TISSUE IRRIGATION- A NEW DIMENSION IN MICRO-IRRIGATION

IRRIGATION DE TISSU UNE NOUVELLE DIMENSION DANS MICRO-IRRIGATION

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ABSTRACT

A new dimension in drip irrigation was achieved during a field study in 2007-08 at GKVK, University of Agricultural Sciences, Bangalore by successful insertion of micro tube emanating from lateral pipes in to the xylem tissues of monocot stems to supply them the water directly. This new method was termed as tissue irrigation, because water was directly supplied to xylem tissues, instead of supply through the soil. Such a system of irrigation is expected to meet the water demand of the crop without any sort of loss including minimal evaporation and percolation expected under conventional drip irrigation. To test this novel idea, a perennial crop of coconut with a well grown trunk was chosen. Besides distinctly demonstrating the technical feasibility of such an irrigation technique, the study indicated that water requirement of the crop could be reduced by 85 per cent as compared to surface irrigation and 47.5 per cent compared to conventional drip method. In this new method of irrigation, efforts were to essentially connect the suction in the plant tissues to the water supply in micro tube and new method was found to be independent of power requirement. Because the water movement in tissues was directly governed by the extent of suction in the tissues, which in turn is dependent on varying levels of vapor pressure deficits experienced by the leaves. This obviated necessity of operating head.

The tissue irrigation is a cost effective, power independent, climate controlled and highly economical method of drip irrigation easily adoptable in perennial monocot plants with large trunks

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RÉSUMÉ ET CONCLUSIONS

d'approvisionnement contrôlé et en temps opportun en quantité mesurée de l'eau à travers les tuyaux en plastique fait une révolution comme l'irrigation goutte-à-goutte en termes d'économies d'eau limitée. En plus d'économies, il également conduit à plusieurs avantages comme l'efficacité de l'utilisation de l'eau plus élevée, moindre croissance des mauvaises herbes, amélioration de l'efficacité des éléments nutritifs et rendement accru. Spot mouillage par dirigée approvisionnement d'eau réalisés dans l'irrigation goutte-à-goutte, cependant, n'est pas en mesure d'éviter l'évaporation de la surface du sol humide. Les pertes dues à la percolation aussi pleinement inévitable lors de la décharge est meme légèrement supérieur au taux d'infiltration de sol. En outre, l'irrigation au goutte à goutte peut être adoptée, seulement lorsque l'eau est transmise par le biais de tuyau dans le cadre de la prise de pression il pouvoir dépendants pour atteindre la tête nécessaire. La dépendance sur la disponibilité de l'énergie est l'une des principales limites dans l'adoption de l'irrigation au goutte à goutte à grande échelle. Un plus novatrices et l'eau sauver approche serait de fournir de l'eau dans le tube micro directement dans les tissus, sans contact avec le sol. Pour ce faire, le tube micro doit être inséré directement dans les tissus de la plante. L'approvisionnement en eau directement dans les tissus a été qualifiée de façon appropriée que l'irrigation des tissus. Cette nouvelle dimension de micro irrigation a été étudiée dans une étude pilote à Bangalore GKVK., University of Agricultural Sciences, principalement pour démontrer la possibilité pratique d'irrigation des tissus. Pour tester cette idée originale, les tubes microentreprises de 0,5 mm de diamètre interne liée aux latérales de 12 mm ont été insérés dans les tissus de xylème de cocotiers bien cultivé (20 ans). En plus distinctement la démonstration de la faisabilité technique de telle une irrigation, l'étude a révélé que l'eau exigence de la récolte a été réduite de 85 % par rapport à la surface d'irrigation et de 47.5 % par rapport à la méthode conventionnelle au goutte à goutte. Telle l'irrigation, étant essentiellement reliant la succion dans les tissus de la plante à l'approvisionnement en eau dans le tube micro, s'est avérée avec succès indépendante du pouvoir. Parce que le mouvement de l'eau dans les tissus était directement régi par l'étendue de la succion dans les tissus, qui à son tour dépend de divers niveaux de pression de vapeur déficits éprouvées par les feuilles. L'irrigation des tissus pouvait être jugée chez d'autres espèces d'arbres avec plus gros troncs à réduire considérablement leur besoin en eau et leur croissance avec conditions pratiquement sans stress. L'irrigation des tissus est rentable, indépendante du pouvoir, climat contrôlé et méthode très économique de goutte à goutte d'irrigation facilement adaptable à des plantes pérennes avec gros troncs

1. INTRODUCTION

Drip irrigation is generally evaluated as one of the most efficient methods of irrigation in terms of savings of water and improved water use efficiency. Essentially, the water is supplied through network of pipes in a fully controlled drip system, wherein the discharge and wetting area are under control. The irrigation water is never allowed to spread on the entire surface of soil and is allowed to wet such part of the soil, where roots proliferate. As a result of this, it achieves high conveyance efficiency and application efficiency (INCID,1994). Such a controlled and directed supply of water in drip method of irrigation has also resulted into number of other practical advantages like limited weed growth, better nutrient use efficiency with higher crop productivity besides possibilities of adopting fertigation. But, the supply of water to the crop roots through partial wetting of surface

leads to unavoidable evaporation losses though minimal from wet areas. The soil texture and water holding capacity of soil would decide the availability of water to the crop roots. In addition, the soil texture also decides the depth and width of wetting, which may or may not be restricted to efficient root zone of the crop being irrigated. In case the discharge is slightly higher than rate of infiltration, losses due to percolation are also possible. All these features of drip method have resulted in to poorer distribution efficiency in the root zone. Above all, the adoption of drip irrigation requires power availability to create necessary head. Such dependence on power has limited its large scale adoption.

The disadvantages of drip method could be overcome, if the pathway of water is short cut and water is directly supplied to the water carrying tissues. This ingenious idea can save substantial quantity of water, besides overcoming the soil controlled limitations of irrigation. This modified system of irrigation can be called appropriately as tissue irrigation, as the tissues have direct access to the water. But, there are number of constraints in achieving the success of such irrigation. Synchronizing the discharge in the tube with ascent of sap and possible injury to the plant during the insertion of tube in the trunk are few of them. An attempt was made in a pilot study and to adopt tissue irrigation in a grown up garden of coconut trees of 20 years old. As the practical possibility of such a proposal is often doubted by many, the experience of field study to adopt this innovative method of irrigation is shared and discussed in this article.

2. METHODOLOGY

To test this innovative idea, a coconut garden of 20 years old trees was selected in the campus of GKVK of University of Agricultural Sciences, Bangalore. Out of 72 plants, 30 plants were selected for the study. The pilot study was conducted during 2007-08 under the grants allotted by the Directorate of Research of the University. A HDPE anodized tank of 500 Lt capacity was mounted on a stand of 10 ft height to provide static head to the system. A rigid PVC pipe of 63 mm was laid underground and connected to the tank to ensure that water supply was made in all six rows, each having five plants. HDPE anodized lateral pipes of 12 mm were connected to the PVC pipes above the ground and spread to reach all five plants of each row. Two 0.5 mm dia. micro tubes, each of 1.5 M length were connected from lateral pipes to trunk each plant at a height of one meter (Fig1)

Figure 1. Lateral pipe connected to micro tube (Pipe latéral connecté à tube micro)

To facilitate the insertion of micro tube, two diagonally opposite holes of 2 mm dia. were drilled up to a depth of 50 mm at one meter height using carpenter's hand operated drilling machine (Fig 2). A small cotton plug was inserted deep into the hole. After placing the micro tube inside the hole to a depth of 50 mm, a paste of Dithane- M 45 (fungicide) was smeared in the cavity to overcome the fungal infection due to injury caused to tissue while drilling. Adhesive gum was used to hold the micro tube intact and maintain continuity of suction between xylem vessels and micro tube (Fig3).

Figure 2. A 2mm hole drilled in the trunk (Un trou de 2 mm forés dans le coffer).

Figure 3. Micro tube inserted in trunk (Micro tube inséré dans le tronc)

A diagrammatic representation of diagonally opposite hole with micro tube inserted is shown in Figure 4.

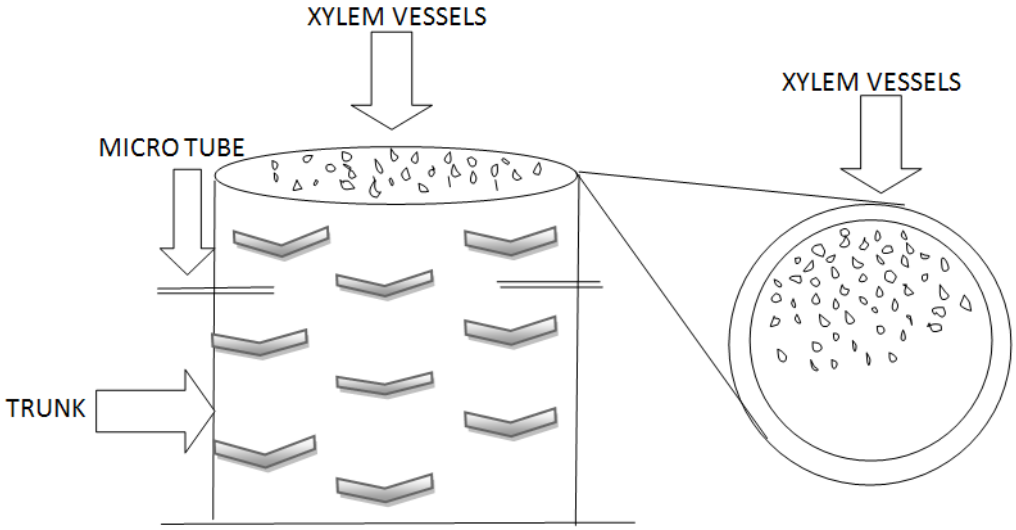

Figure 4. Diagrammatic representation of xylem vessels in coconut and position of micro tube in tissues (Représentation schématique des vaisseaux de xylème de noix de coco et la position du tube micro dans les tissus)

Initially, the water was allowed daily for a period of 4 hours through micro tube at a rate of 0.5 Lt/hr. After leakages in some plants were plugged and after confirming that water was flown from the tank through micro tubes into the xylem vessels, the irrigation period was increased to 8 hours per day with a total supply of 8 Lt/day/plant(by two micro tubes connected to each plant, each delivering 4 Lt/ day). A control was also maintained to irrigate the plants by surface method and conventional drip method to account the water

supplied in these methods. The parameters like height at which the tubes were inserted and number of micro tubes/ plant were earlier standardized by trying out different combinations on trial and error basis.

3. RESULTS AND DISCUSSION

The results of the pilot study have amply demonstrated that system of tissue irrigation achieved a substantial water saving of 68 cm over a period of one year experimentation when compared to surface method of irrigation, normally ring basin method is adopted in coconut, in which 40 irrigations were given at the rate of 200 liters of water per palm per irrigation (Table-1). The conventional drip method could save only 38 cm of water supplied at the rate of 70 liters per palm per irrigation amounting to total supply of 42 cm given in 80 irrigations. When conventional drip and new method of irrigation were compared, it is clear that the tissue irrigation further saved an additional 30 cm over conventional drip method.

Besides these calculations, the growth observations made on number of fronds, number of bunches and the greenness of the palm indicated that there was not much differences among the methods of irrigations tried in a span of 6 months to one year. Since coconut is a perennial monocot tree, the actual data on yield of nuts could not be made. However, one of the interesting observations made on dropping premature nuts showed that it was substantially low under tissue irrigation compared to other two methods. Hardly 3 to 4 premature nuts were dropped from each plant under tissue irrigation when compared to 6 to 8 under conventional drip and 10 to 16 under surface method of irrigation.

The working feasibility of this method could be evidenced from emptying up of 500 lit capacity tank which was filled daily in the morning. Good correlation was also noticed between water consumption through tissue irrigation and bright sunshine hours of the day. Thus, the water uptake in tissue irrigation method could be directly corroborated to climatically controlled water loss from the fronds and consumption depended on transpiration pull by the palms which in turn depended on the evaporative demand of the atmosphere or otherwise vapor pressure deficit of the atmosphere.

Further, this system of irrigation eliminates the power required to create operating head and cumbersome process of scheduling based E-pan rate, as it essentially operated on static head created by placing the water tank at height. This technique needs further refinement by conducting the experiment in a long term replicated trials and by making all possible observations on plant-soil- atmospheric parameters. There is also a good scope to extrapolate the technique many perennial tree species and its benefits would be realized for saving of water across several agro-climatic situations.

Table 1. Water consumption by coconut palms under different methods of irrigation

Method of Irrigation	Water supplied (Liters/Palm /irrigation)	Number of irrigation /year	Total water supplied (L/ha/year)	Depth of water supplied (cm)	Saving of water over control (cm)	% saving of water over control
Tissue Irrigation	8.00	200	1,20,000	12	68	85.0
Conventional drip irrigation	70.00	80	4,20,000	42	38	47.5
Surface Irrigation (Control)	200.00	40	8,00,000	80	-	

4. REFERENCES

INCID,1994, Drip irrigation in India 62-65