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Assessment of Combined Effects of Human Faeces and Mineral Fertilizers on the Behavior of Okra (*Abelmoschus esculentus* L.) Cultivated in Lubumbashi, DR Congo

²Ben Tshibuyi Kasu-Bandi, ¹Laurent Kidinda Kidinda, ¹John Banza Mukalay and ^{1,3}Louis Baboy Longanza

¹Department of Phytotechny, Faculty of Agricultural Sciences, University of Lubumbashi, Lubumbashi, Democratic Republic of Congo

²Institut National Pour l'Etude et la Recherche Agronomique (INERA), Station of Kipopo, B.P. 224, Lubumbashi, Democratic Republic of Congo

³Université Libre de Bruxelles, Ecole Interfacultaire de Bioingénieurs, Service d'Ecologie du Paysage et Systèmes de Production Végétale, B-1050 Bruxelles, Belgique

Corresponding Author: Laurent Kidinda Kidinda, Department of Phytotechny, Faculty of Agricultural Sciences, University of Lubumbashi, Lubumbashi, Democratic Republic of Congo

ABSTRACT

Improving soil fertility through organic fertilizers application has become a major factor that has enabled the world to feed billions of people. However, the required quantities of organic material are enormous, so it becomes necessary to combine different types of fertilizers to feed plants. The objective of this study was to evaluate the effects generated by the integration of human faeces to mineral fertilizers by bringing them to okra (*Abelmoschus esculentus*) crop. The trial was installed according to a 4×3 factorial device. Treatments in three repetitions, included four doses of human faeces (0, 1.75, 3.5 and 7 t ha⁻¹) and three doses of inorganic fertilizers (0 and 150 kg NPK+100 kg urea as mineral fertilizer popularized and 75 kg NPK+50 kg urea as mineral fertilizer popularized halved). These fertilizers were applied alone or in combination and were compared to an unfertilized control. Obtained results showed that emergence rate increases when human faeces are made at low doses. As for the vegetative parameters, the results are similar regardless of the type or dose of made fertilizers. Without mineral fertilizers the different doses of human faeces generate low yields of okra. The application of 7 t ha⁻¹ of human faeces combined with popularized mineral fertilizer dose halved (75 kg NPK+50 kg urea) afforded the highest yield (7.3 t ha⁻¹ or an increase of 348% compared to unfertilized control treatment). In the present study, where access to chemical fertilizers is very limited, these results allow to save a half of usually made mineral fertilizer dose for the cultivation of okra.

Key words: Okra, human faeces, productivity, organic matter

INTRODUCTION

Okra (*Abelmoschus esculentus* L.) is in young immature state (fruits) a very important vegetable (Folorunso and Ojeniyi, 2003). Originally from Africa, okra is currently very re-hanged in the tropics including Democratic Republic of Congo, However, its cultivation is facing many constraints like climate change, natural resources degradation especially the soil, diseases and pests (natural enemies) but also varietal selection that does not make available to producers efficient varieties. The low fertility of agricultural soils is the primary key constraint to increased production.

Soil of the city of Lubumbashi and its hinterland have become increasingly infertile and in extreme cases the agricultural activities are possible only with considerable inputs of nutrients (Useni *et al.*, 2013). This fact increases the poverty of farmers and even threatens their existence. Farmers use essentially the spreading of organic materials consisting of manure, compost or household waste, ash and in some cases with mineral fertilizers (Yeledhalli *et al.*, 2008; Bodruzzaman *et al.*, 2010). Due to the high cost of fertilizer use and rarity, most tropical countries have turned to the use of organic waste as a source of nutrients in agriculture. However, the quantities of organic materials required are huge and it becomes necessary to combine different types of fertilizers to feed plants (Ayeni and Adetunji, 2010; Useni *et al.*, 2013; Kimuni *et al.*, 2014).

Several studies have demonstrated the effectiveness of the use of organic matter in agriculture. In the one hand, it increases the availability of nutrients in the soil, in the other hand it reduces disease incidence. Improving soil fertility through the contribution of organic fertilizer, has become an important factor that has enabled the world to feed billions of people (Brady and Weil, 1999). African soil fertility is generally maintained through the combined contributions of mineral and organic fertilizers, which improves the physical and biological properties of soil (Okwuagwu *et al.*, 2003). The use of the organic material may also improve crop yields, soil pH, nutrient content of the soil and their availability to the plant (Akande *et al.*, 2010). Mukengere (2010) in addition, recent work has shown that the contribution of organic matter not only contributes to improve physical and chemical properties of the soil but it also increases crop yields (Compaore *et al.*, 2010; Ayeni and Adetunji, 2010; Useni *et al.*, 2013; Kimuni *et al.*, 2014; Longanza *et al.*, 2015).

It is proved by Kirchmann and Pettersson (1994), Vinneras *et al.* (2003), Kiba (2005), Useni *et al.* (2013) and Kimuni *et al.* (2014) that human faeces are rich in nutrients and allow to obtain competitive yields to those obtained with mineral fertilizers. Human faeces remarkably improve the stock of nutrients in the soil, decreasing its acidity and can therefore be used as an amendment.

This study test the hypothesis that the contribution of human faeces decreases the amount of mineral fertilizers to make and increases okra (*Abelmoschus esculentus*) yield.

MATERIALS AND METHODS

Study area: The study was conducted at Kassapa farm, a research station of the Faculty of Agricultural Sciences at the University of Lubumbashi (UNILU). This site is located at 1274 m altitude average, 11°39 'S latitude South and 27°28' East longitude. Two seasons characterize the climate of the city of Lubumbashi and its surrounding area, which are more related to variations in rainfall as temperatures: the rainy season and the dry season. The dry season is from April to late October and the October-April rainy season with an average annual rainfall of 1200 mm (Malaisse, 1990).

Soils in Lubumbashi and its surroundings are characterized by a coarse sandy clay, they are poor in organic matter that has resulted in the development of an unstable structure and dominance of macro porosity, these soils have a pH 5.2 in general and even when good land suitable for have crops (Kwey *et al.*, 2015). The soils of Kassapa farm belong to groups red lateritic soils with red ocher. Chemical Analysis at the Centre de Recherche Agro-Alimentaire (CRAA), Laboratory of the Composite Sample of Soil, according to the methods described by Mpundu (2010), gave the following results: Total N = 0.224%, total P = 0.0224%, available P = 0.0058%, S = 1.03%, Ca = 0.04% and Mg = 0.816%. Lubumbashi vegetation consists of three types of vegetation that are: Savanna, steppe and forest. The latter represents over 80% and comes in three aspects: Dense dry

forest, woodland and savanna steppe (Malaisse, 1997). Vegetation in our experimental field consisted of grassland and following plant species were found in the experimental site before its opening: *Cynodon dactylon*, *Imperata cylindrica* and *Tithonia diversifolia*.

Materials: Okra seeds (*Abelmoschus esculentus*) constituted the biological material. Human faeces, exposed to the sun for one year after the emptying of septic tanks, thereby sanitize, were used as organic manure. They were obtained on university campuses (UNILU). Composition, after analysis of a sample to the spectrophotometer of OCC according to the methods described by Mulaji (2011) indicates 6% N, 0.67% Ca, 1% Mg, 2.3% P and 28.8% K. The NPK fertilizer (10-20-10) was used as a base fertilizer, urea 46% fertilizer as cover fertilizer. Both types of fertilizers were bought at the market Mzee Laurent Desiré Kabila.

Experimental design, treatments and conducting the test: The test was installed following a 4×3 factorial device. Treatments in three repetitions, included four doses of human faeces (0, 1.75, 3.5 and 7 t ha⁻¹) and three doses of inorganic fertilizers (0, 150 kg NPK+100 kg urea as mineral fertilizer popularized and 75 kg NPK+50 kg urea as mineral fertilizer popularized halved). These fertilizers were applied alone or in combination and were compared to an unfertilized control. The plowing was done with the tractor and sowing was carried out on 20th December, 2010 at 2 seeds per hole spacing to 40×40 cm with a density of 125000 plants ha⁻¹. Human faeces were buried 7 days before sowing with 3 levels of different doses 1.575, 3.15 and 6.3 g as well as mineral NPK fertilizer (20-10-10) and the amount of 150 kg ha⁻¹. During the experiment until harvest, observations focused on the emergence rate, plant height, number of fruits per plant, average fruit weight per plot, fruit length, fruit diameter and fruit yield.

Statistical analysis: The raw data on the vegetative and yield parameters were treated by analysis of variance (ANOVA) with *post hoc* test (Tukey test) for average separation.

RESULTS

Results in Table 1 show that the emergence rate and yield of fresh fruit are statistically different. Human faeces doses, significantly influenced emergence rate (p<0.05), fruit weight per

Table 1: Effect of increasing doses of human faeces, mineral fertilizers and their combination on the growth and yield of okra at farm Kassapa

Human faeces (t ha ⁻¹)	Doses of mineral fertilizers	Emergence rate (%)	Plant height (cm)	No. of fruits per plant	Fruit length (cm)	Fruit diameter (cm)	Fruit weight per plot (kg)	Fresh fruit yield (t ha ⁻¹)
0	0	54.7±2.3	43.8±19.8	5.1±3.0	10.1±0.26	3.03±0.4	0.392±0.03	2.1±0.6
	VMF	39.1±5.3	64.4±13.5	7.3±4.2	11.1±0.7	3.23±0.28	0.611±0.03	4.7±0.8
	GMF/2	45.9±5.7	42.7±7.5	6.1±5.2	11.6±0.3	3.43±0.05	0.613±0.01	4.3±0.4
1.75	0	70.7±7.2	40.5±6.7	4.5±2.7	14.1±0.2	2.90±0.3	0.445±0.02	2.8±0.1
	VMF	46.9±5.4	45.5±0.9	6.3±3.1	13.4±0.6	3.40±0.1	0.912±0.01	5.8±0.8
	GMF/2	54.0±5.1	41.7±7.6	5.3±3.4	13.4±0.1	3.40±0.3	0.884±0.02	6.1±1.3
3.5	0	67.7±9.5	50.5±8.4	4.9±2.3	11.6±0.2	2.80±0.4	0.445±0.01	2.7±0.1
	VMF	49.7±3.6	41.6±4.4	6.0±3.9	10.8±0.55	3.50±0.0	1.036±0.02	6.6±1.2
	VMF/2	55.1±7.7	62.2±15.7	7.3±4.0	12.3±0.2	3.03±0.3	0.968±0.02	6.2±0.3
7	0	67.6±4.1	40.5±14.1	5.1±2.3	10.6±0.05	2.90±0.9	0.403±0.01	2.9±0.2
	VMF	46.2±3.1	43.8±6.3	5.3±3.7	13.4±0.9	3.40±0.05	1.138±0.01	6.1±3.2
	VMF/2	60.9±7.1	52.7±8.2	6.7±1.02	13.8±0.8	3.50±0.1	1.099±0.01	7.3±0.5
p-value		0.639	0.072	0.988	0.785	0.415	0.000	0.722

Mean±Standard deviation. VMF: Vulgarized mineral fertilizer, VMF/2: Vulgarized mineral fertilizer (halved)

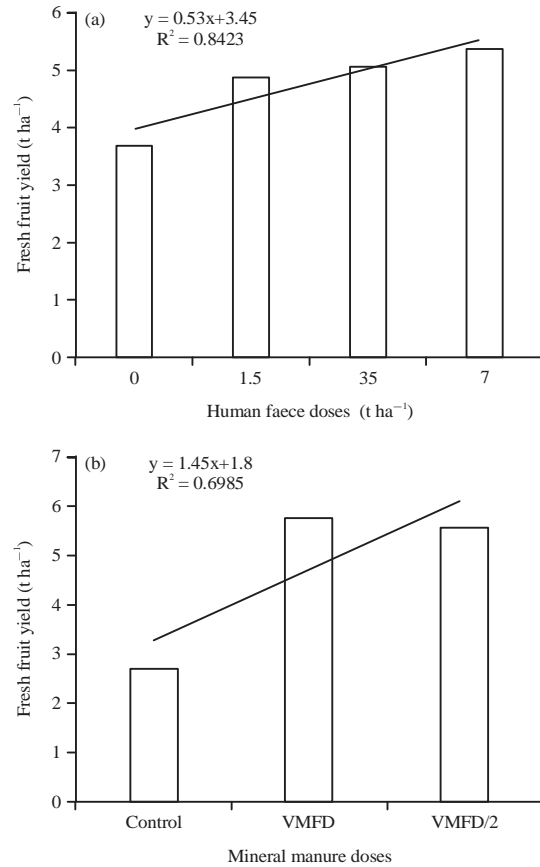


Fig. 1(a-b): Influence of (a) Human faeces doses and (b) Mineral fertilizer on okra fresh fruit yield, VMFD: Vulgarized mineral fertilizer dose, VMFD/2: Vulgarized mineral fertilizer dose halved

plot ($p < 0.05$) and fresh fruit yield ($p < 0.05$). Furthermore, no significant difference was observed on the plant height number of fruits per plant, the length of the fruit and fruit diameter. The average yields on plots fertilized at doses of mineral fertilizers are higher than those obtained on control plots without mineral fertilizers ($p = 0.025$) (Fig. 1).

Plots receiving mineral fertilizer and human faeces showed higher average weight relative to the control, in suite a significant influence is observed on emergence rate ($p = 0.001$) and the weight of fruit per plot ($p = 0.000$). Unlikely no significant difference was observed at the plant height, the number of fruits per plant, length on fruit and fruit diameter.

Statistical analysis: Statistical analysis reveals that the contribution of human faeces only positively influences the yield of fresh fruit ($p = 0.000$). The combination of different doses gave similar results ($p = 0.722$) on all observed parameters.

DISCUSSION

Table 1 reveals that emergence rate varies according to the applied doses of fertilizers regardless of the type; it varies between 39.1 and 70.7%. The statistical analysis, however, revealed that the interaction between the various doses of fertilizer did not give significant differences ($p = 0.639$). Despite this observation, it should be noted that the contribution of human faeces

(1.75 t ha⁻¹) yielded the highest percentage of emergence rate (70.7%). This percentage is higher than that obtained by adding the dose of vulgarized mineral manure (46%) and vulgarized mineral manure halved (54%) or by applying these mineral fertilizers alone. The applied organic material has provided a good environment for seed germination, while the phenomenon of plasmolysis (in the presence of small amount of water) caused by mineral fertilizers that caught the water at the expense of seed explain the low rate lifting observed on plots fertilized only with mineral fertilizers. As reported by Useni *et al.* (2013) and Kasongo and Banza (2015), the seed emergence rate is not influenced by the amount of nutrients in the applied fertilizer but by other extrinsic and intrinsic conditions (created by the fertilizer). The beneficial effects of organic matter on plant production have been proven by many researchers and it has been shown that the application of organic amendments improves the physical, chemical and biological soil (Kasongo *et al.*, 2013; Kwey *et al.*, 2015).

Concerning vegetative parameters, statistical analysis revealed not any inter-treatment difference was significant. Despite this, observed small numerical differences, allowed to say that plants of larger size are obtained by bringing to okra crop the Vulgarized Mineral Fertilizer Dose (VMFD) alone (generating plants of 64 cm in length) or dose VMFD/2+3.5 t ha⁻¹ of human faeces (vulgarized mineral fertilizer vm 62 cm in length).

The average yields on plots fertilized with mineral fertilizers are higher compared to those obtained on unfertilized control ($p = 0.025$). The same observation is made on the average fruit weight, emergence rate ($p = 0.001$) and fruit weight per plot ($p = 0.000$). Unlikely no significant difference was observed on the number of fruits per plant, fruit length and diameter. Without mineral fertilizers, yields of fresh okra fruits obtained in this study are significantly lower (between 2.7 and 2.9 t ha⁻¹). This corroborate to observation made by Ayeni and Adetunji (2010), studying the effects of chicken manure combined to mineral fertilizers, they found that the chicken manure applied alone did not significantly increase maize yields compared the unfertilized plots. However, the addition of the mineral fertilizer increased the solubility of the minerals contained in the organic matter and the yield increased very significantly compared with unfertilized plots. By providing the high dose human faeces (7 t ha⁻¹) combined with the VMFD/2 (75 kg NPK+50 kg urea) the highest yield is obtained (7.3 t ha⁻¹). The combination of organic and mineral fertilizers creates the best conditions of production because organic matter improves soil properties as mineral fertilizers provide plants with the nutrients that are required to increase their agronomic effectiveness (Mukengere, 2010). Several studies have shown that organic fertilizer applications decrease mineral fertilizers use frequency (Mulaji, 2011; Jama *et al.*, 2000; Mucheru-Muna *et al.*, 2007; Kasongo *et al.*, 2013). It is reported that the mineral fertilizers have a greater agronomic efficiency because their elements are available and readily absorbed by crops (Useni *et al.*, 2013). The low agronomic efficiency of organic amendments (when applied alone) is probably attributed to the slow decomposition of these for the availability of nutrients in the soil (FAO., 2005). However, several authors have demonstrated the effectiveness of human faeces to improve the physical and chemical conditions of the soil and thus increase crop yields (Useni *et al.*, 2013; Kimuni *et al.*, 2014). On unfertilized plots, the yield is very low and three times less than the yield obtained by bringing 7 t ha⁻¹+VMF/2. The low production of control soils can be attributed to factors characteristic of acidic soil pH acid toxicity of Al and Mg and nutrient deficiencies (Ca, Mg, P, K, B and Zn). In addition, the control plots, lack of organic inputs is accompanied by loss of organic matter and nutrients, soil acidification, reduction of biomass and microbial activity,

unsolubilization of phosphorus which together contribute to the significant drop in crop yields (Mulaji, 2011). A study in the same region Useni *et al.* (2013) on maize produced the same result.

CONCLUSION

The objective of this study was to evaluate the effects of mineral fertilizers, human faeces and their combination on the behavior of okra (*Abelmoschus esculentus*). Obtained results showed that the application of human faeces alone increases okra emergence rate. However, to increase the yield of fresh okra, their use requires additional contribution of mineral fertilizers. Without mineral fertilizers, yields of fresh okra are significantly lower regardless of the dose of human faeces made. Application of 7 t ha⁻¹ of human faeces combined with popularized mineral fertilizer dose reduced to half afford the highest yield (7.3 t ha⁻¹).

It would suit to future studies to evaluate the profitability of these doses of human faeces for their cost-effective use in agriculture.

REFERENCES

- Akande, M.O., F.I. Oluwatoyinbo, E.A. Makinde, A.S. Adepoju and I.S. Adepoju, 2010. Response of Okra to organic and inorganic fertilization. *Nat. Sci.*, 8: 261-266.
- Ayeni, L.S. and M.T. Adetunji, 2010. Integrated application of poultry manure and mineral fertilizer on soil chemical properties, nutrient uptake, yield and growth components of maize. *Nat. Sci.*, 8: 60-67.
- Bodruzzaman, M., C.A. Meisner, M.A. Sadat and M.I. Hossain, 2010. Long-term effects of applied organic manures and inorganic fertilizers on yield and soil fertility in a wheat-rice cropping pattern. Proceedings of the 19th World Congress of Soil Science, Soil Solutions for a Changing World, August 1-6, 2010, Brisbane, Australia, pp: 1-6.
- Brady, N.C. and R.R. Weil, 1999. *The Nature and Properties of Soils*. 12th Edn., Prentice Hall, New Jersey, USA., ISBN-13: 9780138524449, pp: 5.
- Compaore, E., L.S. Nanema, S. Bonkougou and M.P. Sedogo, 2010. [Evaluation of urban solid wastes composts quality in Bobo-Dioulasso city Burkina Faso for best efficient use in agriculture]. *J. Applied Biosci.*, 33: 2076-2083, (In French).
- FAO., 2005. Nutrition notions of plants and soil fertilization. Training Manual, Project Promotion of the Use of Agricultural Inputs by Producer Organizations of Niger, FAO., Rome.
- Folorunso, O.O. and S.O. Ojeniyi, 2003. Effect of sole and amended plant residues on soil nutrient content and yield of okra. *Asset Ser. A*, 3: 45-53.
- Jama, B., C.A. Palm, R.J. Buresh, A. Niang, C. Gachengo, G. Nziguheba and B. Amadalo, 2000. *Tithonia diversifolia* as a green manure for soil fertility improvement in Western Kenya: A review. *Agrofor. Syst.*, 49: 201-221.
- Kasongo, L.M.E., M.T. Mwamba, M.P. Tshipoya, M.J. Mukalay, S.Y. Useni, K.M. Mazinga and K.L. Nyembo, 2013. [Response of soybean (*Glycine max* L. (Merril) to the green biomass of *Tithonia diversifolia* (Hemsley) A. Gray used as organic fertilizer on a Ferralsol in Lubumbashi, DR Congo]. *J. Applied Biosci.*, 63: 4727-4735, (In French).
- Kasongo, L.M.E. and M.J. Banza, 2015. [Assessment of the response of soybean to the supply of increasing amounts of compost of *Tithonia diversifolia* on a highly weathered soil]. *Int. J. Innov. Applied Stud.*, 11: 273-281, (In French).

- Kiba, D.I., 2005. Valorisation agronomique des excreta humains: Utilisation de feces humaines et des urines pour la production de l'Aubergine (*Solanum melongena*) et du maïs (*Zea mays*) dans la zone centre du Burkina Faso. Memoire de Fin d'Etudes, Universite Polytechnique de Bobo Dioulasso, Institut de Developpement Rural, Burkina Faso, June 2005, pp: 1-79.
- Kimuni, L.N., I.T. Hugues, E.M. Musaya, A.E. Okese and M.A. Lukangila *et al.*, 2014. [Influence of fertilization based on recycled human waste, mineral fertilizers and their combination on the behavior of three varieties of maize (*Zea mays* L.)]. *J. Applied Biosci.*, 77: 6500-6508, (In French).
- Kirchmann, H. and S. Pettersson, 1994. Human urine-chemical composition and fertilizer use efficiency. *Fertilizer Res.*, 40: 149-154.
- Kwey, M.M., S.K. Banze and J.B. Mukalay, 2015. [Impact of organic amendments on salinity in banana crop: A case study]. *Afrique Sci.*, 11: 152-160, (In French).
- Longanza, L.B., L.K. Kidinda, D.T. Tamina, A.T. Jacob and M.T. Ikatalo, 2015. [Agricultural valorization of waste as an alternative to their management in the sub-Saharan Africa cities: Characterization of urban waste at Lubumbashi and evaluation of their effects on the growth of the staple crops]. *Afrique Sci.*, 11: 76-84, (In French).
- Malaisse, F., 1990. La Couverture Vegetale de Lubumbashi. In: Atlas de Lubumbashi, Bruneau, J.C. and M. Pain (Eds.). PUBLIDIX, Universite Paris X, Nanterre, France, pp: 30-31.
- Malaisse, F., 1997. Se Nourrir en Foret Claire Africaine: Approche Ecologique et Nutritionnelle. Presses Agronomiques de Gembloux, Belgium, ISBN-13: 9782870160459, Pages: 384.
- Mpundu, M.M., 2010. Contamination des sols en elements traces metalliques a lubumbashi (Katanga/RD Congo). Evaluation des risques de contamination de la chaine alimentaire et choix de solutions de remediation. Ph.D. Thesis, Faculte des Sciences Agronomiques, Universite de Lubumbashi, Congo.
- Mucheru-Muna, M., D. Mugendi, J. Kung'u, J. Mugwe and A. Bationo, 2007. Effects of organic and mineral fertilizer inputs on maize yield and soil chemical properties in a maize cropping system in Meru South district, Kenya. *Agrofor. Syst.*, 69: 189-197.
- Mukengere, B.E., 2010. Evaluation de l'efficacite d'usage des engrais dans les sols degrades du Sud-Kivu sur la culture du maïs et du haricot. Cas du groupement de Burhale. Memoire de fin d'Etudes, Faculte des Sciences Agronomiques et Environnement, Universite Evangelique en Afrique, Congo, pp: 1-59.
- Mulaji, C.K., 2011. [Use of household biowaste composts to improve acid soils fertility of the province of Kinshasa (Democratic Republic of Congo)]. Ph.D. Thesis, Universite de Liege, Gembloux Agro-Bio Tech, Gembloux, Belgium, (In French).
- Okwuagwu, M.I., M.E. Alleh and I.O. Osemwota, 2003. The effects of organic and inorganic manure on soil properties and yield of okra in Nigeria. *Afr. Crop Sci. Conf. Proc.*, 6: 390-393.
- Useni, S.Y., K.M. Chukiyabo, K.J. Tshomba, M.E. Muyambo and K.P. Kapalanga *et al.*, 2013. [Use of recycled human waste to increase the production of maize (*Zea mays* L.) on a ferralsol of Southeast DR Congo]. *J. Applied Biosci.*, 66: 5070-5081, (In French).
- Vinneras, B., H. Jonsson, E. Salomon and A.R. Stintzing, 2003. Tentative guidelines for agricultural use of urine and faeces. Proceedings of the 2nd International Symposium on Ecological Sanitation, April 7-11, 2003, Lubeck, Germany, pp: 101-108.
- Yeledhalli, N.A., S.S. Prakash, M.V. Ravi and K.N. Rao, 2008. Long-term effect of fly ash on crop yield and soil properties. *Karnataka J. Agric. Sci.*, 21: 507-512.