Plant Dry Matter Production and Partitioning with the Use of Human Urine

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ABSTRACT

Urine is a well-balanced nitrogen-rich quick-acting liquid Organic fertilizer. The study aimed to know the responses of plants in relation to dry matter production and partitioning, and variation in root morphology to organic fertilizers like urine and vermicompost compared with control. Sour lime (Citrus aurentifolia) was selected as planting material. Pot and root box experiments were conducted. The absolute plant growth parameters like shoot dry weight, root dry weight and total plant dry weight were not differ significantly in both pot and root box experiments compared to control. However, results from both experiments indicated that human urine application in sour lime had different plant growth and development response (promote more shoot biomass than roots, seminal root length, root branching number and total root length) and it might be important in quality sapling production, plant mortality rate reduction during transplanting and quality fruits production.

Key words: Human urine, plant dry matter, root morphology, sour lime, vermicompost

INTRODUCTION

Nitrogen is the most limiting nutrient in the soils of Nepal and is the most important macronutrient for plants. Traditionally, Nepalese farmers have applied farmyard manure; but in many places this is being supplemented by inorganic fertilizers, mainly urea. At the same time, cultivation practices are being intensified with greater cropping intensities and use of more nutrients demanding crops such as hybrid varieties instead of local. This can easily led to nutrients mining and soil fertility decline unless there is an equivalent increase in inorganic or mineral fertilization. So, there is need of alternative fertilizer sources. Human urine could be a viable alternative to mineral fertilizer. Human urine is rich in plant nutrients as it contains most of the nutrients present in human food (Sullivan and Grantham, 1982). Use of organic manures alone cannot fulfill the crop nutrient requirement (Deore *et al*., 2010). The use of human urine in crop production is proved to be safe (Hamdine, 2008). It does not pose any significant hygienic threats or leave any distinctive flavor in food products (Pradhan *et al*., 2007). Reuse of excreta on arable land secures valuable fertilizers for crop production and limits the negative impact on water bodies (WHO, 2006).

Urine is a well-balanced nitrogen-rich quick-acting liquid fertilizer. It contains most of the macronutrients as well as small fractions of the micronutrients excreted by human beings. The nutrient content in urine depends on the diet but as a rule of thumb nitrogen concentration is 3-7g/l, phosphorus 1g/l and potassium 2g/l. This is to be expected, as 90-100% of urine N is found as urea and ammonium and has been verified in fertilizing experiments (Kirchmann & Pettersson, 1995). The P in urine is almost entirely (95-100%) inorganic and is excreted in the form of phosphate ions. These ions are directly plant available and thus it is no surprise that their plant

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availability has been found to be at least as good as that of chemical phosphate (Kirchmann & Pettersson, 1995). K is excreted in the urine as ions, which are directly plant available. S is mainly excreted in the form of free sulphate ions (Kirchmann & Pettersson, 1995), which are directly plant available. Thus urine is taken as a well balanced nitrogen rich fertilizer that can replace and normally gives the same yields as chemical fertilizer in crop production. In addition to essential plant nutrients urine can supply significant quantity of water to the plants. The quickly available form of plant nutrients and ample amount of water contain in human urine (irrigation and fertilization) are the key characteristics that makes different from other source of fertilizers. Scant information is available on the specific effect of root volume on uptake rates of water and N by trees as related to dry matter production and partitioning in plant (Ran *et al*., 1992). Recent development in technologies of irrigation and fertilization enable us to control root size and environment under field conditions. Low volume irrigation and fertilization affects root size and rate of rootlets production and consequently vegetative and reproductive processes of whole plants. The ability to respond to localized nitrate supplies by proliferating lateral roots within the nitrate-rich zone is a property common to many species of plants (Robinson, 1994; Hodge, 2004). Nitrate stimulates lateral root elongation by increasing rates of cell production in the root tips directly exposed to the signal (Zhang *et al*., 1999). Ma *et al*., 2001 indicated that lateral roots contribute to the Si uptake in rice plant, whereas root hairs do not. Hence, the study aims to know the response of plants in relation to dry matter production and partitioning, and variation in root morphology to different sources of fertilizers.

MATERIALS AND METHODS

Sour lime (*Citrus aurentifolia*) was selected as planting material. Health risks associated with the use of human urine in fruit sapling production is very low. The quality saplings produce from nursery were uprooted and transplanted to the real fruit growing field. These transplanted samplings could take couple of years to bear fruits. Thus it is better to use human urine in fruit sapling production in terms of minimizing health risk associated with the use of human urine and might be an avenue for motivating farmers in utilizing human urine in crop production.

Pot experiment

Seeds of sour lime were collected from matured fruits. Collected seeds were thoroughly washed with tap water and treated with Benlate® solution. Treated seeds were sown in earthen pots. For this experiment, 20 earthen pots filled with 3.5kg air-dried medium texture soil sieved through a 2 mm mesh and grown in a greenhouse at Central Horticulture Centre, Kirtipur, where air temperature was not controlled. All pots were well watered and maintained soil moisture (25% w/w, dry-mass basis) throughout the experiment.

Vermicompost and human urine were obtained from Central Horticulture Center, Kirtipur. Full dose of vermicompost, one third of mineral nitrogen and human urine, total dose of phosphorus and potash were applied at the time of final soil preparation to fill pots. After two months of plant establishment remaining one third of urea and human urine was top dressed and remaining one third at four months after seed sowing. Mineral nitrogen, phosphorus and potash were applied through urea, diammonium phosphate (DAP) and murate of potash (MOP). The amount of human urine, urea and DAP was calculated based on nitrogen content of the vermicompost.

The amount of vermicompost to fulfill the required nitrogen was doubled assuming that only 50% of N would be available for the crop (Bary *et al.*, 2004). The experiment was laid out in a randomized complete block design (RCBD) consisting of three treatments with eight replication (Fig.1a). Plants from each pot was selected and sampled separately after six months of seed sowing. Roots were washed thoroughly with tap water and rinsed with distilled water. Plant samples were oven dried at 75ºC for two days and dry weight was determined.

Fig.1: (a) Experimental set-up: Pot experiment (b) Root box experiment

Root box experiment

Nine root boxes (size: 40cm x 29.5cm x 3cm) filled with 4.3kg air-dried medium texture soil sieved through a 2mm mesh and grown in a greenhouse at Central Horticulture Centre, Kiritpur. All the boxes were well watered and soil moisture was maintained (25% w/w, dry-mass basis) throughout the experiment. Full dose of vermicompost and one third dose of human urine were applied at the time of final soil preparation to fill the root boxes. After two months of plant establishment remaining one third of human urine was top dressed and remaining one third at three months after seed sowing. The amount of human urine was calculated based on nitrogen content of the vermicompost. The amount of vermicompost to fulfill the required nitrogen was doubled assuming that only 50% of N would be available for the crop. Benlate® treated sour lime seeds were sown in root box. Human urine, vermicompost and control (without any additional fertilizers) were taken as different treatments. The experiment was laid out in a randomized complete block design (RCBD) consisting of three treatments with three replication. Root length, rooting depth was traced and measured in every week in in-situ condition (Fig.1b). One set of destructive samplings was performed at 126 days after seed sowing. Plant samples were obtained by separating the leaves, stem and roots. Roots were washed thoroughly with tap water and rinsed with distilled water. Total root length and root branching number were measured. Plant samples were oven dried at 75ºC for two days and dry weight was determined.

RESULT AND DISCUSSION

In both pot and root box experiments, the absolute plant growth parameters like shoot dry weight, root dry weight and total plant dry weight were not differ significantly compared to control (Fig.2). This result revealed that plant nutrient is not limiting factor in these experiments. In other words soil is rich in fertility status. However, results indicated that human urine application in sour lime had significantly higher shoot and plant dry weight compared to vermicompost. These data indicated that urine did promote more shoot biomass than roots.

Results from root box experiment indicated that urine treated sapling had highest seminal, root branching number and total root length but control had the highest lateral root length (Fig.3 and 4). This result might be due to physical and chemical characteristics of urine that differed from other organic source of fertilizers. Saplings grown in control box had the highest specific root length (Fig.4). It is well understood that the spatial configuration of a root system in the soil, plays an important role in below-ground resource acquisition (Lynch, 1995).The possible reason for the highest specific root length in control might be due to the downward growth of roots of saplings to acquire plant nutrients that is limited and well distributed in control compared to both human urine and vermicompost applied boxes. Human urine that provides major and many micronutrients in easily available form helps plants to promote seminal roots.

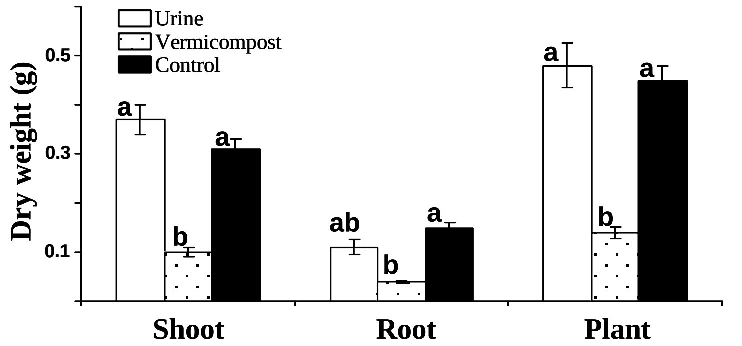

Figure 2. Dry weight of plant and plant parts of sour lime grown in pot culture. Data are shown in the mean of eight samples ± SE. Within the same parameter, each column followed by common letter are not significantly different at 5% level by DMRT.

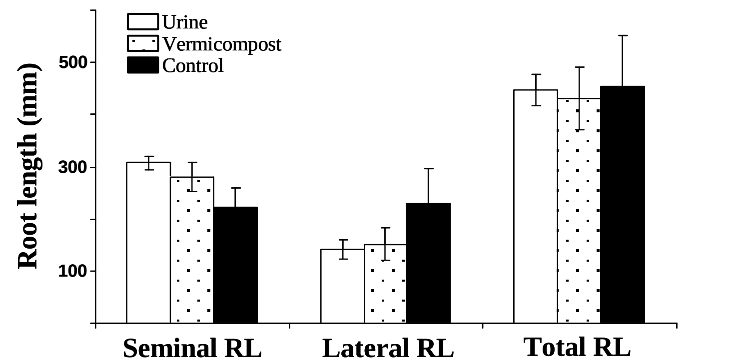

Figure 3. Seminal root length (seminal RL), lateral root length (lateral RL) and total root length (total RL) of sour lime grown in root box. Data are shown in the mean of triplicate samples ± SE.

Human urine contains varying quantities of one or more substances having an effect on the growth of plant roots. Auxins are phytohormones affecting the elongation of certain plant cells, and their predominant characteristic is that at low concentrations they inhibit the elongation of root cells, whereas at sufficiently high concentrations they stimulate the elongation of coleoptiles (Ronnike, 1960). This hormonal effect of human urine might be the reason for the highest root branching.

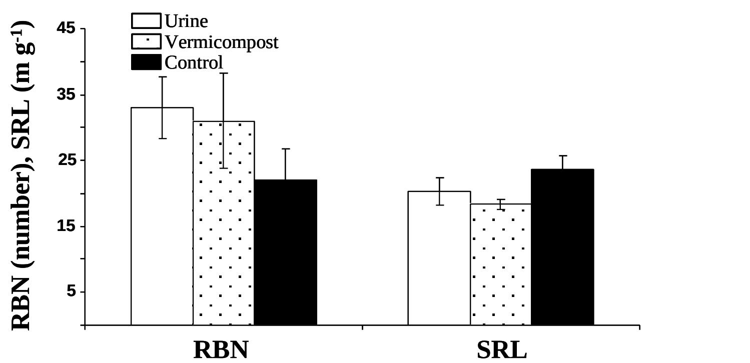

Figure 4. Root branching number (RBN) and specific root length (SRL) of sour lime grown in root box. Data are shown in the mean of triplicate samples ± SE.

Our results from both pot and root box experiments indicated that urine and vermicompost had different plant growth response. Human urine was able to produce different root architecture than that from vermicompost. This root architecture is important for plant productivity and survivable from the fact that many soil resources are unevenly distributed in space and time and are often subject to localized depletion (Robinson, 1994). Drought tolerance is commonly associated with depth of rooting (Sanders and Markhart, 1992), while greater nutrient acquisition has been associated with increased soil exploration by roots in surface layers (Lynch and Brown, 2001). Furthermore, these different root architecture responses of fertilizers might be a good tool for fruit nursery owners to produce different fruit saplings having different root system. Saplings having different root system will help to reduce mortality rate during transplanting, life of the plant tree and produce quality fruits.

CONCLUSION

Human urine application in sour lime gave different plant growth response than vermicompost. This different plant growth and development response might be important in quality sapling production, decreasing plant mortality rate during transplanting and quality fruits production.

ACKNOWLEDGEMENT

Our sincere thanks go to Environment and Public Health Organization (ENPHO) and Water Aid Nepal (WAN) for providing financial and technical support for this study.

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