, respectively. Observations taken were plant height (cm), days to 50% germination, days to 50 % flowering, cobs /plant, ear length (cm), ear diameter (cm), ear weight (g), cob yield (quintal/ha) and fodder

yield (quintal/ha). Date of occurrences of phenophases like, plant emergence, 50% flowering, emergence of cobs and harvesting were recorded. Accordingly, weather parameters and derivatives pertaining to plant emergence to 50% flowering (P₁), 50% flowering to emergence of cobs (P₂), emergence of cobs to harvesting (P₃), plant emergence to cob emergence (P₄), 50% flowering to harvesting (P₅) and plant emergence to harvesting (P₆) were also studied. Weather related parameters like, Growing Degree Day (GDD), calculated with a base temperature (T_b) of 6.6°C (Borowiecki, 1992), Heat Use Efficiency (HUE), Day Temperature (DT), Night Temperature (NT), Accumulated Diurnal Variation of Temperature (AcDVT) pertaining to those phenological stages were also estimated to study the development and productivity of the crop. Parameters were measured using following relations.

Parameter	Relationship	Reference
GDD (°C-days)	$GDD = \sum_{i=1}^n \frac{[T_{max} + T_{min}]}{2} - T_b$	-
HUE (Kg/Ha/°C)	Yield (Kg/Ha) / GDD	-
DT (°C)	TMax - 0.4 (TMax-TMin)	Venkatraman and Krishnan, 1992
NT (°C)	TMin + 0.4 (TMax-TMin)	Venkatraman and Krishnan, 1992
AcDVT	$\sum (DT - NT)$	-

The soil was sandy loam in texture with pH about 6-6.5. The crop was fertilized @ 100 kg N, 60 kg P₂O₅ and 60 kg K₂O per hectare. FYM was applied @ 20 t/ha before four weeks of sowing. Young cobs were harvested 2-3 days after silking or 60-65 days after plant emergence and the harvesting was done by hand picking.

Results and Discussion

In order to find out the degree of association between various weather parameters pertaining to phenophases of Baby corn and yield and yield components of this crop, correlation coefficients were estimated and presented in Table-1. Data revealed that phenophasic weather parameters had a statistically significant degree of association with ear diameter, cob yield and fodder yield. However, other yield components like ear length, No. of cobs/plant and cob weight had no such significant relationship. It was noted that thermal environment during reproductive phase of baby corn contributed more towards the yield formation process, as compared to that during vegetative phases.

Among these three crop parameters, ear diameter showed consistently negative correlation with thermal environment whereas cob and fodder yield showed consistently positive correlation with the thermal environment. This might be due to the fact that cobs took longer days to mature when they were sown during early to mid winter (D₁, D₂, D₃) whereas cobs took lesser number of days to mature when they were sown during late winter to early summer (D₄, D₅). During latter dates of sowing, cobs matured early mostly due to higher ambient temperature regime which favoured the cob yield and at the same time good quality cobs. Vanaja *et al.*, (2017), reported the same as higher temperature significantly lowered the time to 50% flowering and total crop duration in maize. However, during earlier dates of sowing cobs took longer time to develop as the ambient temperature was low and this favoured the crop in attaining higher cob diameter (poor quality cobs) despite lower yield at harvest. Since baby corn with small girth or diameter has more market value compare to those with large diameter, sowing of crop during late winter and early summer is preferred over early plantings.

Among the weather parameters, maximum temperature for all phenophase combinations showed consistently significant correlation with cob yield at harvest. However, other parameters pertaining to the vegetative stage of crop did not show any significant correlation with cob yield at harvest indicating thereby that the maximum temperature during vegetative phase is best indicator of cob yield. Among the weather variables, GDD and AcDVT showed poorer correlation with cob yield as compared to others. AcDVT, among the weather parameters, particularly during cob development stage showed strong negative correlation with cob yield at harvest, implying that shorter the difference between day-time and night-time thermal regime, greater will be the prospect of cob yield at harvest. El Shaer *et al.*, (1991) also reported that summer season sowings (i.e. with smaller diurnal variation of temperature) reduced the time for seedling emergence, the period to silking and physiological maturity. Growing Degree Days (GDD) required for emergence and physiological maturity were 80 and 1952 °C-days, respectively. Delaying sowing by 9 weeks reduced GDD by up to 200 °C-days. The degree of association between weather variables at various phenophases with fodder yield of baby corn showed similar trend as recorded in case of cob yield but the magnitude of correlation for most of the weather variables were little higher than those with cob yield.

In order to study the consistencies of various weather parameters pertaining to different phenophase of baby corn, coefficients of variabilities of these weather parameters were estimated across date of sowing and presented in Table-2. Study of these tables showed that CV% of most of the weather parameters were lowest during P₁ stage indicating the fact that sowing to 50% flowering stage of Baby corn received increasingly stable weather condition

as compare to other phenophases when the sowing operation was stretched from October to February. In contrast, the highest coefficients of variabilities of most of the weather parameters were recorded at P₂ phenophase, which indicated that 50% flowering to cob emergence stage of baby corn were exposed to maximum variability of weather parameters due to shift to dates of sowing from October to February. These variabilities of weather parameters at different phenophases were reflected in the variabilities of yield components of yield at harvest.

Variabilities of the duration of different phenophase across the dates of sowing were summarized and presented in Table-3. The mean duration of emergence to 50% flowering (P₁), 50% flowering to emergence of cobs (P₂) and emergence of cobs to harvest (P₃) were 59.3, 5.2 and 12.2 days, respectively.

Among the phenophases, the highest duration of P₁ stage (63.5 days) was associated with D₃, whereas the maximum duration of P₂ (6.5 days) and P₃ (14.5 days) stages were associated with D₁ date of sowing. When the entire crop growth stage was considered (P₆), the maximum duration of 82 days was associated with D₂ date of sowing. Studying the corresponding weather parameters pertaining to the different phenophase vis a vis dates of sowing, it was revealed that the duration of phenophases were mostly associated with Tmax and AcDVT.

Lowest average temperature of 25°C and highest AcDVT of 227.4°Cd was associated with the highest crop duration of 82 days, when the crop was sown during November (D₂). Duration of Baby corn growth stages, were thus, directly proportional to AcDVT and inversely proportional to average Tmax. Detailed studies from correlation coefficients across all weather parameters and phenophase

combinations, weather variables pertaining to a particular phenophase showing maximum degree of association with cob yield were identified and their impacts on cob yield were presented in more detail manner in Fig-1. Data revealed that all the weather variables corresponding to entire reproductive stage, except AcDVT, contributed substantially towards cob yield and more than 90% variability of cob yield could be attributed to each of these weather variables. Since variables showed a strong positive correlation with the cob yield within the range of values of atmospheric variables experienced during the period of experimentation, no optimum values of this weather parameter were identified. Always, the highest values of this parameter were associated with highest cob yield. Only one weather variable i.e., AcDVT during the emergence to harvest (P₃) showed a strong negative relationship with cob yield at harvest.

The relationship indicates comparatively higher difference of day and night temperature that prevails during winter period is not conducive for higher cob yield. This phenomena also corroborated by Hemalatha *et al.*, (2013), where they revealed that higher accumulation of heat units increased yield in maize, while lower accumulation of heat units resulted low yield. On the contrary, comparatively lower difference between day and night temperatures as prevailed during summer contributed positively towards cob yield at harvest. Accumulated diurnal variation of temperature during P₃ phenophase could explain 60% variability of cob yield at harvest. This relationship can well be utilized for estimating cob yield from weather information.

Heat use efficiencies as estimated from dividing cob yield with accumulated GDD values were presented in Table-4.

Table.1 Correlation coefficient between phenophasic weather parameters and yield component and yield of baby corn

	No. of Cobs/Plant						
	Tmax	Tmin	Tavg	GDD	ADT	ANT	AcDVT
P ₁	-0.28	-0.05	-0.18	-0.34	-0.18	-0.12	-0.31
P ₂	-0.43	-0.36	-0.4	-0.40	-0.35	-0.35	0.15
P ₃	-0.19	-0.21	-0.20	-0.08	-0.20	-0.20	0.30
P ₄	-0.40	-0.28	-0.35	-0.36	-0.31	-0.30	-0.33
P ₅	-0.32	-0.29	-0.30	-0.19	-0.29	-0.29	0.29
P ₆	-0.33	-0.27	-0.30	-0.34	-0.28	-0.27	-0.17
	Ear Length (cm)						
	Tmax	Tmin	Tavg	GDD	ADT	ANT	AcDVT
P ₁	-0.40	-0.27	-0.33	-0.403	-0.32	-0.30	-0.029
P ₂	-0.40	-0.42	-0.41	-0.30	-0.40	-0.42	0.40
P ₃	-0.21	-0.31	-0.27	-0.17	-0.25	-0.28	0.51
P ₄	-0.42	-0.41	-0.42	-0.406	0.40	-0.40	0.04
P ₅	-0.32	-0.38	-0.34	-0.22	-0.33	-0.35	0.51
P ₆	-0.37	-0.39	-0.37	-0.40	-0.37	-0.38	0.25
	Ear diameter(cm)						
	Tmax	Tmin	Tavg	GDD	ADT	ANT	AcDVT
P ₁	-0.40	-0.13	-0.28	-0.19	-0.27	-0.21	-0.23
P ₂	-0.81*	-0.74*	-0.74*	-0.403	-0.73*	-0.75*	0.60
P ₃	-0.79*	-0.82*	-0.80*	-0.75*	-0.80*	-0.81*	0.87*
P ₄	-0.64*	-0.60	-0.62	-0.21*	-0.61	-0.60	-0.11
P ₅	-0.77*	-0.80*	-0.80*	-0.72*	-0.79*	-0.80*	0.89*
P ₆	-0.73*	-0.72	-0.73*	-0.37	-0.72*	-0.72*	0.21
	Cob weight(g)						
	Tmax	Tmin	Tavg	GDD	ADT	ANT	AcDVT
P ₁	-0.21	-0.06	-0.14	-0.20	-0.13	-0.10	-0.18
P ₂	-0.34	-0.34	-0.34	-0.14	-0.33	-0.35	0.41
P ₃	-0.28	-0.38	-0.32	-0.27	-0.31	-0.32	0.57
P ₄	-0.31	-0.27	-0.30	-0.20	-0.29	-0.29	-0.08
P ₅	-0.32	-0.37	-0.34	-0.24	-0.33	-0.34	0.57
P ₆	-0.32	-0.32	-0.32	-0.24	-0.30	-0.31	0.14
	Cob yield(q/ha)						
	Tmax	Tmin	Tavg	GDD	ADT	ANT	AcDVT
P ₁	0.65*	0.41	0.55	0.42	0.56	0.51	0.17
P ₂	0.90*	0.94*	0.93*	0.71*	0.94*	0.94*	-0.46
P ₃	0.94*	0.95*	0.95*	0.93*	0.95*	0.95*	-0.81*
P ₄	0.87*	0.84*	0.88*	0.46*	0.88*	0.85*	0.09*
P ₅	0.95*	0.97*	0.97*	0.95*	0.98*	0.98*	0.80*
P ₆	0.94*	0.93*	0.94*	0.63*	0.95*	0.97*	-0.20*
	Fodder yield (q/h)						
	Tmax	Tmin	Tavg	GDD	ADT	ANT	AcDVT
P ₁	0.70*	0.43	0.57	0.47	0.60	0.53	0.20
P ₂	0.93*	0.97*	0.97*	0.73*	0.97*	0.97*	-0.49
P ₃	0.94*	0.95*	0.97*	0.92*	0.95*	0.97*	-0.83*
P ₄	0.91*	0.87*	0.90*	0.51*	0.9*	0.89*	0.12*
P ₅	0.97*	0.97*	0.99*	0.95*	0.99*	0.99*	-0.82*
P ₆	0.97*	0.95*	0.97*	0.68*	0.98*	0.96*	-0.20*

Table.2 Coefficients of variabilities of various weather parameters pertaining to different phenophase of baby corn across dates of sowing

	Tmax (°C)			Tmin(°C)		
	MEAN	S.D.	C.V%	MEAN	S.D.	C.V%
P ₁	27.9	3.06	10.9	14.3	3.11	21.7
P ₂	29.9	5.97	19.9	15.9	5.51	34.6
P ₃	29.6	5.39	18.2	15.5	5.68	36.5
P ₄	28.9	4.23	14.6	15.1	3.85	25.5
P ₅	29.8	5.52	18.6	15.7	5.49	34.9
P ₆	29.1	4.41	15.1	15.3	4.25	27.8
	T-avg(°C)			GDD(°C-days)		
	MEAN	S.D.	C.V%	MEAN	S.D.	C.V%
P ₁	21.1	3.00	14.2	871.3	133.39	15.3
P ₂	22.9	5.66	24.7	81.4	13.44	16.5
P ₃	22.6	5.47	24.2	186.0	36.18	19.4
P ₄	22.0	3.99	18.1	952.7	142.62	14.9
P ₅	22.8	5.45	23.9	267.4	45.67	17.1
P ₆	22.2	4.28	19.3	1138.7	157.91	13.9
	ADT(°C)			ANT(°C)		
	MEAN	S.D.	C.V%	MEAN	S.D.	C.V%
P ₁	22.4	3.04	13.56	19.7	3.05	15.5
P ₂	24.1	5.72	23.77	21.2	5.66	26.7
P ₃	24.0	5.44	22.69	21.2	5.49	25.9
P ₄	23.3	4.09	17.60	20.5	4.03	19.7
P ₅	24.0	5.45	22.68	21.2	5.46	25.7
P ₆	23.5	4.32	18.38	20.71	4.29	20.7
	AcDVT(°C-days)					
	MEAN	S.D.	C.V%			
P ₁	161.9	18.82	11.6			
P ₂	14.8	3.48	23.4			
P ₃	34.1	6.65	19.5			
P ₄	88.3	9.00	10.2			
P ₅	24.4	4.53	18.5			
P ₆	70.3	6.45	9.2			

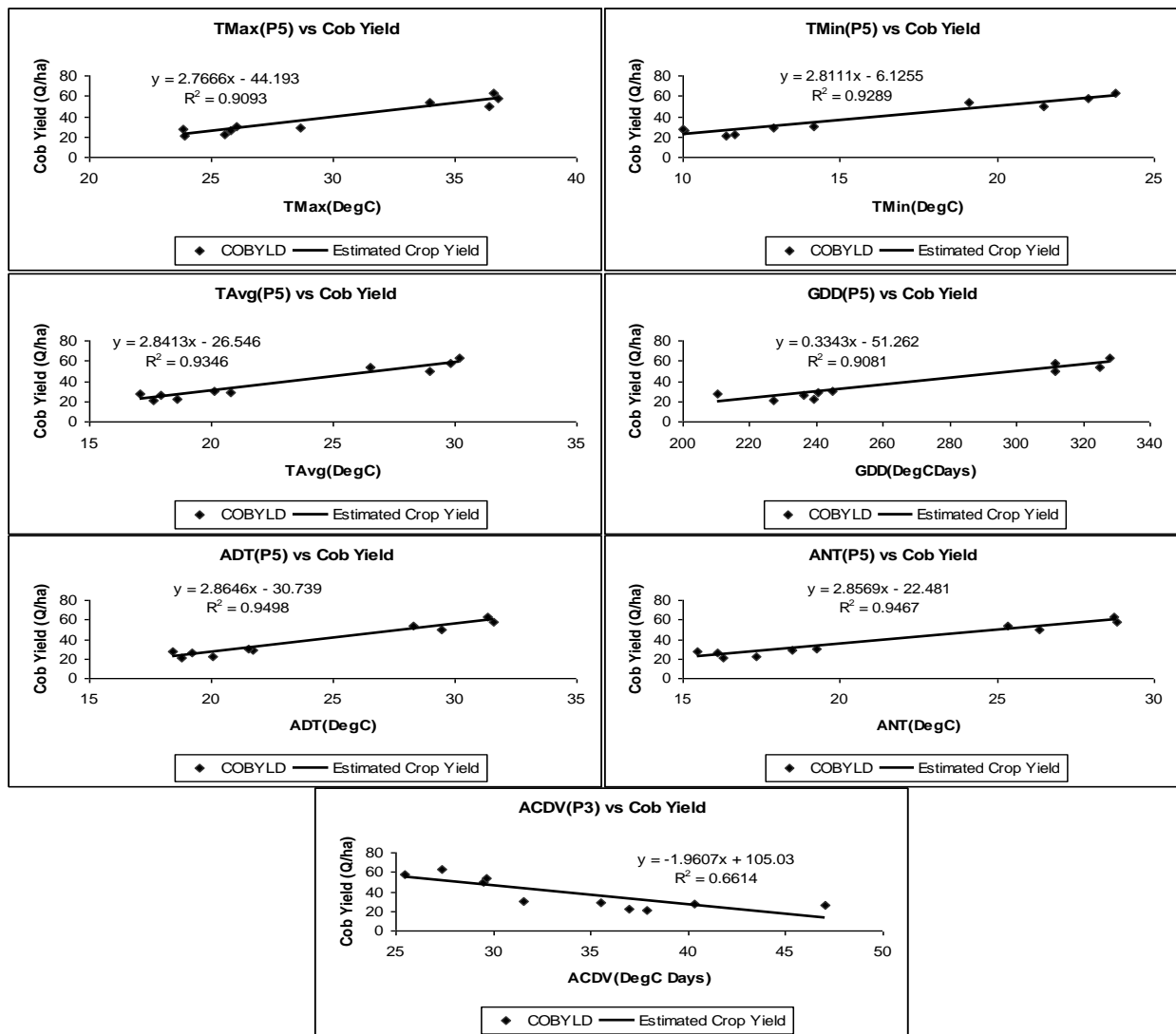
Table.3 Duration of different phenophases and their variability of baby corn as influenced by dates of sowing (Pooled for two years)

Pheno-phases	Duration of different phenophases							
	D ₁	D ₂	D ₃	D ₄	D ₅	MEAN	S.D	C.V%
P ₁	58	62	64	59	55	59.3	3.43	5.8
P ₂	7	6	5	5	4	5.2	1.04	19.9
P ₃	15	14	12	11	10	12.2	2.02	16.5
P ₄	64	68	69	63	59	64.5	3.90	6.1
P ₅	21	20	17	15	14	17.4	3.05	17.5
P ₆	79	82	81	74	69	76.7	5.37	7.0

Table.4 Heat use efficiency (kg/ha/°C days) of baby corn as a function of spacing and dates of sowing

	S ₁	S ₂	S ₃	Mean
D ₁	2.12	2.94	5.38	3.48
D ₂	1.81	2.64	5.01	3.15
D ₃	1.86	2.49	4.97	3.11
D ₄	1.91	2.62	5.09	3.21
D ₅	2.29	3.16	5.92	3.79
Mean	2.00	2.77	5.27	
	D	S	D X S	S X D
S.Em(±)	0.033	0.023	0.057	0.051
C.D.(5%)	0.109	0.07	0.162	0.167

Fig.1 Impacts of phenophasic thermal regime on the cob yield of baby corn



The difference in heat use efficiencies (HUE) values among the dates of sowing as well as among the spacing levels were statistically significant. Among the dates of sowing, maximum HUE was recorded for D5 sown crop and minimum HUE for D3 sown crop across the spacing levels. Higher HUE for baby corn crop grown during late rabi season under Tamilnadu condition was also obtained by Thavaprakash (2007). Highest HUE recorded during D5 was also associated with highest baby corn yield at this date of sowing. Sahoo and Panda (1999) got the highest yield of Baby corn in both wet and winter season. Where as, Basu *et al.*, in 2009 noted that summer sown baby corn rendered maximum yield in baby corn. Borowiecki *et al.*, (1992) reported that May sowing shortened the period from emergence to spikelet differentiation of the tassel and effective heat sums was 1299-1450 oC-days for May sowing. Baby corn sown at D5 recorded highest HUE vis-a-vis baby corn yield, which might be associated with the exposure of average Tmax of 35.4oC that favoured the crop yield level to its maximum.

In conclusion, higher average maximum temperature, even beyond 35°C, during 50% flowering to harvest stage has been found to be beneficial for higher baby corn yield. Such thermal regime was obtained when the crop was sown on 15th February in the new alluvial agroclimatic zone of West Bengal. It was also evident that equitable day-night temperature condition, as evidenced from lower values of accumulated diurnal variation of temperature, was congenial for higher baby corn yield. Yield-weather relationship studies clearly indicate that the crop is thermo- sensitive and performs better at higher thermal regimes.

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