

Original Research Article

<https://doi.org/10.20546/ijcmas.2018.702.366>

Effect of Urine Application on System Efficiency and Economics under Maize (*Zea mays* L.) and Toria (*Brassica campestris* L.) Cropping System

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ABSTRACT

Keywords

Human urine,
Maize, Toria,
Cropping system,
Economics

Article Info

Accepted:

26 January 2018

Available Online:

10 February 2018

A two years research experiment was conducted during 2014-15 and 2015-16 at upland farm of the ICAR research complex for NEH region, Barapani, Meghalaya. The experiment was undertaken to evaluate the effects of urine application as the alternative source of fertilizers in maize and toria cropping system. Among the treatments, application of human urine in combination with urea (T₈) produced the highest maize equivalent yield (98.80 q ha⁻¹), system productivity (27.07 kg ha⁻¹ day⁻¹), economic efficiency (135.21 ₹ day⁻¹), return day (211.81 ₹ day⁻¹) and production efficiency (42.40 kg ha⁻¹ day⁻¹) of maize-toria cropping system. The highest monetary return was recorded from human urine in combination with urea for maize but it was found under FYM (T₅) in case of toria. However, the system gross return and B: C were observed under human urine in combination with urea.

Introduction

Maize – toria is the most prevalent cropping sequence adopted by the farmers in the north eastern hill region of India. This system is followed in the mid hill areas without proper nutrient management leading to fast depletion of soil fertility and crop productivity. The rising prices and lack of availability of inorganic fertilizers at right time to the farmers due to poor transport facility necessitates some alternative ways of nutrients supply (Munda *et al.*, 2011). On the other

hand, use of animal and crop waste in the form of farm yard manure (FYM) or compost is common practices in majority of the farm community. However, the progress of organic agriculture has been very slow due to rapid declination of organic raw materials such as animal waste, crops residues and green manure which is due to burning of waste and residues and also due to utilization of straw and grass as animal feed (Tejada *et al.*, 2008).

Urine is therefore worth using as fertilizer, especially as its content of NPK is readily

available to the plants (Jonsson *et al.*, 2004). The concentrations of heavy metals in human urine are negligible, an important advantage over chemical fertilizer (Palmquist and Jonsson, 2004). Urine can be applied in a variety of ways including in undiluted form to soil beds before planting where the bacteria in the soil change the urea into nitrate which can be used by the plants, during the entire cropping cycle as a liquid plant food and as an 'activator' for compost heaps where the transformed organic nitrogen will be available to plants when the compost has matured (Rahman and Chariar, 2015). The value of the nutrients in urine can be calculated by comparing the quantity of plant nutrients in urine to the price of the same nutrients in chemical fertilizers on the local market (Richert *et al.*, 2010), which are getting free of cost if applied own urine to crops.

Materials and Methods

The experiment was conducted during 2014-15 and 2015-16 in upland research farm of ICAR for NEH region, Umiam, Meghalaya on sandy clay loam soil having pH of 4.92, 1.21% OC with available NPK of 285, 16.4 and 165 kg ha⁻¹, respectively. The average of two years total rainfall received during the crops growth was 1920 mm. An average maximum and minimum temperature of 32°C and 6°C was recorded during the entire growing period. Nine treatments from different sources of nitrogen applied at same rate of N:P:K @ 80:60:40 kg ha⁻¹ viz. T₁- Absolute control, T₂- chemical fertilizers, T₃- 100% N through human urine (only basal), T₄- 100% N through cow urine (only basal), T₅- 100% N through FYM (only basal), T₆- 100% N through human urine in 2 split application (basal and top dressing), T₇- 100% N through cow urine in 2 split application (basal and top dressing), T₈- 50% N through human urine (basal) + 50% N through urea (top dressing), T₉- 50% N through cow urine (basal) + 50% N

through urea (top dressing) replicated forth in randomized block design. The maize var. DA-61A and toria var. M-27 were sown on May and October during 2014-15 and 2015-16 keeping sowing distance of 50 × 25 cm² and 40 × 10 cm², respectively. All the treatments were furnished with SSP and MOP to supplement the deficit amount of P and K, and to make the same rate as recommended dose in all the treatments except control. However, the above treatments were not applied to toria crop as the toria crop was grown to check the residual fertility effect from above treatments which were applied to preceding crop (maize). Irrespective to the treatments above, toria crop was furnished with N: P: K @ 40:30:20 kg ha⁻¹. Total cost of cultivation was calculated in terms of ₹ ha⁻¹ for different treatments. Cost of seed was considered to ₹ 30 kg⁻¹ for maize and ₹ 110 kg⁻¹ for toria while costs of fertilizer were taken as ₹ 13.22 kg⁻¹ N through urea, ₹ 63.05 kg⁻¹ P₂O₅ through SSP, ₹ 33.37 kg⁻¹ K₂O through MOP and ₹ 2.6 kg⁻¹ FYM. There was no cost for urine however charges on collection of urine were applied. Gross return was calculated in ₹ ha⁻¹. Price of maize grain, toria seed, maize and toria over was taken from the minimum support price of maize and toria given by govt. of India for the year 2015-16 and 2016-17. The benefit: cost ratio was computed by dividing the gross return by the cost of cultivation in each treatment. The analysis and interpretation of data were done using the Fisher's method of analysis of variance technique.

For system efficiency, the following indices were calculated (Devasenapathy *et al.*, 2008; Gangwar *et al.*, 2006; Lal and Ray, 1976)

$$\text{System productivity (kg ha}^{-1}\text{day}^{-1}\text{)} = \frac{\text{Seed equivalent (kg ha}^{-1}\text{)}}{365 \text{ Days}}$$

$$\text{Maize equivalent yield (q ha}^{-1}\text{)} = \text{maize yield (q ha}^{-1}\text{)} + \frac{\text{monetary value of crop as intercrop or sequence crop (ha}^{-1}\text{)}}{\text{Selling price of maize}}$$

$$\text{Economic efficiency } (\text{₹ day}^{-1}) = \frac{\text{Net monetary return over year}}{365 \text{ days}}$$

$$\text{Return day } (\text{₹ day}^{-1}) = \frac{\text{net monetay return of the cropping sequence}}{\text{Total duration of the cropping sequence (days)}}$$

$$\text{Production efficiency } (\text{kg ha}^{-1} \text{ day}^{-1}) = \frac{\text{Maize equivalent yield of sequence (kg ha}^{-1})}{\text{Total duration of the cropping sequence (days)}}$$

Results and Discussion

All the data given are pooled of two years data viz. 2014-15 and 2015-16.

System efficiency

Higher MEY from human urine in combination with urea (T₈) (98.80 q ha⁻¹) which were 7.04%, 9.21%, 12.99%, 14.56%, 14.82%, 22.55%, 27.95% and 57.89% more maize equivalent yield over cow urine in combination with urea (T₉), human urine in split application (T₆), chemical fertilizers (T₂), cow urine in split application (T₇), human urine applied once (T₃), cow urine applied once (T₄), FYM (T₅) and control (T₁), respectively (Table 1). The highest MEY in human urine in combination with urea may be attributed to higher yield production in integration treatment of urine and urea. Higher equivalent yield of maize in integrated application of plant nutrient was in conformity with the findings of (Munda *et al.*, 2011).

In terms of system productivity, human urine in combination with urea was far better than the rest of the treatments. However, combination of cow urine with urea also proved to be better than split application of urine, urine applied once, chemical fertilizers and FYM but at par with human urine in split application. Among the treatments, there was similarity of system productivity between chemical, human urine applied once, human urine in split application and cow urine in split application but they were higher than cow

urine applied once, FYM and control. FYM produced the least system productivity. Table 1 showed that, human urine in combination with urea, cow urine in combination with urea, human urine in split application, chemical treatment, cow urine in split application, human urine applied once cow urine applied once and FYM produced 57.89%, 54.69%, 56.60%, 51.59%, 50.69%, 50.06%, 45.63% and 45.57% more system productivity over control, respectively.

Similar to the above two system efficiency parameters, economic efficiency was higher in integrated application of urine and urea than split application and nutrient applied once. Application of FYM in maize-toria system to the recommended dose of NPK produced least economic efficiency.

Highest value from human urine in combination with urea produced 14.42%, 16.51%, 26.60%, 32.76%, 37.67%, 46.78% and 78.56% more economic efficiency over human urine in split application, cow urine in combination with urea, cow urine in split application, chemical treatment, human urine applied once, cow urine applied once and FYM, respectively. Combination application of urine and urea and split application of urine produced higher economic efficiency than chemical, however, at par with cow with cow urine in split application and chemical produced higher efficiency than urine applied once and FYM.

Return day from Table 1 showed that the negative value from FYM applied treatment, which is due to more expensive in application of FYM to get the same recommended dose of nutrient. This negative value showed to loss of capital in this treatment. Among the urine applied treatments, integrated application of urine and urea or urine in split application led to higher return day than chemical treatment except cow urine in split application.

Table.1 Effect of urine application on efficiency of maize-toria cropping system

Treatment	Maize equivalent yield (q ha ⁻¹)	System productivity (kg ha ¹ day ⁻¹)	Economic efficiency (₹ day ⁻¹)	Return day (₹ day ⁻¹)	Production efficiency (kg ha ⁻¹ day ⁻¹)
T ₁ . Control	41.60 ^e	11.40 ^e	28.98 ^f	45.40 ^f	17.85 ^e
T ₂ . Chemical	85.97 ^c	23.55 ^c	90.92 ^{cd}	142.43 ^{cd}	36.90 ^c
T ₃ . HU	83.98 ^c	23.01 ^c	84.27 ^d	132.01 ^d	36.04 ^c
T ₄ . CU	76.52 ^d	20.97 ^d	71.96 ^e	112.72 ^e	32.84 ^d
T ₅ . FYM	71.20 ^d	19.51 ^d	-123.24 ^g	-193.05 ^g	30.56 ^d
T ₆ . HU in 2 split	89.70 ^{bc}	24.57 ^{bc}	115.71 ^b	181.27 ^b	38.50 ^{bc}
T ₇ . CU in 2 split	84.41 ^c	23.12 ^c	99.24 ^c	155.46 ^c	36.23 ^c
T ₈ . 50 HU + 50 urea	98.80 ^a	27.07 ^a	135.21 ^a	211.81 ^a	42.40 ^a
T ₉ . 50 CU + 50 urea	91.84 ^b	25.16 ^b	112.89 ^b	176.85 ^b	39.42 ^b
SE(m)±	2.02	0.55	4.00	6.27	0.87
CD (p=0.05)	5.75	1.58	11.38	17.83	2.47

Means within the column followed by the same letter (s) do not differ significantly at 5% level of significance by LSD

Table.2 Effect of urine application on economics of maize-toria cropping system

Treatments	System cost of cultivation (₹)	Gross return from system (₹)	B:C
T ₁ . Control	40505	51083 ^g	1.26 ^f
T ₂ . Chemical	53814	86999 ^{cd}	1.62 ^d
T ₃ . HU	53908	84667 ^{de}	1.57 ^{de}
T ₄ . CU	52491	78756 ^f	1.50 ^e
T ₅ . FYM	127163	82172 ^{ef}	0.65 ^g
T ₆ . HU in 2 split	47476	89717 ^{bc}	1.89 ^b
T ₇ . CU in 2 split	49561	85784 ^{cde}	1.73 ^c
T ₈ . 50 HU + 50 urea	47994	97345 ^a	2.03 ^a
T ₉ . 50 CU + 50 urea	50079	91284 ^b	1.82 ^b
SE(m)±	-	1461	0.03
CD (p=0.05)	-	4155	0.08

Means within the column followed by the same letter (s) do not differ significantly at 5% level of significance by LSD

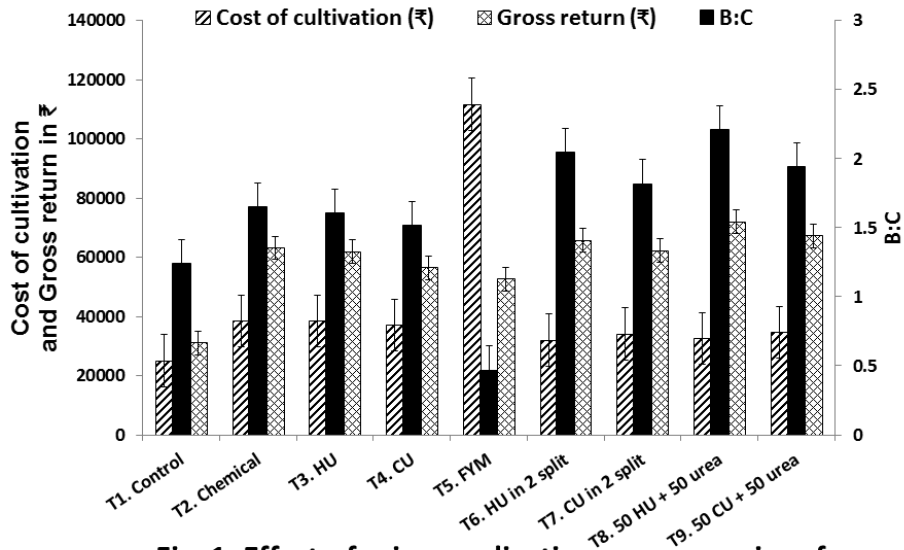


Fig. 1. Effect of urine application on economics of maize alone

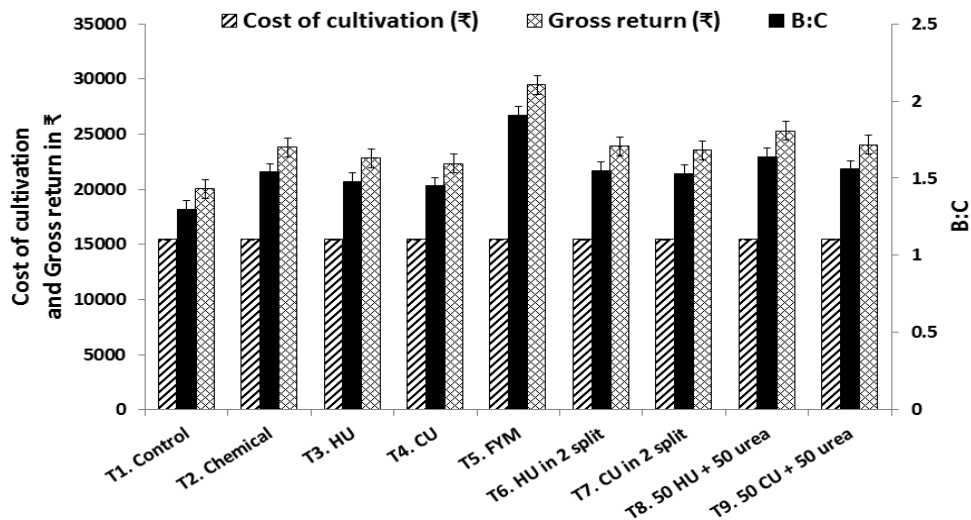


Fig. 2. Effect of Urine application on economics of toria alone

Human urine in combination with urea, cow urine in integration with urea, split application of human urine and cow urine produced 32.76%, 19.46%, 21.43% and 8.38% more return day over chemical treatment, respectively. However, chemical treatment had more return day than urine applied once, FYM and control. Application of FYM alone as recommended dose could not bring the production efficiency as of urine and

chemical treatment but higher than control. Among urine and chemical treatments, integrated application of urine either human or cow with urea were 12.97% and 6.39% more production efficiency than chemical treatment. Relatively higher production efficiency in integration of different plant nutrient source could be because of prolonged supply of nitrogen as results of mineralization (Reddy *et al.*, 2004). This result was in

conformity with the findings of (Rama Lakshmi *et al.*, 2012). However, split application of urine could not produce significantly higher over chemical treatment.

Application of urine alone at once was inferior as compare to combination application or split application of urine. But there was no significant variation between chemical treatment and human urine applied once similarly cow urine applied once and FYM in terms of production efficiency.

Economics

Cost of cultivation accounts for expenditure in inputs, labour, land, interest and other various expenses. Figure 1 showed that the highest cost of cultivation in maize crop alone was under FYM, it is because of FYM application in bulk amount to get the same recommended dose of NPK. The least cost was found under control as there were no additional nutrient inputs in it. Among the urine and chemical treatments, human urine applied once needed more expenses than other treatments followed by chemical treatment (Fig. 1). The gross monetary return from the integrated application of urine with urea was more than chemical. Human and cow urine in combination with urea produced 12.31% and 6.05% more return than chemical treatment. However, split applications were statistically at par to chemical but higher than urine applied once. Similarly, B: C ratio from combination application and split application of urine were more than chemical treatment and other urine and FYM applied treatments. Integrated application of human or cow urine with urea could increase the B: C upto 14.94-25.35% whereas in split application of urine it was 9.34-19.51% more as compared to chemical treatment for maize crop alone. Similar, results of higher gross return and B: C ratio under integrated nutrient management was found by Rama Lakshmi *et al.*, (2012).

All the treatments have similar cost of cultivation in case of toria as the nutrient inputs were similar to all the treatments; however, toria was grown to check the residual nutrient effect from the nutrient applied to previous crop (maize). Even if FYM could not produce better monetary return to maize, its residual fertility effect to the succeeding crops leads to higher gross return and B: C ratio than the other treatments (Fig. 2). Residual nutrient effect of human and cow urine in combination with urea were higher than chemical treatments, it leads to higher monetary return and B: C ratio. But chemical treatment was at par with split application of urine. The highest monetary returns and benefit-cost ratio realized with the supply 100 per cent nitrogen through FYM (T₅) to preceding toria was in conformity with the findings of Kumari and Reddy (2010).

Maize and toria in a system as a whole, all the urine applied treatments required less cost of cultivation than chemical treatments except human urine applied once (Table 2). Human urine in split application required least cost followed by human urine in combination with urea, cow urine with urea and cow urine in split application. But the highest cost of cultivation in FYM was due to application of FYM in bulk amount to meet the same NPK dose as of other treatments. All the treatments produced higher monetary return than control. Among the nutrient treated plots, the higher monetary return was recorded from urine either in split application or in combination with urea than other treatments except cow urine in split application which was higher by chemical application. Human urine in combination with urea, cow urine with urea and human urine in split application produced 10.71%, 4.69% and 3.02% higher monetary return than chemical treatment. However, chemical treatment produce more return over cow urine in split application, human and cow urine applied once, FYM and control.

Application of human urine either in combination with urea or in split application proved to have higher B:C ratio followed by cow urine in combination with urea or in split application, chemical treatment, human and cow urine applied once, control and FYM, respectively. However, human urine in combination with urea produced 6.09%, 10.34%, 14.78%, 20.20%, 22.66%, 26.11%, 37.93% and 69.98% more B:C ratio than human urine in split application, cow urine in combination with urea, cow urine in split, chemical treatment, human urine applied once, cow urine applied once, control and FYM, respectively. Similar result of higher gross return, net return and B: C ratio under integration of different plant nutrient applied to maize-toria cropping system was found by Munda *et al.*, (2011).

From the above results and discussion, it can be concluded that application of urine in integration with urea was the most profitable under maize- toria cropping system or under maize crop alone than the plant nutrient applied in single either urine or chemical fertilizers. But the residual effect of FYM from the previous crop leads to get better monetary return from the succeeding crop *i.e.* toria.

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How to cite this article:

Sanjenbam-Dayananda Singh, Vishram Ram and Naveen Khoisnam. 2018. Effect of Urine Application on System Efficiency and Economics under Maize (*Zea mays* L.) and Toria (*Brassica campestris* L.) Cropping System. *Int.J.Curr.Microbiol.App.Sci.* 7(02): 3008-3015. doi: <https://doi.org/10.20546/ijcmas.2018.702.366>