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Seasonal Influence on the Quality and Yield of Four Different Cassava Varieties Grown in the Central Midland Agro-ecological Zone of Kerala

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A B S T R A C T

Studies on crop-weather relations in cassava varieties were carried out for three plantings *viz.*, May, October and December at Agronomy farm, College of Horticulture, Vallanikkara. Four varieties of two short-duration, (VellayaniHraswa and SreeVijaya) and two normal- duration varieties, (M_4 and SreeAthulya) were grown under rainfed conditions. The result revealed that variety SreeAthulya was the high yielder for all the three plantings but was on par with M_4 and SreeVijaya for May planting. However, cyanogenic glucoside content was found to be higher for SreeAthulya. The most ideal month for planting was found to be May, followed by October. Correlation studies with yield and weather parameters suggest that the yield influencing weather parameters at early crop establishment period were maximum temperature, minimum temperature, rainfall and relative humidity, placing the most promising varieties as SreeVijayaand M_4. From this study it was also concluded that May planting was the most ideal month of planting cassava, followed by October planting.

Introduction

Global climate change tends to unfold with respect to temperature and soil moisture within the tropics and environmental stress is resulted (IPCC, 2014). So as to fulfil the future food demand, cultivation needs to be extended to poorer soil and more parched regions. Future increase in frequency and intensity of drought due to climatic change, especially in most agriculturally productive zones around the world is envisioned. Cassava is one among the foremost important staple foods in the tropics and is well-known for withstanding challenging environmental conditions with little need for active agronomic management relative to other crops. In Kerala, cassava is a vital crop and therefore the state stands second within the country with a production of 26,62,000 tonnes (FIB, 2018). The role of cassava in the food security of the state is more prominent today with ever declining area and production under rice. Presently, cassava is gaining popularity as a connoisseur dish in high class restaurants. It is grown mainly as a rainfed crop, but planting is done throughout the year to ensure year long availability.

Even though the crop can withstand relatively prolonged periods of drought, it is sensitive to soil water deficit during the first three months after planting. In southern India, its water requirement is put at 400 to 750 mm for a 300-day production cycle. But higher yields have been obtained with much higher levels of water supply. Water stress during later stages of crop growth causes reduced yield and quality of tubers. Little is known about the effect of inadequate water at different stages in varieties of varying duration and this key information would help to choose varieties suitable to specific agro-ecological location. Therefore the present experiment was planned to study the crop-weather relations in cassava under moisture stress and to identify varieties of varying duration under inadequate water in different plantings.

Materials and Methods

Field experiments were conducted with three seasons of planting in 2015-16 at Agronomy farm of College of Horticulture Vellanikkara, Kerala Agricultural University, Thrissur. The experiment was laid out in Randomized Block Design with three plantings *viz.*, May, October and December, with 4 varieties. Two short duration (VellayaniHraswa and SreeVijaya) and two normal duration (M_4 and SreeAthulya), varieties were chosen. A brief description of varieties is given in Table 1. The package of practices recommendations of the Kerala Agricultural University (KAU, 2011) was followed for raising the crops. The crops in the first two plantings were entirely rainfed. In third season (December), irrigation was provided for two weeks to facilitate sprouting and to avoid prolonged dry spell. The site enjoys a typical humid tropical climate. Data on weather conditions that prevailed during the experimental periods are illustrated in Fig**.** 1. During the period of the first experiment, a total of 5694.20 mm of rainfall was obtained, of which 2191.20 mm was received during the period of the first crop, 1809.60 mm during the second crop and 1693.40 mm during the third crop. Observations were made on yield and yield attributes and correlated with weather parameters of three plantings *viz.*, rainfall, maximum-minimum temperature, and mean evaporation for all three seasons. The analysis was done by satisfying analysis of variance using WASP statistical software. For getting precision in the crop-weather effect, variety and month of planting were taken as main and sub factor respectively and calculated using split plot analysis.

Results and Discussion

Quality parameters

Quality of each variety was determined for the three seasons *viz.*, May, October and December and I presented in Table 2. Seasonal comparisons of different cassava varieties with regard to starch, total sugar content and cyanogenic glucoside were done. The data indicated that significantly higher starch content was observed for SreeAthulya (26.26 %) among varieties. May planted cassava varieties had significantly higher starch content for (26. 28 %), and was followed by October planting (23.98 %). Effect of varieties x month of planting interaction indicated that the long duration variety SreeAthulya, when planted during May had significantly higher starch content (29.73 %) and was comparable with M_4 planted during May (29.16 %).

Varietal effect was significant for total sugar content with highest value recorded for SreeVijaya (0.74 mg/g) and was followed by variety VellayaniHraswa (0.65 mg/g). Though significantly higher starch content was present, sugar content wasfound to be less for the variety SreeAthulya (0.56 mg/g). Analysis of seasonal effect revealed that higher total

sugar content was for December planting (0.88 mg/g) and the lowest was for May planting with a total sugar content of 0.37 mg/g. SreeVijaya and VellayaniHraswa planted in December recorded significantly higher total sugar content (0.99 and 0.90 mg/g respectively). Depending on environmental condition a negative correlation between starch and sugar was noted. A better sink-source relationship might have favoured the high starch variety to have more sugar transformation into starch (Lu, 2005). The decrease in total sugar in varieties might have possibly led to a decrease in metabolic activity and thereby helped to conserve energy and resource under moisture stress. The results here indicated that the total sugar in all cassava varieties was highest in the crops planted in December which received low rainfall compared to other two plantings.

The results indicated that the highest cyanogenic glucoside content was noted for long-duration variety SreeAthulya (90.60 ppm) compared to all other varieties. The high cyanogenic glucoside content in variety SreeAthulya could be attributed to its varietal character added to the seasonal effect, with highest content produced during dry season, (Cigleneki *et al.,* 2011).While considering the seasons of planting, significantly higher HCN content was noted for December planting when rainfall was comparatively less and significantly lower for May planting. The per cent increase in cyanogenic glucoside content for December planting was 53.84 compared to May planting. Cyanogenic glucoside content and bitterness of varieties were found to progressively increase from May to October to December planting season. Interaction effect indicated that lowest cyanogenic glucoside content was recorded for long-duration variety M_4 (45.14 ppm) and short-duration variety VellayaniHraswa (43.19 ppm) planted during May, which were comparable. Here, cyanogenic glucoside content has a positive correlation with total and reducing sugar since cyanogenic glucosides such as linamarin are formed by the association of cyanohydrins, stabilized by the attachment of sugars with free hydrogen cyanide (Agbor-Egbe and Lape-Mbome, 2006).

Yield and yield attributes

Considering the yield attributes of cassava, significantly longer tubers, tuber girth and tuber number were observed for long-duration variety SreeAthulya (44.89cm, 12.20 cm and 9.67 respectively) and the lowest was recorded for the short-duration variety VellayaniHraswa (Table 3). Tuber length, girth and number of tubers of different cassava varieties was significantly influenced by the month of planting, with significantly greater length and girth recorded for cassava varieties planted during May (41.21 cm, 12.20 cm respectively). However number of tubers was higher when planted during October season.

Normal-duration variety SreeAthulya had significantly higher yield of 27.67 t/ha, followed by M4 (23.58 t/ha) and SreeVijaya (20.61 t/ha), whereas short duration variety, VellayaniHraswa was observed to have lowest yield per ha (18.11 t/ha) (Table 4). Comparing the seasons, May planting registered a significantly higher yield (27.82 t/ha) followed by planting in October (21.82 t/ha), with lowest yield of 17.84 t/ha for December planting. Interaction effect showed that SreeAthulya when planted during May recorded significantly higher yield (36.00 t/ha) and followed by M_4planted in May (32.57 t/ha). Among short-duration varieties, SreeVijaya planted in October recorded significantly higher yield (25.39 t/ha) and was on par with normal-duration variety SreeAthulya planted in the same month (23.86 t/ha).

Table.1 Description of varieties of cassava

Varieties	Pedigree and source	Description
VellayaniHraswa	College of Agriculture, Vellayani, Thiruvanathapuram, Kerala Agricultural University	Early maturing variety (5-6 months duration) Not drought tolerant The tubers are reddish brown in colour with good cooking quality.
SreeVijaya	Variety released from Central Tuber Crops Research Institute, Sreekaryam. It is a selection from the germplasm of cassava.	Short-duration, high yielding The tuber flesh colour turns light yellow after cooking. Average yield : 25-28 t/ha Starch content : 25-30%.
M_4	Local variety procured from farmers field, Vellanikkara	Erect type with excellent cooking quality having 10 months duration. The starch content is 29 %.
SreeAthulya	Triploid cassava hybrid released fromCentral Tuber Crops Research Institute, Sreekaryam.	High yielding variety with high Average yield : 39 t/ha Starch content : 34.80 % SreeAthulya is ideal for cassava based industries

Source : (CTCRI, 2014;KAU, 2011)

Table.2 Seasonal influence on quality attributes of cassava varieties

Month of planting/Variety	Starch (%)					Total sugar content (mg/g)					Cyanogenicglucoside content (ppm)				
	VellayaniHraswa	SreeVijaya	M_4	SreeAthulya	Mean	VellayaniHraswa	SreeVijaya	M_4	SreeAthulya	Mean	VellayaniHraswa	SreeVijaya	M_4	SreeAthulya	Mean
May	25.97	22.26	27.16	29.73	26.28	0.36	0.47	0.32	0.32	0.37	43.19	63.03	45.14	79.96	57.83
October	21.03	24.80	23.69	26.36	23.98	0.67	0.76	0.60	0.56	0.65	70.06	61.60	84.13	83.20	74.75
December	18.43	24.83	18.96	22.56	21.20	0.90	0.99	0.80	0.79	0.88	92.10	72.76	81.90	109.12	88.97
Mean	21.81	23.97	23.28	26.22		0.65	0.74	0.58	0.56		68.45	65.80	70.39	90.76	
CD (0.05) **Variety: 1.78** **Month of planting :1.59** **Variety x month of planting :3.19**						CD (0.05) Variety CD(0.05) : 0.04 Month of planting CD (0.05): 0.04 Variety x month of planting :0.09					CD (0.05) Variety CD(0.05) : 7.14 Month of planting CD (0.05): 4.71 Variety x month of planting :9.42				

Table.3 Seasonal influence on yield attributes of cassava varieties

Month of planting/Variety	Tuber length (cm)					Tuber girth (cm)					Number of tubers per plant				
	VellayaniHraswa	SreeVijaya	M_4	SreeAthulya	Mean	VellayaniHraswa	SreeVijaya	M_4	SreeAthulya	Mean	VellayaniHraswa	SreeVijaya	M_4	SreeAthulya	Mean
May	40.68	34.43	45.40	44.33	41.21	6.26	6.36	11.63	12.40	12.20	8.00	5.97	9.00	9.00	7.99
October	25.95	32.00	40.45	39.04	34.36	6.62	12.13	7.80	14.06	9.17	9.02	12.97	7.80	11.00	10.20
December	33.16	30.93	36.23	51.13	37.80	6.49	8.60	9.25	10.13	10.16	6.49	7.00	10.00	9.00	8.12
Mean	33.27	32.46	40.69	44.89		6.46	9.03	9.56	12.20		7.84	8.65	8.93	9.67	
CD (0.05) **Variety : 3.90** **Month of planting : 2.18** **Variety x month of planting :4.37**						CD (0.05) Variety : 0.86 Month of planting : 0.60 Variety x month of planting :1.20					CD (0.05) Variety : 0.76 Month of planting : 0.51 Variety x month of planting :1.06				

Table.4 Seasonal influence on yield of cassava varieties

Month of planting/Variety	Yield (t/ha)				
	VellayaniHraswa	SreeVijaya	M_4	SreeAthulya	Mean
May	21.26	21.43	32.57	36.00	27.82
October	18.25	25.39	19.76	23.86	21.82
December	14.80	15.00	18.40	23.13	17.84
Mean	18.11	20.61	23.58	27.67	
CD (0.05) **Variety: 2.40** **Month of planting :1.32** **Variety x month of planting : 2.65**					

Fig.1 Weather conditions during the three plantings

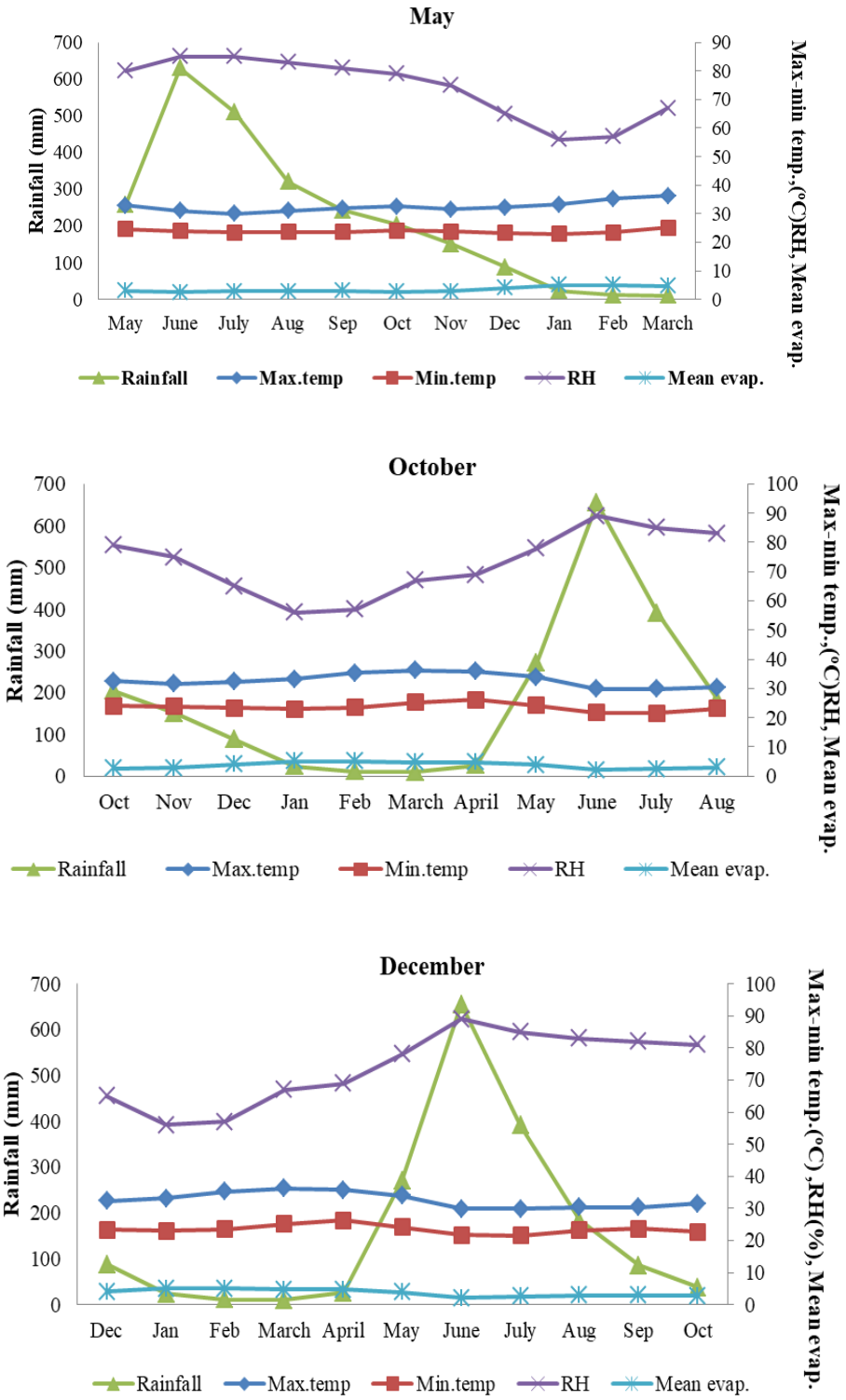

Table.5 Correlation of yield of short- duration varieties with HCN, total starch and weather parameters

Months After Planting	HCN	Starch	Max. temp	Min.temp	Rainfall	RH	Mean eavp.
VellayaniHraswa							
2 MAP	-0.635	0.947	-0.759	0.801**	0.790*	0.791*	-0.700
4 MAP	-0.635	0.947	-0.814**	-0.526	0.732*	0.665	-0.751*
6 MAP	-0.635	0.947	-0.567	-0.807**	0.255	0.265	-0.523
SreeVijaya							
2 MAP	-0.623	0.414	-0.784	0.691*	0.387	0.723*	-0.844**
4 MAP	-0.623	0.414	-0.609	-0.894**	0.212	0.071	-0.262
6 MAP	-0.623	0.414	0.094	-0.664	-0.472	-0.44	0.061

MAP-Months after planting, ** Correlation is significant at the 0.01 level (2-tailed); * Correlation is significant at the 0.05 level (2-tailed)

Table.6 Correlation of yield of normal- duration varieties with HCN, total starch and weather parameters

Months After Planting	HCN	Starch	Max. temp	Min. temp	Rainfall	RH	Mean eavp.
M_4							
2 MAP	-0.835**	0.753*	-0.600	0.721*	0.902**	0.685*	-0.475
4 MAP	-0.835**	0.753*	0.739*	-0.190	0.930**	0.924**	-0.926**
6 MAP	-0.835**	0.753*	-0.888**	-0.748*	0.678*	0.684*	-0.865**
8 MAP	-0.835**	0.753*	-0.034	0.095	-0.562	-0.655	0.126
10 MAP	-0.835**	0.753*	0.918**	0.349	-0.589	-0.912**	0.897**
SreeAthulya							
2 MAP	-0.424	0.453	-0.531	0.654	0.848**	0.617*	-0.406
4 MAP	-0.424	0.453	0.793*	-0.190	0.930**	0.924**	-0.926**
6 MAP	-0.424	0.453	-0.888**	-0.748*	0.678*	0.684*	-0.865**
8 MAP	-0.424	0.453	-0.032	0.095	-0.562	-0.310	-0.111
10 MAP	-0.424	0.453	0.918**	0.349	-0.589	-0.912**	0.899**

MAP-Months after planting ,** Correlation is significant at the 0.01 level (2-tailed); * Correlation is significant at the 0.05 level (2-tailed)

Lowest yields were observed for SreeVijaya (15 t/ha) and VellayaniHraswa (14.80 t/ha) planted in December. For all the varieties and seasons greater tuber length, girth and number of tubers were recorded for the normal-duration varieties, which might have added to the significant higher yield of the varieties. The yield increase in the two 10 month duration varieties as compared to the shorter duration varieties might have been due to the availability of rainfall throughout the planting season, and longer durations. Tuber bulking in cassava is a continuous process (Ramanujam, 1990) and longer duration of crop under favourable environmental conditions led to more tuber yield. Again, lesser amount of assimilate deposition required for storage root formation in a taller variety like SreeAthulya under water stress might have been a reason for more yield per plant for this variety (El- Sharkawy and De Tafur, 2010).

The variation in yield was related to the precipitation distribution within season, with dry and wet spells being key determinants of crop yield. Root yield of cassava from the crop with initial water stress, *i.e.*, in December planting, was found to be lowest. Lower root yield and starch content in crops planted after the rainy period have been reported by Sriroth *et al.*, (2001).

Crop-weather relations

Correlation of yield with maximum-minimum temperature, total rainfall, mean evaporation and relative humidity was analyzed. Significant positive correlation of minimum temperature, rainfall and relative humidity with yield of VellayaniHraswa at initial growth stages was noted (Table 5). Orimoloye and Adigun (2017) also reported these parameters to be most important during the initial stage of crops growth. Significant negative correlation with maximum temperature and mean evaporation and positive correlation with rainfall was observed in VellayaniHraswa at tuber bulking stage. SreeVijaya variety was found to be negatively correlated with minimum temperature. However, the effect of maximum temperature and rainfall with yield was not seen on the same.

Significant positive correlation of rainfall and relative humidity with tuber yield in initial stages was noted with normal-duration cassava varieties. At tuber bulking stage (6MAP), significant negative correlation of tuber yield with maximum and minimum temperature was observed in both M_4 and SreeAthulya (Table 6). A positive impact of rainfall and relative humidity was noted for the varieties.

The main yield influencing weather parameters were thus identified to be maximum and minimum temperature and rainfall. However, the variety SreeVijaya was seen to be not influenced by prevailing weather conditions indicating the high adaptability of the variety. Consistently better yield performance in the entire season places this variety as most promising for all seasons.

Considering the stages of crop growth, a positive effect of rainfall in both short and normal-duration varieties was significant just after planting, stressing the necessity of sufficient moisture at this period, and justifies the better performance of the crop when planted during the south- west and north-east monsoon seasons (*ie.*, May and October). Temperature being linked to rainfall, was also more favourable during the two plantings, with lower maximum and minimum temperature prevailing. Any temperature extreme condition experienced during the two seasons might have been compensated by spells of wet weather resulting in higher yield, as noted by Kahsay and Hansen (2016).
However, in case of normal- duration varieties, at maturity and harvest stages, a drier weather condition was seen to promote tuber yields as evident from the negative correlation with rainfall and mean relative humidity and positive correlation with low rainfall and high mean evaporation. This again was typical of the prevailing weather conditions if the cassava crop had been planted in the most ideal month *i.e.*, May.

From this study it could be concluded that short- duration variety SreeVijaya and normal-duration variety M_4 were the most promising varieties, since they were found to be more adaptable to changing weather parameters. Even though, variety SreeAthulya recorded highest yield during May and December plantings, qualitatively it could be regarded only as the second ordered variety since it is not suitable for edible purpose. The most ideal month for planting was identified as May, followed by October. Correlation

between yield and weather parameters suggested that yield influencing weather parameters at early crop establishment period were maximum temperature, minimum temperature, rainfall and relative humidity. Reduced maximum and minimum temperature, high rainfall and high relative humidity were desirable at this stage.

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