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Critical period of crop sensitivity to water deficit stress in elephant foot yam (*Amorphophallus paeoniifolius*)

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ABSTRACT

The effect of Water Deficit Stress (WDS) at different growth period on growth and productivity of *Amorphophallus* and the critical period of crop sensitivity to WDS was investigated during 2011-12 and 2012-13 with the variety Gajendra. Cut pieces of corm weighing 500 g were planted in RBD with four replications in the experimental plot of CTCRI. The treatments were, viz. T_1 - Control (without water deficit stress), T_2 - WDS during four and five months after planting, T_3 - WDS during five and six months after planting and T_4 - WDS during six and seven months after planting. Control plots were irrigated when the soil moisture was depleted to 50% of field capacity, whereas WDS was imposed by withholding water. The significant reduction in leaf area in WD stressed plants resulted in significant reduction in corm dry matter as well as corm yield per plant. Compared to control plants, the reduction in corm yield was 41.19% more due to WDS during 4-5 Months After Planting (MAP) (78.52%) than during 6-7 MAP (37.33%). The observed results indicate that WDS during 4 and 5 or 5 and 6 months crop growth period significantly affected growth and productivity of *Amorphophallus*. Apart from the initial establishment period and growth period between 4 and 6 months are critical and therefore crop must be irrigated adequately during these periods for achieving more corm yield.

Key words: Corm yield, Elephant foot yam, Water deficit stress

Amorphophallus paeoniifolius (Dennst.), syn. *A. campanulatus* (Roxb.) BL. Ex Dence (also elephant foot yam) is an herbaceous, perennial C_3 crop of South Eastern Asian origin. The corms are usually eaten as a vegetable after boiling or baking and are rich in calcium, phosphorus and vitamin A and serve as a source of starch as well as protein. The leaves are used as a vegetable by local tribes in India because they contain a high concentration of vitamin A (Rajalakshmi *et al*. 2001). It has long been used as a local staple food in many countries such as the Philippines, Java, Indonesia, Sumatra, Malaysia, Bangladesh, India, China and South Eastern Asian countries (Chandra 1984, Sugiyama and Santosa 2008). It is commercially cultivated due to its production potential and popular vegetable in various Indian cuisines. In India, it is cultivated in Andhra Pradesh, West Bengal, Gujarat, Kerala, Tamil Nadu, Maharashtra, Uttar Pradesh, and Jharkhand states, whereas in northern and eastern states, the wild, local cultivars grown are generally used for making vegetable pickles and medicine preparations for various ailments. In Kerala, the crop is also cultivated as an intercrop under coconut or banana. In recent years, farmers in Bihar and Uttar Pradesh have also begun cultivation. Under improved cultural practices and high yielding varieties, the production potential of this crop varies between 30 and 100 tonnes/ha and the net profit (economic return) is about ₹ 120 000–180 000/ha (AICRP 2009).

In many states of India (Kerala, Andhra Pradesh, West Bengal, Bihar and Odisha) elephant foot yam is cultivated under rainfed conditions during *kharif* (rainy) season in areas receiving well distributed rainfall of 1500-1800 mm over a period of 6 to 8 months (Narasimha Murthy *et al*. 2008, Singh *et al*. 2008a, Sengupta *et al.* 2008, Saraswathi *et al*. 2008, Sunitha *et al*. 2013). Nevertheless, little research work has been done on the response of *Amorphophallus* to water deficit stress and the sensitive period of crop growth to water deficit stress is not known. This paper reports the response of *Amorphophallus* to water deficit stress (WDS) and the critical period of crop sensitivity to WDS or water requirement.

MATERIALS AND METHODS

The experiment on the effect of water deficit stress (WDS) on growth and productivity of elephant foot yam was conducted in the experimental plot of Central Tuber Crops Research Institute (CTCRI), Sreekariyam, Thiruvananthapuram, Kerala during 12 May 2011 to 12 January 2012 and during 14 May 2012 to 12 January 2013.

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For this experiment, 500 g of cut pieces of corm of the variety Gajendra was planted in RBD with 4 replications in Block IV of CTCRI farm and cultivated under rainfed conditions following package of practices recommended by CTCRI. There were four treatments, viz. T_1 - Control (without water deficit stress), T_2- WDS during 4 and 5 months after planting , T_3- WDS during 5 and 6 months after planting and T_4 - WDS during 6 and 7 months after planting. Control plots were irrigated when the soil moisture reached 50% of field capacity, whereas WDS was imposed by withholding water. Black polythene sheet was spread on experimental plots to prevent rainfall during WDS treatment. Observations on soil moisture content, plant and petiole height, number of leaflets per plant, leaf area index were recorded at monthly intervals. Total leaf area per plant was estimated by non-destructive, linear measurement method (Ravi *et al.* 2010). Number of leaves per plant was recorded at 3 and 6 months after planting (MAP). Total dry matter production and partitioning per plant was observed at 5 and 8 MAP. Corm yield per plant was recorded at final harvest at 9 MAP. Methodology adopted for statistical analysis to be given here

RESULTS AND DISCUSSION

At full field capacity, soil moisture content varied between 10.4 to 18.2% with an average of 14.3%. Among the control and three WDS treatments, the average plant height and petiole height during 3 -8 months growth period varied between 60.34 and 71.67 cm and between 51.34 and 60.84 cm respectively. The difference in plant height, petiole (pseudostem) height and girth among the control and three WDS treatments was not significant (Fig 1).

Elephant foot yam leaves are basal, compound, pinnate, solitary and erect. Leaves are composed of a petiole (pseudostem) and three rachises with many leaflets. The new leaf sprout emerges from the cut corm pieces or full corm used as planting material. The time of emergence (sprouting) of the leaf depends on the dormancy status of the planting material as well as whether the whole corm or cut pieces of corm is used as planting material. Once the sprout is initiated, further development of the leaf (Fig 2, 3, Ravi *et al.* 2011) is completed within 30 days provided adequate soil moisture is available.

Fig 2 Emerging leaf from cataphyll

Fig 3 Fully expanded leaf

The number and size of leaves which develop during the growing season is dependent on quantity of planting material used, soil fertility, soil moisture and developing corm age (Sen and Das 1991, James and Nair 1993, Das *et al*. 1997). In the present study, we used uniformly 500 g cut pieces of corm as planting material with adequate supply of N, P and K nutrient. At 3 MAP the per cent of plants with 1 leaf was greater (53–55%) than per cent of plants with 2 leaves (21–23%). The difference in plants with half leaves among control and treatment plants were not significant. At 6 MAP, in control plants, the per cent of plants with 1 leaf was minimum (65%), whereas per cent of plants with two leaves was maximum (31%). In plants subjected to WDS during 4 and 6 months after planting, per centage of plants with 1 leaf was maximum (65–70%), whereas per centage of plants with two leaves was minimum (20–25%).

Therefore, in the present study, WDS between 4 and 6 months crop growth period significantly affected the leaf production. The average canopy spread per plant between 3 and 8 months growth period varied between 106.17 and 141.0 cm in control plants and between 84.67 and 123.34 cm in plants subjected to WDS between 4 and 6 months crop growth period (Fig 4).

Total number of leaflets between 3 and 8 months growth period varied between 455.34 and 656.17 in control plants and between 388.67 and 542.0 in plants subjected to WDS

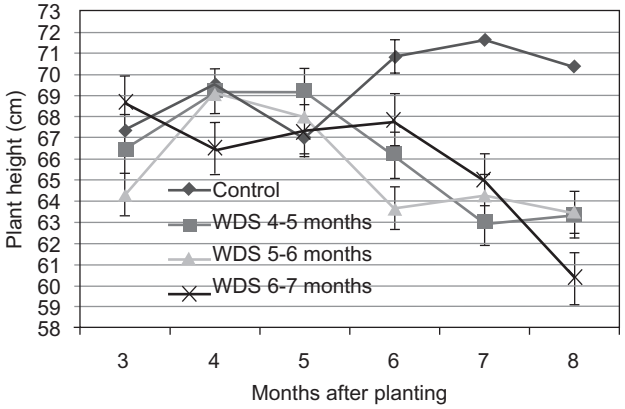

Fig 1 Plant height as affected by WDS in elephant foot yam.

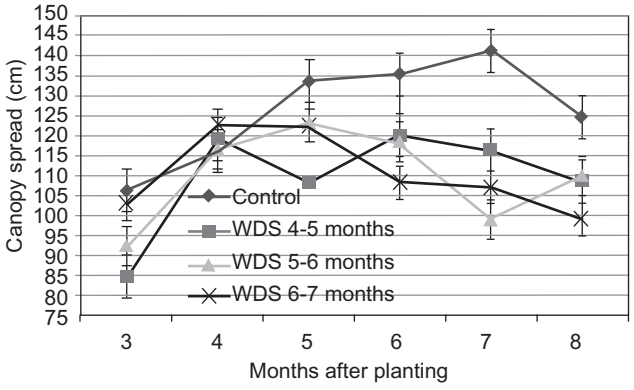

Fig 4 Canopy spread as affected by WDS in elephant foot yam

between 4 and 6 months crop growth period.

The differences in canopy spread and total number of leaflets per plant among the control and three WDS treatments was significant. While maximum canopy spread and total number of leaflets per plant was observed in control, WDS free plants, these two parameters were significantly reduced by WDS during 4 and 5 and 5 and 6 months after planting. The difference in the total number of leaflets per plant among the control and three WDS treatments were also reflected in the Leaf Area Index (LAI) (Fig 5).

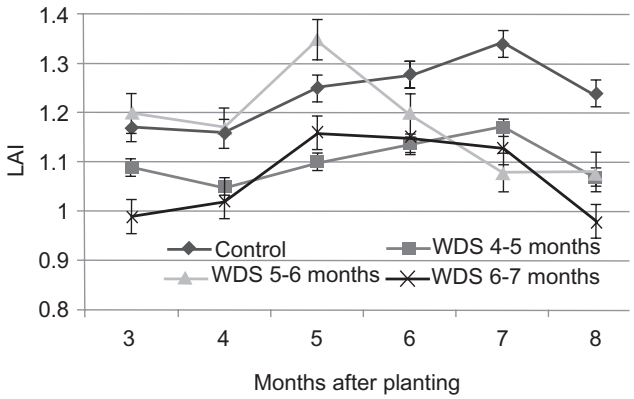

Fig 5 Leaf area index as affected by WDS in elephant foot yam

Elephant foot yam plants have been reported to produce more number of larger leaves under frequent watering (1/3 /5-day intervals) than under 7/15-day intervals (Santosa *et al*. 2004 b). In the present study, the average leaf area index (LAI) between 3 and 8 months was observed to be maximum (1.24) in control plants, the LAI was significantly reduced in plants subjected to WDS during 4 and 5 as well as 5 and 6 months growth period. The significant reduction in LAI in WDS plants resulted in significant reduction in corm dry matter (Fig 6) as well as corm yield per plant.

Corm yield was significantly reduced due to water deficit stress (WDS) during 4-5 MAP as well as 5-6 MAP (Table 1).

Table 1 Corm yield as affected by water deficit stress during four to seven months after planting in elephant foot yam

Treatment	Corm yield per plant (g/plant)		Mean
	2011-12	2012-13	
Control	1623.33	1634.50	1628.92
WDS (4-5 MAP)	320.00	379.75	349.88
WDS (5-6 MAP)	675.00	640.00	660.00
WDS (6-7 MAP)	1041.67	1000.00	1020.84
CD (0.05%)	124.21	109.05	

As compared to control plants, the reduction in corm yield was 41.19% more due to WDS at 4-5 MAP (78.52%) than at 6-7 MAP (37.33%) whereas, the reduction in corm yield was 19.04% more due to WDS at 4-5 MAP than at 5-6 MAP (59.48%). Elephant foot yam plants produce large

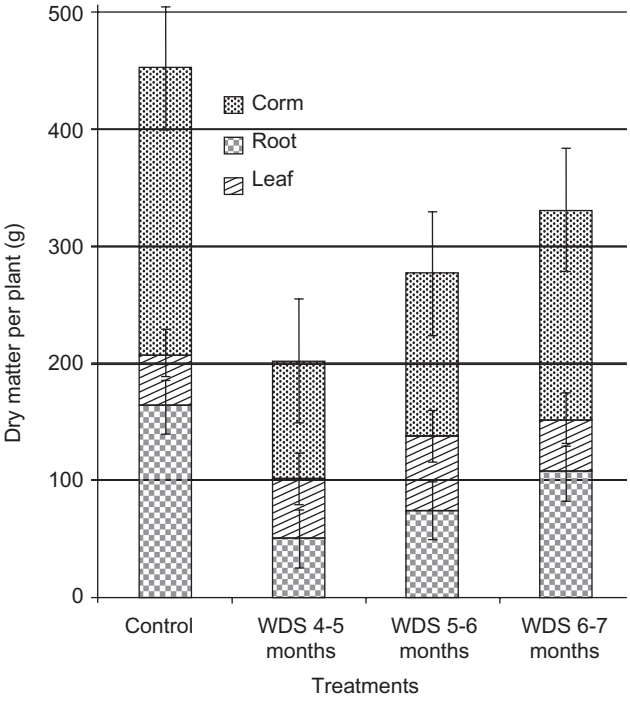

Fig 6 Total dry matter production affected by WDS in elephant foot yam

corms and yields more when the water supply is adequate (AICRP 2008). At the rate of 3.5 to 4.00 mm pan evaporation rate per day, a well distributed rainfall of 1000 mm over a period of 10 months is optimum for the crop. Many plants enter dormancy earlier than usual when the rainy season is shorter than four months and supplementary irrigation is necessary for high productivity under the same conditions. Soil moisture status affects not only the utilization of dry matter in planted corms but also the production and translocation of photoassimilates into daughter corms (Sugiyama and Santosa 2008). The roots dried earlier than usual when the soil water content decreased to less than 40% of field capacity (Santosa *et al*. 2004 b). Elephant foot yam crop tolerates water deficit stress conditions for about 30 to 60 days but prolonged stress affects corm yield (Santosa *et al*. 2004 b). Nevertheless, infrequent watering (watering at seven- or 15-day intervals) reduced corm yield and forced the corms to enter into dormancy. Corm yield was significantly reduced when irrigation was less than 100% CPE (AICRP 2009). In the present study, the results indicated that WDS during 4 and 5 months crop growth period drastically affected growth and productivity of elephant foot yam. Furthermore, soil moisture status did not influence corm sprouting but further development of the leaf depended on adequate soil moisture. WDS during growth stages, i.e. from the time of sprouting to development of full leaf (Fig 3) (Ravi *et al.* 2011) suppressed the development of leaf indicating that the initial establishment is a critical period of crop sensitivity to WDS. Because 75-80% of the sprouting of planted corms and development to a full first leaf occurs during 2-3 months (Ravi *et al.* 2010), this crop growth period requires adequate soil moisture through irrigation or

rainfall. Similarly, crop growth period between 4 and 5 months also is critical period which requires adequate soil moisture for achieving more corm yield.

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