学 位 論 文 内 容 の 要 旨

博士の専攻分野の名称　博士（工学）　氏名　Sene Moustapha

学 位 論 文 題 名

Application of human urine as liquid fertilizer in agriculture
(尿の農業利用に関する研究)

Introduction

Human urine contains valuables plant nutrients such as nitrogen (N), phosphorus (K) and potassium (K) and has a potential to be reused in arable land to replace commercial fertilizer. However, urine contains some salts, pathogens, pharmaceuticals and hormones. Concerning salts issues too much urine application in agriculture land may cause simultaneously soil salinity, sodium and nitrogen accumulation in soil. Excess of Na in soil have a potential to be detrimental to plant growth; while high concentration of N in soil might affect negatively amount of sugar and vitamins in vegetables and built up in plant tissue, causing therefore health and taste issues to consumer. Subsequently, to address salts issues and provide a better understanding of urine application in agriculture, this present research work was carried out with these specific objectives 1) evaluate when and how often-human urine should be applied in agriculture as liquid fertilizer 2) examine the effects of uncontrolled application of human urine dose in agriculture 3) examine the effects of continuous application of uncontrolled human urine application dose in agriculture.

Chapter 1

This chapter summarized the state of the art regarding the reuse of human urine in agriculture as liquid fertilizer. Therefore, after thoroughly reviewing the literature, the present research work was carried out to address some issues concerning the use of urine in the viewpoint of sustainable agricultural production.

Chapter 2

This chapter addressed when and how often-human urine should be applied agriculture as liquid fertilizer. Thus pot test was conducted in greenhouse using synthetic urine, spinach and sandy soil as media. Seven treatments, those apply same amount of urine in different pattern and control (total 8 cases) were set to know adequate urine application way. From this research, the results revealed clearly that, human urine application at one time before seedlings is not effective for plant growth and production due to mainly a high leached of nutrients from soil (N= 38.3%, P= 9.1%). Besides, when urine is used as fertilizer, phosphorus (P) limitation occurs in plant (N/P>16 in plant shoot for all treatments); therefore urine controlled with P-fertilizer such as industrial P205 or supplied P through compost might be a better idea to promote high plant growth.

Chapter 3

Although it has been known that human urine could be reused in agriculture as nutrients for plant, too much urine applied in agriculture may cause an accumulation of sodium (Na) and/or nitrogen (N) in soil. Therefore, this chapter examines the effects of extra human urine volume application in plant and soil. Thus, pot test was conducted in greenhouse using synthetic urine, Komatsuna and sandy soil. 34.86ml of urine (U-Vo) which contained 140mg-N and corresponded to N-based standard requirement for Komatsuna, 69.72ml of urine (U-2Vo), 104.58ml of urine (U-3V0), 58.82ml of modified Hoagland ' s solution (V-H) which contained 140mg-N as positive control and non-fertilizer (C) were applied into different pots (1/10000a). The results show that, in one time cultivation, application of extra urine volume in the range of 2-3 higher than plant requirement does not affect plant growth and production, since in all treated soils EC and SAR was far to be saline when considering the references values given by FAO, 1998 (EC<2mS/cm; SAR<13); and more than 68.1% of the total Na applied in all urine treatments was removed by plant. Subsequently, a low K/Na ratio in plant shoot and root,

defined as a primary salt stress, was observed in all urine treatments compared to modified Hoagland 's solution (V-H) and this phenomenon was accentuated in the highest urine application volumes. Therefore urine used as fertilizer causes a primary salts stress for plant (substitution of K+ by Na+) which is severe in extra urine applications. Moreover, excess of urine volume application increases accumulation of nitrogen in plant tissues. Furthermore focusing in soil part, our data show that too much urine application causes accumulation nitrogen and sodium in soil especially in the highest urine application case (U-3V0) but no accumulation was observed in both parameters with adequate urine application volume (U-2Vo). Besides, the " Unknown-N " calculated from N-balance before and after cultivation could be N-volatilization and was higher in extra urine treatments, U-2V0 (28.75%) and U-3Vo (24.37%) compared to the adequate urine application conditions, U-Vo (17.1%). The results suggest that application of adequate urine volume based on N requirement is a better option for its reuse in agriculture.

Chapter 4

Application of extra human urine volume in one time cultivation had no depressed growth in Komatsuna plant and promoted a slight increase of sodium in soil (chapter 3). Therefore, this chapter examine the effects of continuous application of extra human urine volume on plant and soil through continuous cultivation. Thus, the experiment was continued using same soil, same plant (Komatsuna) and similar rate of fertilizer as designed in the 1st cultivation and then 2nd and 3rd time cultivation were performed. The results revealed that continuous application of extra human urine volume in the range of 2-3 times higher than plant requirement had not inhibition effects on plant growth and dry matter production during three times cultivations, since treated soils still remained non-saline (0-2 mS/cm) even after three-step cultivation with extra urine application. However, the primary effects of plant stressed Na causes by urine application (substitution of K+ by Na+ in plant) was constantly observed after each cultivation compared to modified Hoagland solution but this phenomenon was not accelerated under three times cultivations, in extra urine application cases. Besides, continuous application of excess did not also affect nitrogen contents in plant, because N decrease from 1st to the 2nd cultivation, however N contents was always high in excess urine application in comparison to the adequate urine application. Conversely, to these findings, it was clearly observed that, continuous application of too much urine causes a significant increase in soil EC and a gradual accumulation of Na in treated soil after three times cultivation. Similarly to Na in soil, nitrogen was accumulated in soil with continuous application of excess urine, but at the meantime the " Unknown-N " was not affected by continuous cultivation and was constantly high in extra urine treatments. While, in adequate urine application, no accumulation of Na in soil was observed even after 3rd time cultivation, since 98.9% of the total Na applied through urine during the 3 times cultivation was uptake by plant compared to U-2V0 (80.0%) and U-3V0 (58.8%) treatments. Therefore, adequate urine application causes no accumulation of Na in soil with continuous cultivation. Thereafter, from these results, it is suggest that application of adequate human urine based on N requirement, might be a better practices for a sustainable reuse of urine in arable land.

Chapter 5, Conclusion and recommendations

This chapter summarized the major findings of this research work and proposes some recommendations for a sustainable reuse of urine in agriculture.