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EFFECT OF DIFFERENT IRRIGATION LEVELS AND FREQUENCIES ON GROWTH, FLOWER ABSCISSION AND YIELD OF PIMENTO AND CONGO PEPPER *(CAPSICUM CHINENSE* JACQ) IN TRINIDAD

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ABSTRACT: Pimento and Congo peppers are both important commercial crops in Trinidad but depend on irrigation for cultivation during the drier months. An experiment was conducted to compare six irrigation treatments (630 ml of water per plant per day and 950 ml of water per plant per day applied daily, every two days and every three days) on both landraces of pepper (Pimento and Congo). The crops were planted in January 2006 and harvesting was observed from April to July 2006. Comparison was made with a non-irrigated plot placed next to the experiment. The weather conditions were dry until the onset of the rainy season in late June. All plants in the non-irrigated plot died, but all of the irrigated plots gave pepper yields. However, there were no significant differences (P>0.05) in yield between the six irrigation treatments. The landraces were observed for differences in yield and size. Both landraces yielded similar amounts in April and June, but Pimento out-yielded Congo in May and July. Congo pepper fruits were generally larger than Pimento in the earlier harvests, especially for the plots with the higher irrigation amounts, but fruit sizes were similar in the later harvests. It was observed that there was a negative correlation between the number of flower abscission scars and fruit yield, and a positive correlation between the number of scars and fruit sizes. There were generally more flower abscission scars on Congo as compared to Pimento. Monthly yields were very variable; the June yields for Congo were only the equivalent of 6,000 kg/ha, but were at least six times that amount in May and July. Pimento yields were similar to Congo in May and July, but higher than Congo during June. The results show that both Congo and Pimento can be grown in dry conditions and the water requirements are not more than 630 ml/plant/day.

Keywords: Pepper landraces, Irrigation, Trinidad

INTRODUCTION

Pimento and Congo hot pepper are two landraces indigenous to Trinidad and Tobago. They both belong to the Solanaceae family, genus *Capsicum*, and the species *chinense*. Both types of pepper are exported and widely used in fresh and processed forms in the preparation of various culinary dishes. These peppers have been recognized for their pungency, aromatic qualities, unique, distinct flavours, and rich colour. These landraces are also well adapted to the country's hot, humid climate and appear to be tolerant to prevailing fungal, bacterial and viral disease infestations.

The hot pepper and Pimento industry in Trinidad and Tobago comprised 500 registered farmers with the National Agricultural Marketing and Development Company (NAMDEVCO) in 2006. A total of 1,293.8 metric tonnes of peppers was exported in 2006 mainly to the USA and Canada (Central Statistical Office, 2008). This produce was valued at TT$11,897,962.00 (TT$6.33 = US$1.00).

Hot pepper is one of the priority crops identified as having a competitive advantage on the export market. It is also one of seven commodities that constitute the Regional Transformation Programme (RTP) coordinated by the CARICOM Secretariat. It is intended that both Pimento and hot pepper will generate new internationally value-added products for local and international markets.

In Trinidad and Tobago, irrigation water is arbitrarily applied to pepper and other crops. This practice may be attributed to the dearth of research on yield response to water, under local growing conditions, and consequent absence of recommendations to growers.

Water is becoming a scarce commodity, not only in arid and drought-prone areas, but also in regions where water was once abundant (Pereira et al., 2002). Some territories in the Caribbean are experiencing frequent and prolonged droughts. This scarcity has been blamed on the global climate change phenomena. There is need to maximize the productive potential of the limited land resources through irrigation, using low cost, simple technologies on small farms. Consequently, studies were undertaken on a marginal soil, Piarco Fine Sand of the Long Stretch Series (Brown and Bally, 1966), to determine the effects of various levels and frequencies of irrigation on growth, flower abortion and yield parameters of Pimento and Congo hot pepper.

MATERIALS AND METHODS

This study was conducted in Trinidad at the Central Experiment Station, Centeno, Ministry of Agriculture, Land and Marine Resources (MALMR) (10° 35´N, 61°20´W). Seeds from two landraces, Congo pepper and Pimento pepper were sown in speedling trays containing peat moss and perlite. These landraces were used in this study because they are widely known, grown, marketed and consumed in Trinidad and Tobago.

The seeds were sown on December 8, 2005; 28 days later (January 5, 2006), uniformed, hardened seedlings, 15 cm in height, with four developed true leaves were transplanted. The flat block of land was prepared by ploughing and rotovating with beds 15 cm high and drains 30 cm wide and 15 cm deep. The inter-plant and inter-row spacing were 60 cm x 75 cm respectively (approximately 22,000 plants per hectare). The distance between plots was 75 cm. The planting holes were drenched with Banrot® to control soil-borne fungi. Each plant was irrigated with 400 ml water from a calibrated container for a period of four weeks after transplanting. This procedure allows growth, development and flowering to proceed.

There were 18 plots of Congo pepper, 18 plots of Pimento and six plants per plot. Six irrigation treatments were replicated three times in a split plot design in which the main plots were the irrigation treatments and the sub plots were the two pepper landraces. The six treatments and frequencies of application were as follows:

- 630 ml water applied to each plant each day
- 1,260 ml water applied to each plant every two days
- 1,890 ml water applied to each plant every three days
- 950 ml water applied to each plant each day
- 1,900 ml water applied to each plant every two days
- 2,853 ml water applied to each plant every three days

The control treatment was located in an adjoining plot and consisted of 15 plants each of Pimento and Congo pepper, which were untreated, i.e., which received no irrigation.

The irrigation treatments were applied to the plants 34 days after transplanting and continued up to the 11th harvest on June 23. The water used for irrigation was sourced from the domestic supply and stored in metal drums at convenient locations on the experimental site.

The determination of the irrigation treatment options for screening in this study was based on earlier studies on *Capsicum chinense* by the Soils Department of the Central Experiment Station, Centeno, MALMR, over the period 2001 to 2005. The calculations and procedures used were from publications by Doorenbos and Kassan (1979), and Israelsen and

Hansen (1962). The information used in the soil water depletion studies for pepper on Piarco Fine Sand included the following:

- Bulk density (dry) 0.916 g/cm^3
- Bulk density (wet) 1.3 g/cm^3
- Moisture content (Field capacity) 22.1%
- Moisture content (Wilting point) 8.1%
- Area occupied / plant (0.45 m^2)
- Volume occupied / plant (0.095 m^3)
- Available water (28.0 mm)
- Crop coefficient at harvest (kc) 1.15
- (ETm) Maximum evapotranspiration rate of the crop when soil water is not limited (6.8 mm/day)

A water ring was made about 20 cm from the stem of each plant and consisted of a circular depression about 6 to 8 cm deep. This served to prevent any run-off of irrigation water and fertilizer from the root zone.

A pre-plant application of 14 g 12:24:12 fertilizer was incorporated into each planting hole. Two weeks after transplanting, each plant received 10 g 20:20:20. This was repeated bi-weekly until flowering commenced. Thereafter, 12:12:17+2 (N P K + Mg) was applied at 20 g per plant up to the 12th picking.

All weeds within the experimental area were controlled manually. Weeds outside the plot were controlled with a hand-held brushcutter. Abamectin was applied at 14-day intervals and alternated with Pyriproxyfen to control insects. Copper hydroxide was alternated with Copper sulphate pentahydrate to control fungal problems. All pesticides were applied at the recommended rates along with a spreader/sticker. Four out of six plants per plot, for each treatment were randomly selected and tagged for fruit harvesting. Pimento and Congo peppers were harvested from these plots at weekly intervals for 12 pickings. Peppers were harvested when the first streaks of red were apparent. The fruit stalk was left intact on the fruit. The first harvest was done on April 4 and the 11th harvest occurred on June 23. The crops were rain-fed over the period June 24 to July 7. The 12th and final harvest was done on July 7.

The pedicel of the flowers emerged in and around the nodes of the branches for both landraces. Any aborted flower left a scar at the point where the pedicel was attached. At 48 days after transplanting, two plants were randomly selected from each plot. Three branches from each plant were tagged and weekly counts of the scars were made.

Soil core samples were taken from an adjoining plot at three depths, 0 to 10 cm, 11 to 20 cm and 21 to 30 cm and the soil moisture percentage was determined.

Data collected comprised the following information:

- Fruit number per plant
- Fresh fruit weight per plant
- Number of flower abscission scars
- Time from transplanting to the onset of flowering
- Time from transplanting to first harvest
- Fruit length, fruit width, and flesh thickness
- Soil moisture percentage
- Plant height and canopy width
- Depth of penetration and spread of roots in the rhizosphere

The analyses were computed by using the GENSTAT software (Numerical Algorithms Group, 2008).

RESULTS AND DISCUSSION

The plants in the control plot all wilted and died by mid February. The results below for the various parameters consider only the plots with the irrigation treatments; these yielded fruit throughout all harvests.

Yield of fruit

The ANOVA of number of fruit per plot per month showed significant effects for variety (P=0.010); time (P<0.001) and variety*time (P=0.042). There were no significant effects (P>0.05) for volume of water, frequency and the interactions associated with volume and frequency. Yields were higher in May and July than they were in April and June (Table 1). Pimento gave more fruit numbers than Congo pepper in June and July but fruit numbers of both varieties were similar in April and May.

The repeated measures ANOVA of total weight of fruits showed significant effects for time (P<0.001) and variety*time (P=0.003), but all other effects were not significant (P>0.05). Highest fruit weights were in May and July, with June having lowest fruit total weights. Pimento weights in June were more than treble those for Congo pepper. In May and July total Pimento weights were also higher, but by a much smaller margin than in June. In April the highest total fruit weight was for Congo pepper (Table 2).

Over the total of the 12 harvests Pimento out-yielded Congo pepper in both irrigated and rain-fed conditions. An estimated equivalent overall yield of 136.5 and 117.6 metric tonnes/ha (fresh weight) of Pimento and Congo pepper, respectively, was obtained in this study after 12 pickings, at a high density spacing of 0.6 m x 0.75 m at the various irrigation levels and frequencies of application. Applying a minimum rate of 630 ml water per day produced an estimated equivalent yield of 128.0 and 153.5 metric tonnes per ha of Congo and Pimento peppers, respectively, after 12 pickings.

Yields of 30.3 metric tonnes/ha hot pepper have been obtained over a 15 to 20 week period at spacing 0.9 m x 1.5 m (Ministry of Agriculture, Land and Marine Resources 2006). Doorenbos and Kassam (1979) noted that under irrigation, commercial yields are in the range of 15 to 20 tonnes/ha. Yields of 20 to 25 tonnes/ha can be obtained under favourable climatic conditions and from high-producing varieties under high levels of management. Adams et al. (2007) reported that an average yield of 78.5 tonnes/ha for hot pepper can be obtained at a high density spacing of 0.6 m x 0.75 m.

The repeated measures ANOVA for individual fruit weight showed significant effects for variety (P=0.037), time (P<0.001) and time*variety (P<0.001). Again there were no significant effects (P>0.05) due to frequency, volume of water and interactions associated with frequency and volume of water. Fruits were much heavier in April than in the other three months (May, June and July). In April and July, Congo peppers were heavier than Pimento, but in May and June the weights of the two varieties were similar (Table 3).

Table 1: Average number of fruit per plot by month, variety and treatment

	Congo pepper						Pimento					
	Vol. (ml)	630	1260	1890	950	1900	2835	630	1260	1890	950	1900	2835
Period	Freq. (days)	once	twice	thrice	once	twice	thrice	once	twice	thrice	once	twice	thrice
April		155	119	94	118	93	135	107	115	110	59	163	32
May		343	318	232	334	328	371	323	341	335	423	388	336
June		59	41	40	34	40	93	232	121	104	180	154	187
July		368	235	209	184	273	322	453	408	334	541	236	407

S.E.M Within columns: 64 (42 d.f.) Between columns: 69 (66 d.f.)
L.S.D. (5%) Within columns: 200.06 (42d.f.) Between columns: 1184 (71 d.f.)

Table 2: Average total weight (g) of fruits harvested per plot by month, variety and treatment

	Congo pepper						Pimento					
	Vol. (ml)	630	1260	1890	950	1900	2835	630	1260	1890	950	1260	2835
Period	Freq. (days)	once	twice	thrice	once	twice	thrice	once	twice	thrice	once	twice	thrice
April		1460	1159	1334	1700	1216	1365	1079	1001	940	566	1429	244
May		1978	1568	1606	2233	2431	1985	2190	2416	2285	3039	2173	2365
June		254	177	233	202	257	505	1269	689	695	986	854	989
July		2053	1262	1744	1267	2124	1640	2368	1975	1613	2503	1149	2041

S.E.M Within columns: 347 (49 d.f.) Between columns: 394 (71 d.f.)
L.S.D. (5%) Within columns: 1050 (49 d.f.) Between columns: 1184 (71 d.f.)

Table 3: Mean weight (g) of fruits harvested per plant by month, variety and treatment

	Congo pepper						Pimento					
Vol. (ml) & Freq	630 Daily	1260 2 days	1890 3 days	950 Daily	1900 2 days	2853 3 days	630 Daily	1260 2 days	1900 3 days	950 Daily	1890 2 days	2853 3 days
April	10.0	10.8	13.8	13.4	14.7	10.2	9.6	8.7	8.4	9.8	8.4	7.5
May	5.9	5.5	7.0	6.6	8.0	5.4	6.6	7.0	6.7	7.6	6.0	7.0
June	4.6	4.9	5.9	5.5	6.8	5.4	5.4	5.7	7.6	5.4	5.4	5.3
July	6.0	6.7	8.3	6.8	7.7	5.2	5.0	5.0	4.8	4.6	5.0	5.6

S.E.M Within columns: 0.71 (61 d.f.) Between columns: 1.08 (49 d.f.)
L.S.D. (5%) Within columns: 2.078 (61 d.f.) Between columns: 3.155 (49 d.f.)

Fruit size

During the period April 4 to June 22, regular samples of 10 fruits were taken and measured for length, width and wall thickness of fruit. At each date when samples were taken, treatment and variety differences were examined by using ANOVAs.

Measurement of length at the first harvest on April 4 showed significant differences (P= 0.004) between the treatments and also between varieties (P= 0.046). Table 4 shows that fruits from both varieties were longest for treatments V1260 and V1900; the shortest length fruits for Congo pepper were from treatment V1890, and for Pimento were from treatment V950. Overall, Congo pepper (55.6 mm) was longer than Pimento (49.6 mm) at the first harvest.

For the remaining harvests, there were no treatment differences (P> 0.05) in length of fruit. The length of Congo pepper was fairly constant for the first four harvests, but from the harvest of April 20 onwards the length of Congo pepper fruits began to get smaller, and by the final harvest on June 22 the average length of Congo pepper was 32.3 mm.

On the other hand, the Pimento got slightly longer for the first four harvests with average length on April 20 being 56.9 mm. However, by the final harvest the length of Pimento declined to 40.5 mm. There was no significant difference between the length of the varieties after the first harvest April 4 until April 20, when Pimento was significantly longer (P= 0.004). It remained significantly longer (P< 0.05) until the final measurement taken in June 22.

Table 4: Average length of fruit (mm) at first harvest, April 4

Treatment {volume of water (ml)}	Congo pepper length (mm)	Pimento length (mm)
V630	55.9	52.8
V950	52.7	40.1
V1260	65.5	57.4
V1900	73.0	54.6
V1890	38.7	51.3
V2853	47.5	41.6
S.E.M. 4.51 L.S.D. 10.05 (10 d.f.)		

The width of fruit also displayed treatment (P=0.046) and variety (P= 0.001) differences at the first harvest. The interaction was also significant (P= 0.002).

Table 5 reveals that the two treatments which gave the narrowest Congo pepper (V1260 and V1900) did not give narrowest Pimento, compared to the other treatments. Treatment V950 produced the broadest Congo pepper and the thinnest Pimento. For the remaining harvests there were no treatment differences for fruit width (Table 5).

Table 5: Average width (mm) of fruit at first harvest April 4

Treatment {volume of water (ml)}	Congo pepper width (mm)	Pimento width (mm)
V630	43.2	29.2
V950	44.3	15.3
V1260	19.1	27.3
V1900	25.5	29.7
V1890	39.6	26.2
V2853	33.9	25.1
S.E.M. 3.39 L.S.D. 7.56 (10 d.f.)		

The fruit width of Congo pepper was broader than that of Pimento at the first harvest (34.3 and 25.5 mm, respectively) and apart from the second harvest, Congo pepper remained significantly (P≤ 0.05) broader than Pimento until June 7. For the final harvests (June 13 and June 22), there were no significant differences (P> 0.05) in fruit width.

For the first harvest on April 4 there was a significant treatment effect (P= 0.018) of wall thickness. The wall thickness was greatest for V630, V1260 and V1890 and least for V1900 (Table 6). For the second harvest (April 6) there was a significant (P= 0.028) treatment*variety interaction. Treatment V1890 gave the thickest walls (3.25mm) for hot pepper and the thinnest for Pimento (1.72 mm).

Table 6: Average wall thickness (mm) of fruit at first harvest, April 4

Treatment {volume of water (ml)}	Congo pepper wall thickness (mm)	Pimento wall thickness (mm)
V630	2.75	2.12
V950	2.65	1.70
V1260	2.70	2.32
V1900	1.80	2.18
V1890	3.07	1.98
V2853	2.53	2.00
S.E.M. 0.33 L.S.D. 0.73 (10 d.f.)		

During the period April 20 to May 1, the treatment and variety effects for wall thickness were both significant. Pimento had the thicker walls. Among the treatments, V2835 gave the thickest walls, followed by V950.

From May 5 onwards there were no treatment effects (P> 0.05) for wall thickness except on one occasion (June 13, P= 0.050), but for all except two of these nine harvests, Pimento had significantly thicker walls than Congo pepper (P≤ 0.05).

Plant size

Samples of 10 plants were measured for height on March 7, May 8, and June 5 and were ANOVAs-computed. On March 7 the Pimento plants were significantly (P=0.008) taller than Congo Pepper (43.7 cm as against 36.7 cm). On the other two dates, there were no significant differences (P>0.05) in plant height. The average values (for Pimento and Congo Pepper, respectively) on May 8 were 69.7 and 75.4 cm; and on June 5 were 85.6 and 87.1 cm. There were no significant treatment effects (P>0.05) for plant height.

The samples of plants were measured for canopy width on March 27 and May 8 and ANOVAs computed. On both dates the canopies of Congo peppers were larger. For Congo pepper and Pimento respectively, the average canopy widths were on 27 March, 73.0 and 65.4 cm (P=0.011), and on 8 May, 103.1 and 85.1 cm (P<0.001). There were no significant treatment effects (P>0.05) for canopy width.

Number of scars

The number of scars on the pepper plants was recorded from the beginning of the harvest period until June 7. Table 7 summarizes the mean number of scars per plot per month. Repeated measures ANOVA for mean number of scars showed that there were significantly higher numbers of scars (P<0.001) in plots with Congo pepper plants than in plots with Pimento. The number of scars significantly increased over time (P<0.001). Also, the time*variety interaction was significant (P<0.001). Once again there were no significant effects (P>0.05) for frequency, volume of water and associated interactions.

Table 7: Mean scars per month per plot by variety and treatment

	Congo pepper					
Vol. (ml) & Freq	*630 Daily*	1260 2 days	1890 3 days	950 Daily	1900 2 days	2853 3 days
Apr	70	65	65	77	78	80
May	127	109	113	149	137	123
June	135	134	138	159	143	140
	Pimento					
Vol. (ml) & Freq	630 Daily	1260 2 days	1900 3 days	950 Daily	1890 2 days	2853 3 days
Apr	56	51	54	61	60	64
May	78	61	73	73	68	83
June	85	79	82	94	70	93

S.E.M Within columns: 35 (34 d.f.) Between columns: 48 (48 d.f.)

In April, similar numbers of scars were observed for Congo pepper and Pimento. In May, the number of scars observed on Congo pepper almost doubled when compared to the April numbers, but there was only a slight increase in scars on Pimento in May compared to numbers in April. In June, observations were similar to those in May, with approximately 40% higher number of scars on Congo pepper plants than on Pimento.

The increase in the mean number of scars over time was not unexpected. As crop growth progressed, the number of branches and nodes increased, thus resulting in higher flower production and the dry, hot conditions may have encouraged flower drop. The comparatively low and similar pattern of flower drop in April may be attributed to the two landraces being smaller but similar in size at this stage of growth. Also, the plants may have benefitted from the residual moisture in the soil from scattered showers from January to March (Table 8). Erickson and Markhart (1979) reported that flower drop in pepper is a common problem during hot weather and is responsible for reduced production. It was also noted that decreased pepper yield is due to flower abortion and not due to decreased flower initiation or plant growth.

Table 8. Monthly and mean daily rainfall (mm) for the period January- July 7

Period	January	February	March	April	May	June	July (1-7)
Monthly rainfall	224.7	84.9	114.2	26.8	43.2	244.5	57.1
Daily rainfall	7.25	3.03	3.70	0.89	1.39	8.15	8.16

Bosland and Votava (2000) noted that pepper is known to be sensitive to moisture stress during blooming, and blossoms and immature fruits are likely to abort. On the positive side, these authors noted that water-stressed plants generally produced more pungent pods. They also observed that flowers do not set when mean temperatures are above 32^0 C. In April, there were 22 days when mean temperatures were above 32^0 C compared with 28 days in May, 12 in June, and four days in the first week of July.

These authors also reported that flowers abort when minimum temperatures are above 24^0 C. In April there were four days with minimum temperatures above 24^0 C, compared with 13 in May, and 18 in June; these temperatures may partly account for the flower drop observed. The experimental site at Centeno was not protected by windbreaks; therefore, the strong North East Trade winds may have contributed to flower drop. Poor fruit set at high temperatures was attributed to excessive transpiration by the plant (Cochran, 1932). Dorland and Went (1947) thought it was due to insufficient sugar translocation.

Correlations between number of scars and fruit yield were generally negative. Therefore, there is evidence that large scar numbers do have a somewhat negative effect on fruit numbers and total fruit weight. The correlations between number of scars and individual fruit size were positive. Therefore, there is evidence that large scar numbers are associated with larger fruit. This finding may be due to more metabolites being channeled into a reduced fruit number, resulting in larger fruits produced.

Soil moisture

The moisture content of the soil was measured at three depths on a total of 52 dates between February 22 and July 7. Soil moisture varied highly significantly both among dates and depths ($P<0.001$). Soil moisture declined from approximately 25% near the surface (0 to 10 cm) and 22% between 11 to 20 cm in late February to approximately 8 and 12% at the same two levels at the end of May. Rainfall was generally light for the period February to May (Table 8); 68.3% of the days in this period had less than 0.1 mm of rainfall. By June 6, early rainy season conditions raised the soil moisture to 11% at the surface, but it remained at 12% between 11 to 20 cm. By July 7, rainy season conditions further raised the soil moisture to 23% at the surface and 20% between 11 to 20 cm. Rainfall of high intensity (153.4 mm) was experienced between June 24 to July 7.

The final harvest yield data for Pimento and Congo pepper was taken on July after the plants had been entirely rain fed since July 24^{th}. Although the final harvest was over a two-week duration, yield was higher than that obtained in previous months (Tables 1 to 3). Table 8 shows that the soil moisture percentage increased from 11% in June 6 to 23% in July 7 at the surface (0 to 10 cm). At 11-20cm the soil moisture percentage increased from 12% on June 6 to 20% on July 7. At the final harvest the soil moisture percentage was near to field capacity (22.1%). At the end of the study root measurements on four randomly selected plants of both landraces were taken. The depth of penetration of the tap roots of both landraces averaged 15.6 cm. The branched lateral root system averaged 24 cm at its furthest spread. This increased availability of water in the root zone may have enabled the plant to better utilize the soil nutrients in the rhizosphere, thus giving a boost in yield.

The soil moisture percentage from February 21 to June 6 at both soil depths were below field capacity (Table 9). The results in Tables 1 to 3 indicate that the moisture content of the soil does not have to be at field capacity in order to produce high yields of Pimento and Congo pepper.

Table 9. Soil moisture percentage at two depths for the period February 21 to July 7, 2006.

Period	Soil Depth	Soil Moisture %	Soil Depth	Soil Moisture %
February 21	0 to 10 cm	25	11 to 20 cm	22
May 31		8		12
June 6		11		12
July 7		23		20

The sensitive growth period for water deficit in pepper is throughout, but particularly just prior to the start of flowering (Doorenbos and Kassam, 1979). Pimento and Congo pepper plants flowered at 45 and 47 days, respectively, after transplanting. Prior to this period, all of the plants received an equal amount of irrigation (400 ml/day). Consequently, no plant had an unfair advantage over the other in respect to water application per plant at flowering.

The ETm (mm/day) for Congo pepper on Long Stretch series (soil no. 59) was 6.8 mm/day. The soil depletion fraction (p) as determined by Doorenbos and Kassam (1979) at this ETm was 0.225. This figure meant that about 22.5% of the available soil water over the root depth can be depleted. This could in turn greatly reduce water uptake by the plant. There was evidence of temporary wilting of plants in the afternoon, especially those in plots which received irrigation every three days. However, all wilted plants recovered each morning. There were no plant deaths in this study apart from those in the control treatment.

Soil type

The soil type (Long Stretch series) in this study was poor in both chemical and physical characteristics (Brown and Bally, 1976). It had impeded drainage, and it became easily desiccated. The profile is extremely acidic and is low in all nutrients, especially after being cropped for more than two seasons. The soil pH at 0 to 25 cm was 3.9. The optimum pH for pepper cultivation is 5.5 to 7.0 (Doorenbus and Kassam, 1979). In this study, the soil was not limed, and this lack may have reduced the potential productivity of the plants. Breaking of the surface crust was done bi-weekly in order to facilitate percolation of water into the root zone.

Pepper prices

By planting early in the dry season, as was done in this study (January 5), farmers would have benefitted from the high prices obtained in the rainy months for the period June to December (Table 10).

Table 10: 2006 Hot pepper prices per kg at NAMDEVCO wholesale markets

Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Average Price for the year
$9.13	$8.27	$7.76	$6.39	$8.60	$9.29	$8.84	$9.10	$17.41	$12.92	$11.23	11.29	10.02

Source: NAMDEVCO'S Marketing Department, Debe, Trinidad

CONCLUSIONS AND RECOMMENDATIONS

- Pimento and Congo pepper cannot be grown successfully in the absence of irrigation in the dry season. At locations where there is access to irrigation water, acceptable levels of production can be achieved by applying this irrigation system, rather than deciding not to produce any crop.
- The study did not show significantly greater yields for the higher and more frequent irrigation treatments than for the lower and less frequent irrigation treatments.
- Pimento outyielded Congo pepper in both irrigated and rain-fed conditions. Estimated equivalent overall yields of 136.5 and 117.6 metric tonnes/ha (fresh weight) of Pimento and

Congo pepper, respectively, at a high density spacing of 0.6 m x 0.75 m were obtained at the various irrigation levels and frequencies of application after 12 pickings. Applying a minimum rate of 630 ml water per day produced an estimated equivalent yield of 128.0 and 153.5 metric tonnes per hectare of Congo and Pimento peppers, respectively, after 12 pickings.

- Congo pepper seemed to be more sensitive to drought conditions, evidenced by higher flower abortion.

- Correlations between number of scars and fruit yield were generally negative.

- There is evidence that large scar numbers are associated with larger fruits.

- The results indicated that the soil moisture content does not have to be at field capacity in order to produce high yields of Pimento and Congo pepper.

- The surface irrigation system used in this study was simple and inexpensive and may find applicability on small holdings (0.20 ha) and in home garden plots. In this system, water is applied directly onto the plant's root zone, in a controlled uniform manner. Since the irrigation was applied below the foliage, it had no effect on flower drop, the washing away of pesticides from the foliage and loss of fertilizer in run-off water.

- By having mature plants available at the beginning of the rainy season, growers have a definite head start over farmers who traditionally transplant seedlings to the field at the onset of rains in June-July each year. Additionally, farmers stand to benefit from the favourable prices which usually prevail in the wet season.

- The water ring ensured that all water and fertilizers applied remained within the root zone.

- Water for the small plots can be provided from a number of sources, including a domestic supply, surface storage in tanks or steel drums (barrels), wells (shallow or deep), streams, springs, rivers and irrigation canals.

REFERENCES

Adams, H., P. Umaharan, R. Brathwaite, and K. Mohammed. 2007. Hot peeper production manual for Trinidad and Tobago. CARDI, Trinidad and Tobago.

Bosland, P. W. and E.J. Voltava. 2000. Peppers: Vegetables and spice capsicums. CABI publishing.

Brown, C. B. and G. S. Bally. 1966. Land capability survey of Trinidad and Tobago No. 3. Soils of the Northern Range of Trinidad. Ministry of Agriculture, Trinidad, West Indies. Caribbean Printers Limited.

Central Statistical Office. 2008. CSO trade statistics. Ministry of Planning, Housing and the Environment. Government of the Republic of Trinidad and Tobago.

Cochran, H.L. 1932. Factors affecting flowering and fruit-setting in the pepper. American Society for the Horticultural Science Proceedings 29: 434-437.

Doorenbos, J. and A. H. Kassam. 1979. Yield in response to water. Rome. Food and Agriculture Organization of the United Nations (FAO). Irrigation and drainage paper 33, Rome.

Dorland, R. E. and F. W. Went. 1947. Plant growth under controlled conditions: viii, Growth and fruiting of the Chili pepper *(Capsicum annum)* American Journal of Botany 34 (8): 393-401.

Erickson, A. N. and A. H. Markhart. III.1997. Development and abortion of flowers in capsicum annum exposed to high temperatures. Hort Technology 7 (3): 312-313.

Israelsen, O. W. and V. E. Hansen. 1962. Irrigation Principles and Practices. John Wiley and Sons, Inc. New York.

Ministry of Agriculture, Land and Marine Resources. 2006. A producer's manual on hot pepper production. Trinidad and Tobago. Extension, Training and Information Services Division.

Numerical Algorithms Group. 2008. GENSTAT. Eleventh Edition. Numerical Algorithms Group, High Wycombe, UK.

Pereira, L. S., T. Oweis, and A. Zairi. 2002. Irrigation management under water scarcity. Agriculture Water Management 57: 175-206.