RESEARCH ARTICLE

Seasonality in cocoa : Weather influence on pod characters of cocoa clones

■ **J.S. MINIMOL, T.K. SHIJA, NANTHITHA VASANTHAN, K.M. SUNIL, B. SUMA AND S. KRISHNAN**

SUMMARY

Cocoa (*Theobroma cacao* L.) is the only source of chocolate and worldwide number of people depends upon cocoa for their lively hood. Now the crop is spreading to non-traditional area and it is very much necessary to study the impact of environment of crop production. The present study included seven released selections from Kerala Agricultural University and observations were taken for three years 2012, 13 and 14. From performance analysis CCRP IV and CCRP VI were found to be the best varieties with big pods (440.887 g and 419.0 g, respectively) and high wet bean weight (110.02 g and 107.95 g, respectively). Increase in morning humidity resulted in small pods. Wet bean weight showed a negative correlation with temperature and positive correlation with rainfall and number of rainy days. Almost all varieties showed maximum potential during post monsoon season. Increase in pod and bean characters during post monsoon period can be attributed to favourable condition prevailed during monsoon.

Key Words : Cocoa, *Theobroma cacao* L., Seasonal influence, Pod weight, Wet bean weight, Weather

Cocoa (*Theobroma cacao* L.) is the only source of chocolate and is considered to be the greatest treasure ever discovered by man. Worldwide

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number of people depends upon cocoa for their lively hood and it comes to 40-50 million. Major cocoa growing countries have a temperature minimum 18-20°C and maximum 32°C, total annual rainfall 1500-3000 mm and relative humidity between 70-80 per cent (Wood, 1985; Prasannakumari *et al.*, 2009). Anim-Kwapong and Frimpong (2005) reported that cocoa is highly sensitive to climate change particularly temperature. Similar report was given by Daymond and Hardly (2008). They concluded that mainly bean size is affected by temperature differences.

Now cocoa is spreading to non - traditional areas. Considering the increase of area under cocoa production in each year and supply of seed materials from Kerala

Agricultural University (KAU) directly or through Mondelez International, it can be concluded that 90 per cent of India's cocoa gardens are established with planting materials from KAU. Hence, it is very much necessary to study how various varieties react to environmental changes. Hence, the present study was envisaged.

MATERIAL AND METHODS

Materials includes seven released clones of cocoa (CCRP I to CCRP VII) from KAU. They are budded and maintained at Cocoa Research Centre, KAU, Vellanikkara Thrissur, Kerala. Five plants per clones were selected and five pods per plant were collected monthly for taking observations. Observation period included three years 2012, 2013 and 2014. Observations were recorded on parameters like pod weight (g), pod length (cm), pod breadth (cm), husk thickness (mm), number of beans, number of flat beans, wet bean weight (g) and TSS (%).

To study the seasonal influence, the whole year was divided in to three seasons. Summer (Feb-May), monsoon (June-Sept) and post monsoon (Oct-Jan). Influence of season on each variety separate and pooled

was carried out. Correlation studies were also employed to see how various weather parameters influence various characters.

Statistical analysis :

The obtained data was analyzed by statistical significant at P<0.05 level, S.E. and C.D. at 5 per cent level by the procedure given by (Panse and Sukhatme, 1967).

RESULTS AND DISCUSSION

Performance analysis of all selections (CCRP I – CCRP VII) are presented in Table 1. From this CCRP IV and CCRP VI were found to be the best varieties with big pods (440.887g and 419.0 g, respectively) and high wet bean weight (110.02 g and 107.95 g, respectively). Cocoa is known to show considerable genetic variation in fruit size, shape and bean size (Bekele *et al.*, 2006).

To estimate any relation existing between pod and bean characters and weather parameters correlation studies were carried out. Weather parameters considered were maximum temperature (^{0}C), minimum temperature (^{0}C), RH morning (%), RH evening (%), rainfall (mm), number of rainy days and mean sunshine hours. Results

Table 1 : Performance analysis of cocoa selections

Clones	Pod wt (g)	Pod length (cm)	Pod breadth (cm)	Husk thickness (cm)	No. of beans	No. of flat bean	Wet bean wt (g)	TSS (%)
CCRP I	360.981	14.199	7.601	0.938	42.269	1.269	92.197	19.059
CCRP II	414.069	11.964	8.371	1.139	36.826	1.815	80.696	18.664
CCRP III	281.944	12.911	7.480	0.756	36.209	3.594	87.180	17.641
CCRP IV	440.887	14.375	7.861	0.986	37.665	2.087	110.002	19.265
CCRP V	377.833	11.093	7.916	0.960	42.281	1.083	94.030	18.519
CCRP VI	419.000	11.301	7.823	0.938	50.315	1.781	119.986	19.524
CCRP VII	393.111	12.672	7.696	0.939	47.433	2.033	107.950	20.356
CV (%)	8.030	4.010	3.210	5.390	5.350	48.300	6.790	3.700
C.D. (P=0.05)	22.220	0.365	0.181	0.037	1.613	0.680	4.842	0.507

Table 2 : Correlation of weather parameters with pod weight (g)

Clones	Max- temperature	Min- temperature	RH morning	RH evening	Rainfall	Rainy days	Mean sunshine hours
CCRP1	0.364*	-0.161	-0.741**	-0.627**	-0.693**	-0.624**	0.662**
CCRP2	0.124	-0.447**	-0.557**	-0.431**	-0.457**	-0.408**	0.488**
CCRP3	0.105	-0.375*	-0.581**	-0.425**	-0.502**	-0.424**	0.463**
CCRP4	0.194	-0.354*	-0.606**	-0.481**	-0.493**	-0.458**	0.507**
CCRP5	0.088	-0.473**	-0.587**	-0.397**	-0.411**	-0.376*	0.430**
CCRP6	0.035	-0.461**	-0.470**	-0.314*	-0.325*	-0.285	0.351*
CCRP7	0.197	-0.133	-0.582**	-0.420**	-0.517**	-0.433**	0.429**
Combined	0.142	-0.328*	-0.540**	-0.405**	-0.440**	-0.392**	0.437**

* and ** indicate significance of values at P=0.05 and 0.01, respectively

Table 3 : Correlation of weather parameters with pod length (cm)

Clones	Max- temperature	Min- temperature	RH morning	RH evening	Rainfall	Rainy days	Mean sunshine hours
CCRP1	0.529**	-0.024	-0.714**	-0.701**	-0.685**	-0.681**	0.719**
CCRP2	0.443**	-0.199	-0.719**	-0.668**	-0.629**	-0.643**	0.683**
CCRP3	0.185	-0.322*	-0.565**	-0.467**	-0.496**	-0.463**	0.483**
CCRP4	0.449**	-0.190	-0.763**	-0.681**	-0.638**	-0.657**	0.685**
CCRP5	0.154	-0.411**	-0.528**	-0.406**	-0.367*	-0.376*	0.416**
CCRP6	0.211	-0.294*	-0.535**	-0.429**	-0.391**	-0.401**	0.424**
CCRP7	0.361*	-0.278	-0.774**	-0.641**	-0.649**	-0.633**	0.643**
Combined	0.274*	-0.186	-0.522**	-0.457**	-0.439**	-0.440**	0.464**

* and ** indicate significance of values at P=0.05 and 0.01, respectively

Table 4 : Correlation of weather parameters with pod breadth (cm)

Clones	Max- temperature	Min- temperature	RH morning	RH evening	Rainfall	Rainy days	Mean sunshine hours
CCRP1	0.052	-0.136	-0.247	-0.210	-0.299*	-0.230	0.246
CCRP2	0.160	-0.495**	-0.567**	-0.440**	-0.402**	-0.407**	0.478**
CCRP3	0.054	-0.440**	-0.456**	-0.331*	-0.333*	-0.320*	0.357*
CCRP4	0.331*	-0.331*	-0.719**	-0.603**	-0.574**	-0.575**	0.631**
CCRP5	0.197	-0.401**	-0.583**	-0.449**	-0.405**	-0.422**	0.473**
CCRP6	0.148	-0.382**	-0.522**	-0.380*	-0.338*	-0.350*	0.386**
CCRP7	0.452**	0.063	-0.566**	-0.530**	-0.535**	-0.530**	0.522**
Combined	0.167	-0.296*	-0.474**	-0.377*	-0.369*	-0.362*	0.398**

* and ** indicate significance of values at P=0.05 and 0.01, respectively

Table 5 : Correlation of weather parameters with husk thickness (cm)

Clones	Max- temperature	Min- temperature	RH morning	RH evening	Rainfall	Rainy days	Mean sunshine hours
CCRP1	0.016	-0.496**	-0.435**	-0.318*	-0.337*	-0.302*	0.347*
CCRP2	-0.067	-0.655**	-0.428**	-0.282	-0.295*	-0.257	0.328*
CCRP3	-0.222	-0.591**	-0.166	-0.052	-0.067	-0.042	0.080
CCRP4	0.137	-0.495**	-0.540**	-0.447**	-0.447**	-0.427**	0.490**
CCRP5	0.025	-0.572**	-0.542**	-0.375*	-0.416**	-0.363*	0.431**
CCRP6	-0.085	-0.665**	-0.397**	-0.241	-0.255	-0.221	0.300*
CCRP7	0.158	-0.306*	-0.484**	-0.408**	-0.482**	-0.416**	0.442**
Combined	-0.008	-0.476**	-0.370*	-0.261*	-0.280*	-0.249	0.298*

* and ** indicate significance of values at P=0.05 and 0.01, respectively

Table 6 : Correlation of weather parameters with number of beans

Clones	Max- temperature	Min- temperature	RH morning	RH evening	Rainfall	Rainy days	Mean sunshine hours
CCRP1	0.398**	0.103	-0.530**	-0.507**	-0.548**	-0.515**	0.502**
CCRP2	0.274	0.315*	-0.040	-0.152	-0.133	-0.155	0.172
CCRP3	0.623**	0.749**	-0.261	-0.441**	-0.474**	-0.461**	0.419**
CCRP4	0.563**	0.602**	-0.355*	-0.436**	-0.479**	-0.450**	0.436**
CCRP5	0.397**	0.332*	-0.374*	-0.398**	-0.460**	-0.405**	0.407**
CCRP6	0.072	0.440**	0.345*	0.154	0.143	0.144	-0.179
CCRP7	0.372*	0.343*	-0.227	-0.283	-0.272	-0.280	0.281
Combined	0.254*	0.292*	-0.113	-0.182	-0.196	-0.188	0.179

* and ** indicate significance of values at P=0.05 and 0.01, respectively

are presented in the Tables 2-9. Pod weight showed maximum correlation with RH morning in almost all varieties. When humidity in morning is increased, decrease in pod weight was recorded. For bean weight a negative correlation was observed with temperature and positive correlation with rainfall and number of rainy days. In general cumulative effect of temperature, rainfall, humidity and sunshine hours have impact on cocoa yield (Ojo and Sadiq, 2010).

To study the seasonal influence, observations taken in the three years (2012, 2013 and 2014) were pooled and data are presented in the Fig. 1-8. Almost all varieties showed maximum potential during post monsoon season. Increase in pod and bean characters during post monsoon period can be attributed to favourable condition prevailed

during monsoon (Egbe and Owolabi, 1972). Similar report was also given by Rubeena (2015) in her studies. Most of the varieties showed increase in bean number during summer. This cannot be considered as a good character because large number of beans with small weight is not desirable (Prasannakumari et al., 2005). TSS was high during summer indicating that low water content in the pulp may be contributing to high level of TSS (%). Flat bean which is actually unfertilized ovule is more during monsoon period. Heavy rain may be the inhibiting factor for proper fertilization.

Cocoa selections showed large pods and high wet bean weight (g) during post monsoon due to the favourable conditions prevailed during monsoon. Pod weight was more during summer when compared to

Table 7 : Correlation of weather parameters with number of flat beans

Clones	Max- temperature	Min- temperature	RH morning	RH evening	Rainfall	Rainy days	Mean sunshine hours
CCRP1	-0.504**	-0.109	0.536**	0.542**	0.484**	0.518**	-0.540**
CCRP2	-0.564**	-0.079	0.568**	0.606**	0.512**	0.573**	-0.607**
CCRP3	-0.652**	-0.562**	0.458**	0.580**	0.614**	0.585**	-0.581**
CCRP4	-0.553**	-0.541**	0.368*	0.487**	0.552**	0.500**	-0.498**
CCRP5	-0.378*	-0.351*	0.351*	0.387**	0.482**	0.403**	-0.401**
CCRP6	-0.235	-0.138	0.053	0.177	0.113	0.154	-0.190
CCRP7	-0.539**	-0.243	0.565**	0.584**	0.597**	0.577**	-0.585**
Combined	-0.464**	-0.307*	0.389**	0.452**	0.467**	0.450*	-0.458

* and ** indicate significance of values at P=0.05 and 0.01, respectively

Table 8 : Correlation of weather parameters with wet bean weight (g)

Clones	Max- temperature	Min- temperature	RH morning	RH evening	Rainfall	Rainy days	Mean sunshine hours
CCRP1	-0.123	-0.533**	-0.374*	-0.176	-0.224	-0.171	0.216
CCRP2	-0.417**	-0.292	0.313*	0.378*	0.334*	0.369*	-0.323*
CCRP3	-0.652**	-0.562**	0.458**	0.580**	0.614**	0.585**	-0.581**
CCRP4	-0.178	-0.481**	-0.242	-0.063	-0.065	-0.048	0.068
CCRP5	-0.147	-0.681**	-0.382**	-0.154	-0.133	-0.122	0.217
CCRP6	-0.273	-0.462**	-0.093	0.081	0.057	0.095	-0.071
CCRP7	-0.229	-0.492**	-0.262	-0.016	-0.055	-0.014	0.016
Combined	-0.197	-0.417**	-0.142	0.005	-0.017	0.013	0.019

* and ** indicate significance of values at P=0.05 and 0.01, respectively

Table 9 : Correlation of weather parameters with TSS (%)

Clones	Max- temperature	Min- temperature	RH morning	RH evening	Rainfall	Rainy days	Mean sunshine hours
CCRP1	0.820**	0.461**	-0.641**	-0.783**	-0.729**	-0.783**	0.735**
CCRP2	0.766**	0.505**	-0.544**	-0.699**	-0.656**	-0.706**	0.646**
CCRP3	0.759**	0.749**	-0.345*	-0.549**	-0.489**	-0.561**	0.501**
CCRP4	0.862**	0.505**	-0.624**	-0.771**	-0.667**	-0.761**	0.729**
CCRP5	0.128	0.368*	0.232	0.069	0.161	0.079	-0.131
CCRP6	0.853**	0.665**	-0.482**	-0.680**	-0.592**	-0.675**	0.625**
CCRP7	0.449**	0.058	-0.377*	-0.480**	-0.372**	-0.455**	0.460**
Combined	0.655**	0.456**	-0.405**	-0.558**	-0.483**	-0.554**	0.513**

* and ** indicate significance of values at P=0.05 and 0.01, respectively

monsoon but wet bean yield was low due to low moisture content. The study conducted by Prameela (1997) also states that improved pod and bean character were observed during November-December months.
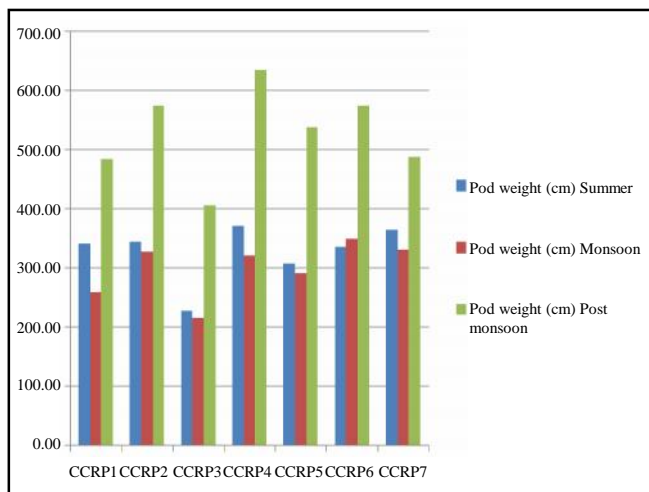
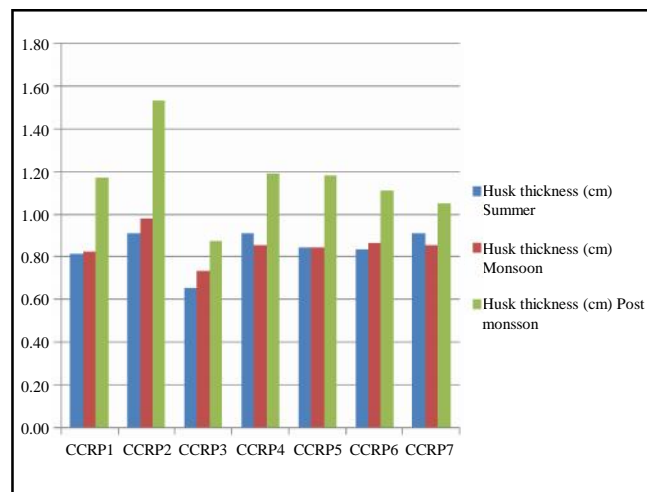Fig. 1: Variation in pod weight (g) in three different seasons

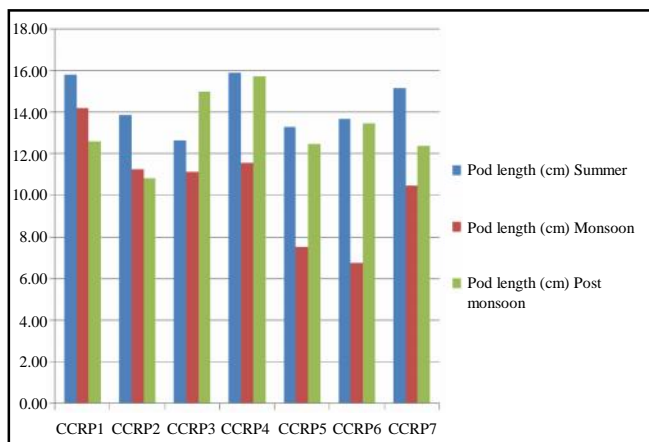Fig. 4 : Variation in husk thickness (cm) in three different seasons

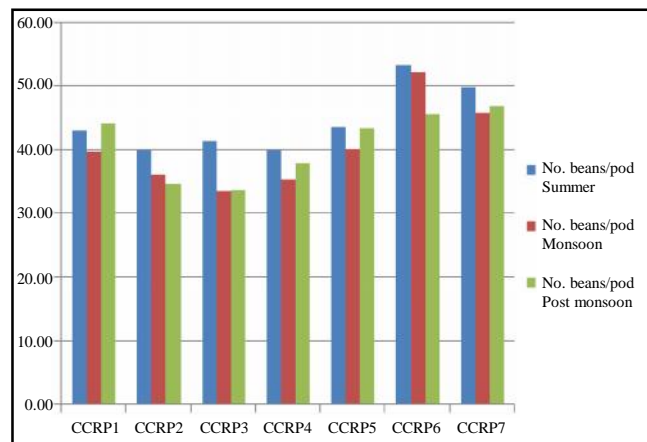Fig. 2: Variation in pod length (cm) in three different seasons

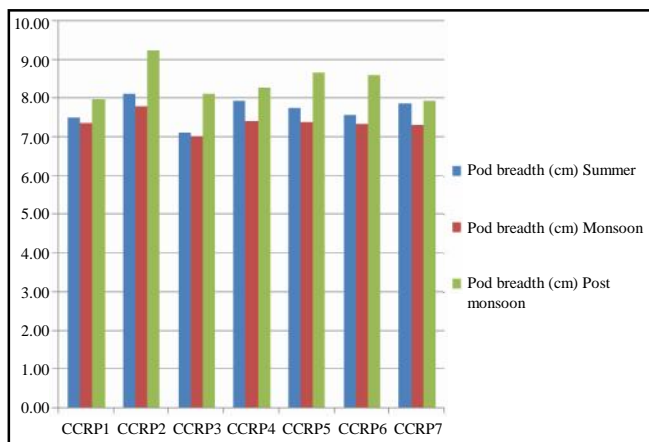Fig. 5 : Variation in number of beans in three different seasons

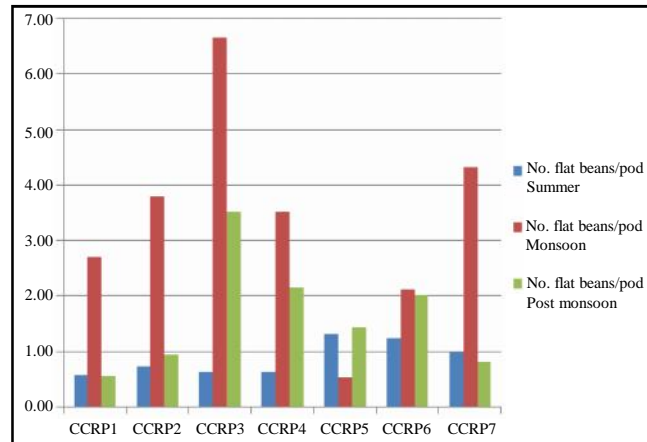Fig. 3: Variation in pod breadth (cm) in three different seasons

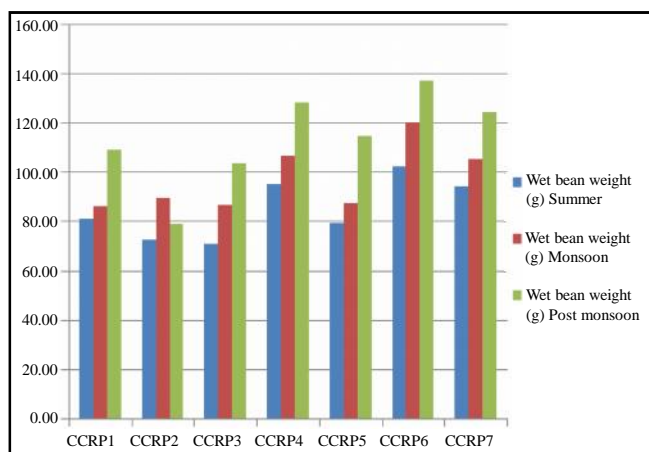Fig. 6 : Variation in number of flat beans in three different seasons

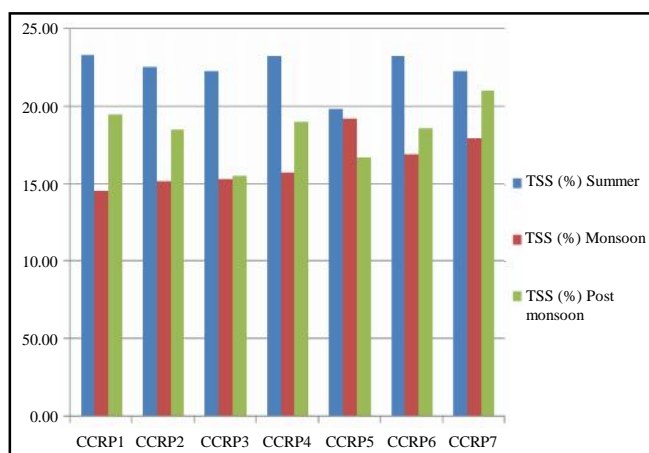**Fig. 7 : Variation in wet bean weight (g) in three different seasons**

Fig. 8 : Variation in TSS (%) in three different seasons

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