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STABILITY ANALYSIS FOR DRY MATTER PRODUCTION AND YIELD COMPONENTS OF COCONUT IN TWO AGROCLIMATIC REGIONS OF INDIA

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SUMMARY

Environmental factors influence productivity of the coconut palms and contribute to fluctuations in nut yield. Analysis of stability parameters assumes significance as it provides information about adaptability of a cultivar to a particular agro-climatic condition. Stability in dry matter production and yield characteristics of four cultivars of coconut (ECT, WCT, LCT, COD) growing at two agro-climatic regions were analysed. In general, dry matter production and yield components were higher in palms growing at eastern costal plains-hot sub humid region (Veppankulam) than at western ghats-hot sub humid per humid region (Kidu). At Kidu region, LCT exhibited stability in dry matter production, while WCT was stable in yield and yield components. At Veppankulam region, LCT produced relatively higher and stable dry matter and yield components indicating the adaptability of this cultivar to this agro-climatic region.

***Key words*: Coconut, dry matter, harvest index, stability analysis, yield.**

INTRODUCTION

Consistency in yield characteristics is an important feature desired by plant breeders. Studies on genotype environment interactions and stability of yield components assume significance as it can provide valuable information about adaptability of a cultivar to a particular region (Crossa 1990, Rafii *et al*. 2001) and help to identify the production constraints at different agro-climatic regions. Environmental factors like rainfall, temperature, relative humidity, solar radiation and other soil factors influence the plant growth and productivity. These factors, vary spatially and also temporally, even at a given location.

In India, coconut is grown in about 1.84 million hectares with a productivity of 6847 nuts per hectare (http://coconutboard.nic.in/statisti.htm). The coconut growing area in India is spread along the entire coastal belt and falls under different agro-climatic regions. In general, the palms require a mean annual temperature of 27^{o}C, a rainfall of 1000 to 3000 mm distributed throughout the year, and 120 hours of sunshine per month for proper growth and yield (Child 1974, Murray 1977). The distribution of rainfall is more important than the quantum of total rainfall received (Peiris and Peiris 1993, Rajagopal *et al.* 1996).

Though coconut is adapted to grow in a wide range of climatic and soil conditions, its productivity varies at different agro-climatic conditions and even within a location during different years. Coconut cultivars show variation in their ability for dry matter production (Corley 1983, Kasturi Bai *et al.* 1996), which is an important parameter determining the final yield of the palms. Similarly, the copra out turn of the palms also varied with climatic

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conditions (Santos *et al.* 1986) indicating the sensitivity of these factors to meteorological variables. Stability in nut yield and copra production are important characters desired during mother palm selection.

Various attempts have been made to study the genotype x environment interactions of perennial crops like tea (Ng'etich and Stephens 2001) and oil palm (Ong *et al.* 1985, Ataga 1993). Balakrishnan *et al.* (1991) and Muralidharan *et al.* (1993) studied the stability of nut yield in coconut cultivars at west coast region. A similar attempt was made by Patil *et al*. (1991) on the Konkan region in western India. Even though a few reports are available on the stability of nut yield of coconut cultivars at different locations (Khan *et al.* 2002), no work has been done to analyse coconut cultivars for its stability for factors contributing to nut yield. Identification of suitable cultivars for specific locations is very important considering the long yielding phase of coconut for obtaining high and stable yield for longer duration. The present study is planned to understand the stability of coconut cultivars for dry matter and yield characteristics at two different agro-climatic regions.

MATERIALS AND METHODS

Data have been collected from palms growing at two agro-climatic locations - western ghats - hot sub humid per humid region (Central Plantation Crops Research Institute, Research Centre, Kidu, Dakshina Kannada district, Karnataka) and eastern coastal plains - hot sub humid region (Coconut Research Station, Veppankulam, Thanjavur district, Tamil Nadu). The cultivars selected are East Coast Tall (ECT), West Coast Tall (WCT), Laccadive Ordinary (LCT) and Chowghat Orange Dwarf (COD). ECT and WCT are the local tall cultivars of Veppankulam and Kidu region respectively, where as, LCT is a popular high yielding tall cultivar native of Lakshdweep islands of Arabian sea, and COD is a dwarf cultivar from Chavakkad region of Thrissur district of Kerala, India, used mainly for tender nut. All experimental palms are of same age group and have attained stabilized yield stage. Based on uniformity of palms in growth and morphology, six palms were selected per cultivar for recording observations. Palms are maintained as monocrop under normal agronomic practices recommended for respective locations.

Vegetative (stem and leaf) dry matter production was estimated using the non-destructive methods developed for coconut (Ramadasan and Mathew 1987). Annual reproductive dry matter was calculated by adding dry weights of nuts, spathes and bunches produced in a year, and annual total dry matter (TDM) production by adding annual vegetative and reproductive dry matter. Due to practical difficulty root dry matter was not considered while estimating total dry matter. Annual nut yield was recorded from each palm and copra weight was determined at 6% moisture, from 16 mature nuts/ cultivar collected during summer months. Annual copra production was estimated using copra weight and nut yield data. Since coconut is a perennial crop with continuous productivity, the term annual productivity index (API) is used instead of harvest index (Ramadasan and Mathew 1987). It is worked out by taking into account annual increment in dry matter production and expressed as the ratio of the dry weight of the economic product to total dry matter production in a year. API is calculated for both nut dry matter and copra production (Kasturi Bai 1993). All the observations were taken for three years from 1999 to 2001.

Stability analysis was done using Eberhart and Russel (1966) and Perkins and Jinks (1971) models to identify the cultivars with stable performance over years at each location. The cultivars were analyzed for their stability in dry matter production, nut yield and yield components in a given location. Cultivars with relatively high mean value, low variance of mean and a regression coefficient near to unity are considered as stable in a given environment.

RESULTS AND DISCUSSION

Weather data of the experimental period show fluctuations in meteorological variables, especially in the case of temperature and rainfall (Table 1). Annual fluctuations in weather factors are more in Kidu than at Veppankulam. Kidu (12.67^{o}N and 75.6^{o}E, 291 m above MSL), falling under western ghats - hot sub humid per humid region, is a high rainfall area where the overall

Table 1. Weather parameters at two agro-climatic regions during the experimental period.

Location	Year	Weather parameters (Annual mean)				
		Max temp. (°C)	Min temp. (°C)	RH (%)	Rainfall (mm)	Rainy days (No.)
Kidu	1999	33.5	21.8	89.5	3159	143
	2000	34.2	22.6	88.5	2546	130
	2001	32.1	23.5	90.3	3030	137
Veppankulam	1999	32.6	25.2	73.2	990	48
	2000	32.6	26.3	75.7	1154	50
	2001	31.7	26.0	75.6	1079	48

annual mean precipitation is 2989 mm compared to Veppankulam (10.29°N and 79.23°E, 20 m above MSL), falling under eastern coastal plains – hot sub humid, where the overall annual mean is only 1117 mm. Fluctuations in mean day/night temperatures were more at Kidu (33.2/16.6°C) compared to Veppankulam (32.6/22.1°C). High humidity prevails at Kidu throughout the year with mean RH around 90% compared to a 75% of Veppankulam. Soil type is red laterite at Kidu with 5.2 pH, while at Veppankulam, the soil type is sandy loam with 6 pH.

Annual total dry matter production varied from 39.4 to 94.3 kg palm^{-1}year^{-1} at western ghats - hot sub humid per humid region (Kidu) for different coconut cultivars during the experimental period (Table 2). Even though average TDM production was higher in WCT at this region, variance of mean also was higher in this cultivar (Table 3). On the other hand, LCT had low variance of mean (88.6) and regression coefficient near to unity compared to other cultivars. This cultivar maintained relatively higher TDM production also (77.0 kg palm^{-1}year^{-1}). Mean annual nut yields of WCT and LCT was on par at this location. However, WCT had low variance of mean for nut yield compared to other cultivars. Annual copra production varied from 6.9 to 16 kg palm^{-1} year^{-1} with COD producing less amount of copra compared to tall cultivars. Local tall cultivar WCT produced more amount of copra at Kidu and had low variance of mean. The annual productivity indices also were higher in this cultivar. In COD, the

Table 2. Dry matter production, yield and yield components of coconut cultivars at two agro-climatic regions (Range).

Location	Cultivar	Parameters (range)				
		TDM#	Nut yield*	Copra#	API for copra production	API for Nut DM
Kidu	ECT	65.4-86.8	59-82	10.2-14.2	0.158-0.168	0.54-0.57
	WCT	77.3-94.3	74-93	12.7-16.0	0.167-0.180	0.63-0.68
	LCT	71.5-87.1	76-105	11.2-15.3	0.156-0.176	0.57-0.65
	COD	39.4-47.7	46-59	6.9-8.9	0.162-0.182	0.53-0.58
Veppankulam	ECT	84.6-94.3	104-120	12.0-13.9	0.142-0.146	0.60-0.62
	WCT	94-108.9	131-162	15.4-19.0	0.166-0.176	0.61-0.66
	LCT	99.7-103.6	126-139	17.1-18.9	0.172-0.182	0.66-0.72
	COD	36.8-49.1	82-88	7.0-10.2	0.181-0.214	0.62-0.70

Kg palm^{-1} year^{-1}, * Nuts palm^{-1} year^{-1}

Table 3. Stability analysis table for TDM production, yield and yield components of coconut cultivars at Kidu.

Parameter/Cultivar	Cultivar mean	Variance of mean	Regression coefficient		S^2 di	Mean square deviation (SD)
			E & R* model	P & J** model		
1. TDM (Kg palm^{-1} year^{-1})						
ECT	73.0	269.6	1.51	0.51	34.2	24.0
WCT	85.9	122.0	0.88	-0.12	42.3	32.1
LCT	77.0	88.6	0.90	-0.10	4.03	-6.1
COD	45.3	59.9	0.71	-0.29	7.10	-3.0
Mean	70.3					
SE	3.3					
2. Nut yield (Nuts palm^{-1} year^{-1})						
ECT	67.3	312.7	1.06	0.06	93.0	78.8
WCT	85.8	159.1	0.58	-0.42	93.4	79.2
LCT	88.6	362.0	1.34	0.34	12.5	-1.7
COD	51.1	210.3	1.01	0.01	12.7	-1.5
Mean	73.2					
SE	5.1					
3. Annual copra production (Kg palm^{-1} year^{-1})						
ECT	11.7	9.51	1.17	0.17	2.78	2.40
WCT	14.8	4.75	0.63	-0.37	2.81	2.42
LCT	13.0	7.80	1.24	0.24	0.27	-0.12
COD	7.7	4.81	0.96	-0.04	0.28	-0.11
Mean	11.82					
SE	0.88					
4. API for nut dry matter production						
ECT	0.56	0.0	0.46	-0.54	0.0	0.0
WCT	0.65	0.0	0.47	-0.53	0.0	0.0
LCT	0.63	0.0	1.80	0.80	0.0	0.0
COD	0.54	0.0	1.27	0.27	0.0	0.0
Mean	0.59					
SE	0.012					
5. API for copra production						
ECT	0.16	0.0	0.55	-0.45	0.0	0.0
WCT	0.18	0.0	0.50	-0.50	0.0	0.0
LCT	0.17	0.0	1.49	0.49	0.0	0.0
COD	0.17	0.0	1.46	0.46	0.0	0.0
Mean	0.17					
SE	0.005					

* Eberhart and Russel model, **Perkins and Jinks model.

regression coefficient was near to unity for nut yield and copra production. Annual productivity indices did not fluctuate much during the experimental period and variance of mean was zero for these parameters.

At Veppankulam (eastern coastal plains – hot sub humid region), mean dry matter production was at par in the tall cultivars WCT and LCT. However, LCT had low variance of mean and regression coefficient relatively closer to unity for this parameter (Table 4). Nut yields were higher in WCT at this location but the annual variations also were more in this cultivar (131-162 nut palm^{-1}year^{-1}). As a result, this cultivar had highest variance of mean. Here, LCT gave good results for stability analysis with lowest variance of mean and regression coefficients near to unity compared to other cultivars. This cultivar also was a high yielder at eastern coastal plains - hot sub humid region, next only to WCT. Annual copra production was comparatively similar in WCT and LCT at this agro-climatic region, while the variance of mean and regression coefficient values were desirable for LCT. Both annual productivity indices were higher in LCT at Veppankulam. However, the regression coefficients were near to unity in ECT and WCT at this region.

High and stable dry matter production and yield performance are desirable traits of cultivars in any crop improvement strategies. This also gives information about the adaptability of a cultivar to a particular location (Crossa 1990, Rafii *et al*. 2001). Genotypic variations in dry matter production characteristics of coconut have been reported earlier (Corley 1983, Kasturi Bai *et al.* 1996). In the present study, fluctuations were also observed in dry matter and yield during different years at both locations, which could be due to genotype-environment interactions (Magat *et al.* 1988, Ataga 1993). Coconut cultivars growing at Veppankulam region are superior in dry matter production and nut yield. However, such difference has not been found in TDM production of dwarf cultivar COD. Although dry matter production was higher in WCT at Kidu region, high variance obtained for this cultivar indicates fluctuations with climatic conditions. Another tall cultivar LCT had regression coefficient close to unity and low variance, at the same time producing relatively higher dry matter, characters ideal for a stable cultivar (Eberhart and Russel 1966). However, high nut yield with low variance in WCT indicate the stability of local cultivar over years. Further, stability of WCT for copra production at this location also is apparent. Even though other cultivars also showed desirable stability parameters for some of the characters under consideration, low cultivar mean values indicate their poor performance at respective regions (Ataga 1993).

In general, both WCT and LCT are performing well at eastern coastal plains – hot sub humid region, in terms of dry matter and yield characteristics. However, WCT palms lack the stability for these characters, in spite of producing higher TDM and nuts. On the other hand, LCT had low variance of mean and a regression coefficient near to unity for these parameters indicating its adaptability to this region. This cultivar also produced steadily high amount of copra at this location, which is a major economic product of coconut. In general, cultivar with very high production exhibited larger annual fluctuations, suggesting that cultivar with highest production need not be a stable yielder. A stable variety is one which performs relatively better under adverse conditions and reasonably well in favourable environments (Eberhart and Russel 1966). At both agro-climatic regions, variance of mean was higher for nut yield, indicating its sensitivity to climatic factors compared to other characters studied. Weather factors during various stages of nut development have considerable impact on fluctuations in annual yield (Rajagopal *et al.* 1996).

Annual productivity index (API) has been considered as an important criterion for selection in crop improvement programmes (Donald and Hamblin 1976) as it indicates the efficiency of dry matter partitioning to economically useful parts of the crop. The importance of API and its relationship with dry matter production characteristics has been established in coconut (Kasturi Bai *et al.* 1996). Since, many parts of coconut are economically useful, different annual productivity indices can be calculated. At Kidu region, API for nut dry matter production was high and relatively stable in the local cultivar WCT, where as at Veppankulam, it was stable in LCT over years, supporting the stability in nut production of these cultivars at respective locations. Higher API for copra production observed in LCT and WCT demonstrate the better nut composition of these cultivars. WCT is

Table 4. Stability analysis table for TDM production, yield and yield components of coconut cultivars at Veppankulam.

Parameter/Cultivar	Cultivar mean	Variance of mean	Regression coefficient		S^2 di	Mean square deviation (SD)
			E & R* model	P & J** model		
1. TDM (Kg palm^{-1} year^{-1})						
ECT	91.4	40.5	-1.51	-2.51	21.7	-27.9
WCT	106.2	135.2	1.31	0.31	151.0	101.4
LCT	104.2	48.4	1.68	0.68	25.0	-24.6
COD	44.6	59.5	2.52	1.52	6.9	-42.6
Mean	86.6					
SE	5.06					
2. Yield (Nuts palm^{-1} year^{-1})						
ECT	116.0	62.38	-1.79	-2.79	3.26	-169.91
WCT	156.0	613.2	3.25	2.25	427.77	251.6
LCT	138.3	12.12	-0.16	-1.16	11.68	-164.49
COD	79.4	346.17	2.70	1.7	217.91	41.74
Mean	122.4					
SE	9.11					
3. Annual copra production (Kg palm^{-1} year^{-1})						
ECT	13.4	0.83	-1.76	-2.76	0.10	-2.78
WCT	18.3	8.43	3.15	2.15	6.06	3.18
LCT	18.8	0.23	-0.16	-1.16	0.22	-2.66
COD	9.2	4.68	2.77	1.77	2.84	-0.04
Mean	14.9					
SE	1.1					
4. API for nut dry matter production						
ECT	0.62	0.0	1.46	0.46	0.0	0.0
WCT	0.64	0.0	6.89	5.89	0.0	0.0
LCT	0.71	0.0	-1.08	-2.08	0.0	0.0
COD	0.67	0.0	-3.26	-4.26	0.0	0.0
Mean	0.67					
SE	0.025					
5. API for copra production						
ECT	0.15	0.0	-0.29	-1.29	0.0	00
WCT	0.17	0.0	-0.55	-1.55	0.0	0.0
LCT	0.18	0.0	-4.74	-5.74	0.0	0.0
COD	0.20	0.0	9.58	8.58	0.0	0.0
Mean	0.17					
SE	0.004					

* Eberhart and Russel model, **Perkins and Jinks model.

considered as a relatively stable cultivar with high nut and copra yield at west coast region (Muralidharan *et al*. 1993). Though COD had higher API's, it cannot be considered for suitable large-scale plantations due to low nut yield and copra content. However, this cultivar has been released for tender nut production.

When all the parameters are considered together, local tall cultivar WCT performed better at western ghats-hot sub humid per humid region (Kidu), showing high and stable dry matter and yield characteristics. Earlier, in a study using non-parametric measures, WCT and LCT were identified as stable cultivars at west coast region (Balakrishnan *et al*. 1991). LCT produced steadily high dry matter and nuts at eastern coastal plains-hot sub humid region (Veppankulam). WCT is a local tall variety in western region and has under gone generations of selections thus bringing about the stability in performance of this cultivar in western coasts of India. This region has high rainfall as compared to that of eastern coast. On the other hand the LCT, which is introduced into main land from Lakshadweep, is found to be more tolerant to stressful conditions like drought (Rajagopal *et al*. 1990). The LCT in Lakshadweep is continuously subjected to salt sprays and inundation with sea water. This might have caused LCT to develop the tolerance to salt and drought conditions over a period of time. These seems to have contributed for the stable performance of LCT in eastern region, a less rain fall zone compared to western zone. However, the performance of ECT was comparatively inferior to other tall cultivars at both locations. ECT is a local tall in eastern coastal coconut growing areas and is generally grown with irrigation and well managed conditions. Such situations might have caused ECT be less adaptive to new environments. Since LCT is a good combiner for annual nut yield (Nampoothiri *et al*. 1999), this can be used as parent for breeding for high and stable nut yield. Also, LCT was found suitable for input intensive cultivation (Khan *et al*. 2002).

In conclusion, the results suggest that, WCT and LCT can produce higher nut yield over a period of time, respectively at Kidu and Veppankulam regions, indicating their adaptability to respective locations. The study emphasizes the need of stability analysis for assessing suitability of a cultivar to a particular location and for selecting the parental lines for breeding for specific traits.

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