International Journal of Oil Palm, **8 (1&2)** : 5-8, June and December, 2011

RESEARCH PAPER

Effect of Different Irrigation Methods and Levels on Nitrate Reductase Activity in Oil Palm

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ABSTRACT

Irrigation scheduling is the most cost effective way of utilising the water resources for enhancing physiological processes. The uptake of nitrate and subsequent reduction by nitrate reductase is the primary pathway of soil nitrogen utilization. The nitrate reductase activity was studied in an adult oil palm plantation under two different irrigation methods (drip and jet) and three sub irrigation levels [crop factor (CF) = 0.6, 0.7 and 0.8]. The nitrate reductase activity ranged from 3.0 to 21.5 nmol NO_2 g^{-1} fr. wt. h^{-1}. Palms irrigated with drips (at irrigation level CF = 0.6) recorded highest nitrate reductase activity, while the activity was lowest in palms irrigated with microjets (at irrigation level CF = 0.6). The nitrate reductase activity was highest in the first frond in all the treatments.

Key words : Oil palm, crop factor, irrigation, nitrate reductase activity.

INTRODUCTION

Oil palm (*Elaeis guineensis* Jacq.) was introduced as an irrigated crop in India and is being cultivated in an area of about 1.64 lakh hectares. The environmental conditions differ from other oil palm growing countries in terms of total rainfall, distribution of rainfall, mean maximum temperature and relative humidity, which reflects on the growth and productivity of oil palm. Prolonged drought spells and water stress during growth considerably reduce the yield. Depending on the stage of crop growth, moisture stress has variable effects on physiological processes.

Plants are good bio-indicators as they play a significant role in food chain transfer and in defining environmental health (Gianazza, 2007). Irrigation is adopted to supplement the soil water reserves and meet the evapotranspiration demands of the crop so as to increase the plant growth and yield. A crop factor is related to the extent of ground covered by the crop canopy and vary depending on the crop stage. Analyzing the information on evaporation, rainfall, water applied, soil moisture or irrigation depth gives the true crop factor and actual water use, depending on the stage of growth of the plant and crop density. The crop water use is composed of evaporation of water from the soil surface and transpiration of water through the leaves.

Scheduling of irrigation is an effective way of enhancing the basic physiological process. Among the physiological process, nitrate reduction plays a pivotal role in nitrogen uptake by plants. Nitrate is considered as primary source of nitrogen available from the soil. Nutrient uptake by oil palm is low during the first year, but increases steeply between first and third years when harvesting commences and stabilizes around fifth to sixth year. The uptake of nitrate and subsequent reduction by nitrate reductase (NR) is the primary pathway of soil nitrogen utilization. Hageman and Flesher (1960) first studied NR activity (NRA) in corn seedlings as affected by light and nitrate. Stimulatory effect on NR activity in green plants with both intensity and duration of light affecting the level of enzyme was also studied (Candela *et al.*, 1957; Hageman *et al.,* 1961). Beevers and Hageman (1969) observed that there is a decrease in the amount of extractable NR enzyme when plants are kept in dark and also when other environmental factors remained constant. NRA

appears to be inducible by nitrate also (Kaplan *et al*., 1974). Hageman *et al.* (1961) also observed that shading decreased NR activity. Light is the main factor known to stimulate NR induction through increased protein synthesis (Beevers and Hageman, 1972; Travis *et al.,* 1970a; Travis *et al*., 1970b; Zielke and Filner, 1971) and for maintenance of high levels of NRA in the leaves of higher plants (Aslam *et al*., 1973; Aslam *et al*., 1976; Beevers and Hageman, 1969; Hageman and Flesher 1960; Hewitt, 1975; Warner and Kleinhofs, 1974). Temperature modifies the response of NR activity to dark period. Lower temperature slows the rate of loss of NR activity when plants are exposed to dark (Onwueme, 1971; Travis *et al*., 1969; Travis *et al.,* 1970a; Zielke and Filner, 1971). No amino acid was found to effect NR activity in radish cotyledons and corn leaves (Schrader and Hageman, 1967). The present study was conducted to determine optimum nitrate reductase activity in oil palm leaves at different irrigation methods and levels.

MATERIALS AND METHODS

The experiment was carried out in an adult oil palm plantation at Directorate of Oil Palm Research, Pedavegi. The palms were planted with 9 m triangular spacing and standard package of practices were adopted. The main irrigation plots were microjet and drip methods of irrigation and sub plots were three irrigation levels (CF = 0.6, 0.7 and 0.8). Crop factor of 0.6 covered half the canopy size and 0.7 crop factor covered three fourth canopy size while, 0.8 crop factor covered full canopy.

Nitrate reductase activity was determined as per Jaworski (1971). Leaf samples were collected and immediately cooled in ice at 0^0C. Leaves were cut into small 3-4 mm pieces including mid-rib and 500 mg samples were placed in test tubes containing 10 ml of buffer solution (0.2 M KNO_3) maintained at pH 7.5. The leaf pieces were vacuum filtered in vacuum desiccator for 2 min. There after, samples were incubated in a boiling water bath for half an hour at 33^0C and a pinch of charcoal was added to stop phenol activity at the end and filtered. To estimate the amount of nitrite formed, 1% sulfanilamide in 1 N HCl and 0.02% naphtylethylene diamine dihydrochloride were added and the test tubes were vortexed. Absorbance of the resulting solution was recorded at 540 nm with a UV-VIS spectrophotometer (Elico, Hyderabad) after 20 min incubation. Concentration of nitrite was calculated by drawing a calibration curve of nitrite. The entire assays were carried out in triplicate and the activity of NR (nmol NO_2 g^{-1} h^{-1}) was computed on fresh mass basis.

RESULTS AND DISCUSSION

The nitrate reductase activity among different irrigation treatments and levels ranged from 3.1 to 23.3 nmol NO_2 g^{-1} fr. wt. h^{-1}. Palms irrigated with drip at CF = 0.6 recorded highest nitrate reductase activity while lowest activity was recorded in palms irrigated with microjets at CF = 0.6. The NRA was highest in the first frond in all the treatments. Palms irrigated with drip showed high NRA than palms irrigated with microjets. The NR activity was highest in fronds

Table 1: Effect of different irrigation methods and levels on nitrate reductase activity (nmol NO_2 g^{-1} h^{-1}) in oil palm

Treatments	Frond No.					Roots	Mean
	1	9	17	25	33		
M1L1	11.9	4.6	3.1	6.0	4.2	10.0	6.65
M1L2	14.4	6.2	8.5	11.5	10.8	21.0	12.05
M1L3	20.0	16.5	12.2	15.6	16.0	12.4	15.44
Mean	15.4	9.1	7.9	11.0	10.3	14.5	
M2L1	23.3	20.0	17.5	17.5	16.0	12.5	17.81
M2L2	21.5	11.0	11.7	9.0	14.2	8.7	12.69
M2L3	15.6	7.8	13.5	8.9	11.7	9.2	11.10
Mean	20.1	12.9	14.2	11.8	14.0	10.1	
Mean (M+L)	17.8	11.0	11.1	11.4	12.1	12.3	

M1L1: microjet with 0.6 CF, M1L2: microjet with 0.7 CF, M1L3: microjet with 0.8 CF
M2L1: drip with 0.6 CF, M2L2: drip with 0.7 CF and M2L3: drip with 0.8 CF

compared to that of roots (Table 1). Similar results were obtained by Boutard (1966) in shoots and roots of barley and field pea (Wallace and Pate, 1967).

With respect to different irrigation methods and levels, palms with microjets showed increasing trend of NR activity. Palms irrigated with drips showed decreasing trend in all the leaves from 0.6 to 0.8 CF.

The activity of NR enzyme decreased with the increasing concentration of some metals like cadmium and is known to restrict the uptake of nitrate by the roots by damaging the normal function of plasma-membrane bound proton pump (Obata *et al.,* 1996) and the fluidity of membrane (Meharg, 1993). Therefore, the restricted supply of the NR inducer and the substrate hamper the activity of NR. Magnesium is present in the cytoplasm of plant cells in a much higher concentration than calcium; magnesium is probably the more important inhibitor and transient lack of NADH apparently inactivate NR in the presence of physiological concentrations of magnesium (Lillo, 1994).

Most of the roots were concentrated around a radius of 2-3 meters (Suresh and Reddy, 2004). The uptake of nitrate and subsequent reduction by nitrate reductase will be more in palms irrigated with drip compared to that of microjets as drip system has the advantage of keeping the root zone in moist condition, and reducing conveyance, percolation and evaporation losses. Microjets on the other hand reduce conveyance losses, but evaporation losses could be high. As water is a valuable/scarce input, effective use of water through different irrigation systems enhances physiological processes in oil palm.

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