DEVELOPMENT OF COMPOST FOR RAISING SINGLE RICE SEEDLINGS IN SYSTEM OF RICE INTENSIFICATION FARMING.

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Abstract

It is important to utilize available organic wastes such as animal dungs and plant residues as reliable (cheaper and healthier) alternative to synthetic fertilizer. Using organic fertilizers on rice crop produced more grain yield than synthetically fertilized rice. But, due to unavailability of the compost in the study area there is need to develop effective compost manure which is suitable for raising single rice seedling by SRI practitioners. Thus, the main purpose of this study was to develop compost for raising rice seedlings individually under system of rice intensification (SRI). Rice seeds were sown in an isolated growing cavities comprising of four different compost mixtures of varying ingredients and the control treatment was 100% soil. Therefore, the experiment comprised of five treatments with three replications. Heights of rice seedlings were measured and recorded at 8, 10, 12 and 15 days after sowing (DAS). Analysis of variance (ANOVA) was used to determine the significant differences among the various treatments. The result showed that the attempt to raise rice seedlings using the newly developed compost is not impossible due to presence of healthy and energetic seedlings. Again, raising rice seedlings without the use of fertilizer especially compost manure allow the seedlings to experience delay in growth and development and it also showed significant reduction in height of the seedlings at 15 days after sowing (DAS). *Finally*, the investigation depicted the suitability of using the newly developed compost for raising rice seedlings under SRI practice.

Keyword: Composting, Compost, Rice seedlings, SRI

1.0 Introduction

The use of organic matter such as animal manures, food wastes, yard wastes, sewage, sludge and composts has long been reorganized in agriculture as beneficial for plant growth, high yield and the mantainance of soil fertility. The new approaches to use of organic amendments in farming systems have proven to be effective means of improving soil structure, enhancing soil fertility and increasing crop yields. Organic matters are excellent source of plant-availabl nutrients and their addition to soil could maintain a high microbial populations and activities (Pascual et al., 1997; Zink and Allen, 1998). The results of several long term studies have shown that the addition of compost improve soil physical properties by decreasing bulk density and increasing the soil water holding capacity (Weber, 2007). Moreover, in comparison with mineral fertilizatio compost significantly increases soil organic carbon and some plant nutrients (Garcia-Gil, 2000, Bullock et al., 2002; Nardi et al., 2004; Weber, 2007).

According to De Bertoldi et al. (1983) and Bernal et al. (2009), composts have several advantages compared to plant residues when applied to soils, such as reduced volume, slower mineralization rates and recycling of municipal biosolid wastes. Compost has two main effects on soils, particularly nutrient-poor soils: replenish soil organic matter and supply plant nutrients (Sanchez-Mondero et al., 2004; Tejada et al., 2009b). Organic matter plays a crucial role in improving physical, chemical and biological properties of soils. Soil structure can be improved by the binding between soil organic matter and clay particles via cation bridges and through stimulation of microbial activity and root growth (Farrell and Jones, 2009; Gao et a1., 2010). According to Tisdall and Oades (1982), organic matter can indirectly improve soil structure by increasing microbial activity and thus production of microbial slimes, fungal hyphae and/or roots bind aggregates together. Organic matter is a significant reservoir of nutrients and can retain nutrients in a plant-available form (Baldock, 2007).

Other beneficial effects of composts include increasing water holding capacity and plant water availability (CIWMB, 2004; Curtis and Claassen, 2005; Farrell and Jones, 2009), decreasing leaching of nutrients (Gale et al., 2006; Hepperly et a1., 2009), reducing erosion and evaporation and prevention of plant diseases (Arthur et al., 2010; Gershuny, 1994). Further, compost can act as a long-term slow release fertiliser. However, the application of immature compost can have negative effects on plant growth due to its unpleasant or nuisance odour production, potential to inhibit plant growth and reduce N availability in the soil. The beneficial effects of compost are only achieved when mature compost is added to soil.

In agriculture, there are two common methods for applying composts to soil: incorporation and mulching (Bastida et al., 2010; Cogger et al., 2008). Compost incorporation into the top few centimetres increases accessibility for soil microbes and also contact with the plant roots, and thus have a greater effect on soil C, N, and bulk density than surface application (mulching)(Cogger et al., 2008). Mulching is a common in horticulture and agriculture in dry climates because it minimizes water loss by evaporation (Agassi et a1., 1998; Agassi et a1., 2004; Gonzalez and Cooperband, 2002; Tu et al., 2006). Compared to incorporation, the effect of

mulching on the underlying soil can be expected to be smaller as it is limited to soluble compounds leaching from the mulch layer into the soil and due to the lower accessibility to soil organisms (Gonzalez and Cooperband, 2002). Compost with a coarse texture is considered the best for mulching because it allows water and air to move through to the soil underneath. It also decomposes slowly and is therefore long-lasting. Fine textured material can also be used as mulch but if applied too thickly it can trap water and prevent it from reaching the soil; this only generally occurs if the compost is applied in a layer of more than 5 cm thickness (Agassi et al., 1998; Paulin and O'Malley, 2008).

Application of compost to soils has been shown to limit water loss via evaporation, increase soil organic matter and thus water retention and availability (Or and Wraith, 2000; Weber et al., 2002). In a 5 y field experiment with compost from cattle manure, Celik et al. (2004) reported that the available water content of soils increased by 58-86% in the compost-amended soil as a result of increase in micro- and macro-porosity. By increasing the water retention of soils, more water can be conserved over the growing season in arid or semiarid regions and in some cases, increase yields of perennial crops (Chantigny et al., 2002; Fageria, 2002; Moran and Schupp, 2003).

Good soil structure favours gas and water transfer in soils, seed germination, and root growth as well as reduce susceptibility to erosion. The gummy, spongy texture of the humus-like substances in the compost facilitates formation of aggregates (Mylavarapu and Zinati, 2009; Sodhi et al., 2009; Tejada et al., 2009b). As a result of increasing microbial activity, soil aggregation can also be improved by bacterial slimes and fungal hyphae (Tisdall and Oades, 1982). In clay soils, addition of compost from MSWs can improve drainage and aeration (Avnimelech et al., 1990) and these benefits may occur within one year after composted cattle manure application (Whalen et a1., 2003). However, the effect of compost from MSWs on aggregate stability may be soil type-dependent as Yuksek et a1. (2009) and Duong et al. (2011) found that compost increased aggregate stability in lighter or medium textured soils but not in sandy or heavy-textured soils.

The addition of compost to soils affects soil microorganisms directly by providing a source of nutrients and indirectly by changing chemical and physical soil properties. Compost stimulates microbial growth and activity, but not to the extent as fresh plant residues because it is already decomposed. Compost generally increases the abundance of soil organisms (including earthworms) (Cheng and Grewal, 2009; Paulin and O'Malley, 2008; Sutton-Grier et a1., 2010).

Addition of compost from various feestocks has been shown to increase the abundance of Gram-positive bacteria (Islam et al., 2009), the density of ammonia oxidisers and denitrifiers in soil (Bastida et a1., 2008), as well as soil respiration (lovieno et a1., 2009), the activity of various enzymes (Antonious, 2009; Bastida etal., 2008; Crecchio et al., 2001) and potential nitrification and denitrification (Bastida et al., 2008; Sutton-Grier et a1., 2010). These changes will affect nutrient availability to plants and nutrient movement in soils.

Changes in microbial activity and community structure after compost application can lead to increased suppression of soil-borne plant pathogens such as Fusarium oxysporum f.sp. lini, Phytophthora cinnamomi and Meloidogyne hapla (Lozano et al., 2009) and enhance degradation of organic pollutants such as polycyclic aromatic hydrocarbons (PAHs) (Yuan et al., 2009), and fuel oil (Jorgensen et al., 2000). However, the effects of compost application on soil microbes may be transient. Crecchio (2001) reported that two years after addition of compost from MSWs the bacterial community composition was similar to that in the unamended control due to the depletion of substrate added with the compost.

In many countries and Nigeria as well, a large proportion of municipal waste is not disposed properly posing a potential environmental threat due to the presence of pathogens and toxic pollutants (Darby et al., 2006; De Araújo et al., 2009). Landfill is problematic as it leads to pollution problems such as leachate and landfill gases, especially when disposing municipal solid waste with high moisture and organic content (CIWMB,2004). Organic municipal waste and other organic material such as manure can be composted. And the resulting compost is nutrient rich and more stable than the original material (feedstock) and can improve soil quality and productivity as wellas sustainability of agricultural production (Barral et a1., 2009; Farrell and Jones, 2009). The cost of chemical fertilizers and the potential environmental risk posed by overuse have renewed the interest in using soil organic matter amendments such as plant residues, manures and composts, The objective of this study is to develop compost for raising rice seedlings and to determine the possibility of raising rice seedlings individually using the newly developed compost under system of rice intensification (SRI).

2.0 Materials and Method

There is need to utilize the available organic wastes as reliable (cheaper and healthier) alternative to synthetic fertilizer. Mohammed et al., (2014) found that rice grown using organic fertilizers on rice crop revealed more grain yield than synthetically fertilized rice.

2.1 Compost and composting

2.1.1 Preparation of compost ingredients

Several ingredients were used in preparing compost in this study. These comprised of cow dung, goat dung, poultry droppings, ash and cowpea husk. Cowpea husk was obtained from local animal feed centre, ash was domestically sourced and the remaining ingredients were entirely obtained from animal farm at Department of Agricultural Education of Umar Suleiman College of Education Gashua, Yobe State. The above mentioned ingredients were then separately ground and sieved using 2 mm sieve.

2.1.2 Preparation of various mixtures for composting

The ingredients used in preparation of compost for the present study were measured and mixed using different proportions, thereby making four different categories or samples of

compost. The first two samples (figure 1) comprised of 30% cow dung, 30% goat dung, 35% cowpea husk and 5% ash (Harden et al., 2007). Again, the measurement of the second treatment (T2) was by weight and for the third treatment (T3) was by volume. The second two samples which were treatment 4 & 5 comprised of 16% cow dung, 16% goat dung, 19% cowpea husk, 3% ash and 46% poultry manure (Figure 2). Still the measurement of third and fourth sample was also done by weight and by volume.



Figure 1: Mixture of various compost ingredients (30% goat dung (GD), 30% cow dung (CD), 35% cowpea husk (CH) and 5% Ash (A)) measured by volume by weight



Figure 2: Mixture of various compost ingredients ((16% goat dung (GD), 16% cow dung (CD), 46% poultry dung (PD), 19% cowpea husk (CH) and 3% Ash (A) measured by volume by weight

2.1.3 Composting process

The four samples which consist of various mixtures of compost ingredients (section 3.2.2) were separately put in to plastic containers. The mixture was being moisturized and turned thoroughly and kept under high temperature throughout the composting period. (Nakasaki et a1., 1985; Venglovsky et a1., 2005).The several compost samples were continuously turned twice daily (morning and evening) for a period of 14 days to achieve good composting, and later on dried, reground and sieve using 2 mm sieve. The plastic containers used during the composting were kept unclose in order to allow aeration in the mixture as well as the presence of aerobic organism to compost the mixture of the compost ingredients.

2.2 Experimental details

2.2.1 Treatment details

The treatments consist of various mixtures of compost manure with diverse ingredients at different proportions and 100% soil (which served as control). The treatments comprised of five treatments and three replications as shown in Table 1.

Table 1: Treatment details

S/No.	Treatments	Description
1	T1	Control (100% soil)
2	T2	GD + CD + CH + A (by weight)
3	T3	GD + CD + CH + A (by volume)
4	T4	GD + CD + CH + A + PM (by weight)
5	T5	GD + CD + CH + A + PM (by volume)

2.2.2 Experimental design

The experiment was done using complete randomized design (CRD) with five treatments and three replications as shown in figure 3. Each replication consists of ten plastic circular isolated cells with 2 cm height and 0.87 cm diameter.

T5R1	**T4R2**	**T5R3**	**T3R1**	**T3R3**
T1R1	**T3R2**	**T5R2**	**T1R2**	**T2R1**
T2R2	**T1R3**	**T2R3**	**T4R2**	**T4R1**

***T**= Treatment and **R**= Replication*

Figure 3: Layout of five treatments with three replications using CRD

2.3 Soil and compost mixture

The rice seeds for the study were sown using soil that is organically fertilized using the four different composts developed in the study. The soil was taken from the paddy field of Mashangwari forest in Gashua town of Bade local government area of Yobe state. The soil was then ground and sieved using 2 mm sieve. The compost was then mixed with soil (Figure 4) using soil to compost ratio of 1:1 (Wayayok et al. 2017).



Figure 4: Soil to compost mixture using 1:1 ratio

2.4 Sorting and priming of rice seeds

Seed sorting was done through putting a fresh egg in water (Figure 5), followed by applying salt (Figure 6) in to the water until the egg floated (Figure 7). The rice seeds were then put in the salty water in order to remove the floated seeds (Figure 8) as immature with less endosperm, and the sunken seeds were considered as the best seeds for the experiment (Bashar et al. 2014). The rice seeds were immediately rinsed for several times to wash away the salt from the seeds. The seeds were soaked in water for 48 hours and later drained and enclosed in piece of cotton sheet. The enclosed seeds in the cotton sheet were kept in high temperature location in order to allow the seeds to be sprouted for easy germination process. This brilliant technique was already been validated by many scientific and research institution

on different crops. It also plays a vital and wonderful role in proliferating the rate of germination and early seedling establishment especially in dry and semi-arid regions (Aboutalebian et al., 2012).

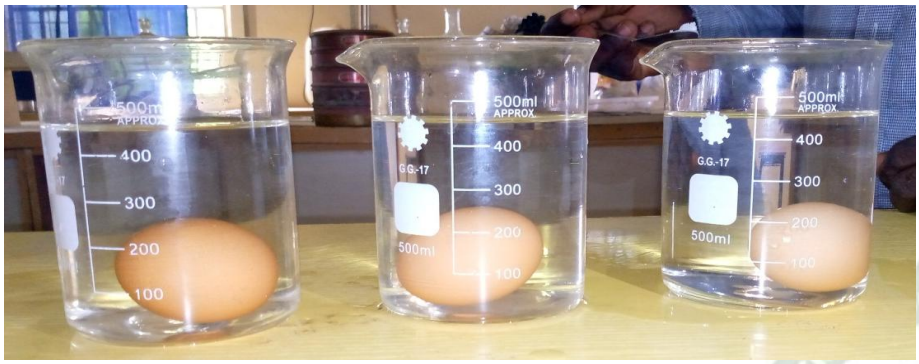

Figure 5: Eggs settled at the bottom of water before salt is added

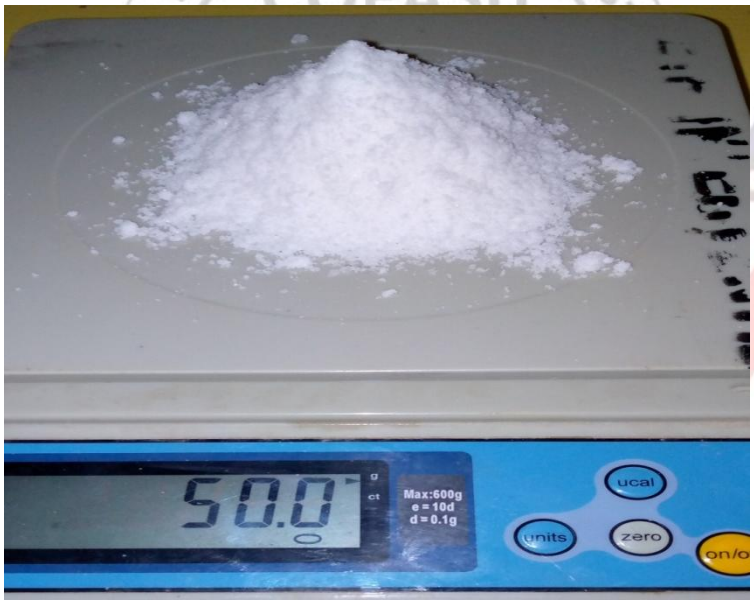

Figure 6: Salt ready to be added in normal water for seed sorting

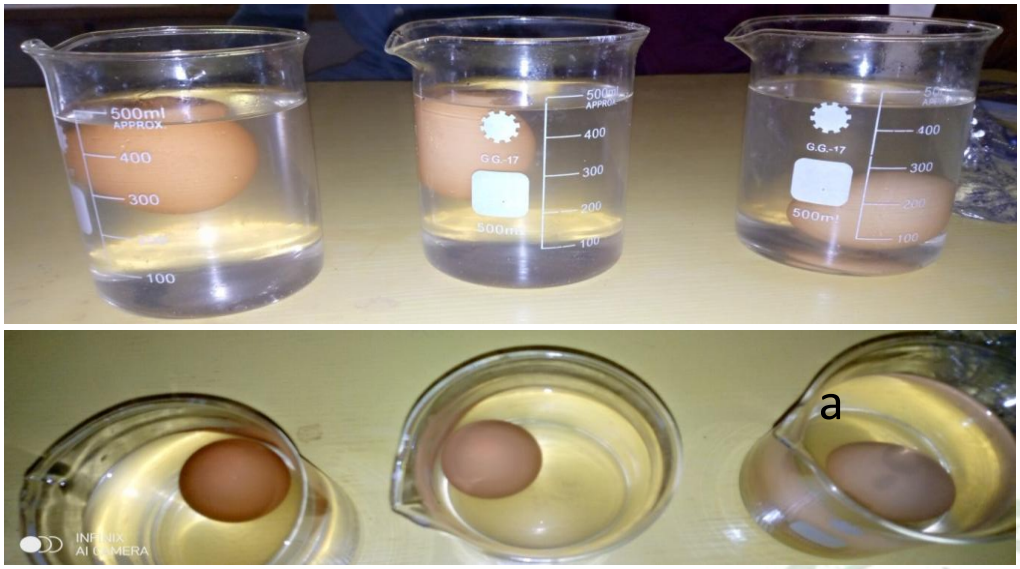

Figure 7: (a) Side view of floated and unfloated eggs in water after salt was diluted in it. (b) Top view of floated and unfloated eggs in water after salt was diluted in it.



Figure 8: The best rice seeds settled at the bottom of water while the floated seeds are the bad seeds.

2.5 Sowing of rice seeds

The rice variety used in this experiment was faro-44. The sorted and primed seeds (section 3.3) were sown individually in plastic circular isolated cells with 2 cm depth and 0.87 cm diameter using soil to compost ratio of 1:1 (section 3.3). The experiment was done at the nursery station of Umar Suleiman College of Education Gashua in Yobe State of Nigeria. The sown seeds were irrigated twice daily (morning and evening) using hand watering jar up to 15 days after sowing to prevent drought and to sustain moist soil condition.

2.6 Data collection

Three rice seedlings were randomly selected, measured and recorded from each replication at 8, 10, 12, and 15 DAS. The measurement was started from the base of the seedlings up to the tip of the leaf. The measurement was done using ruler.

2.7 Data analysis

Statistical package for social sciences (SPSS) version 21 was used to analyze the data collected. Analysis of variance (ANOVA) was to determine the significant differences among the various treatments and means were compared using Duncan assumption.

3.0 Results and Discussion

Intensive agriculture may result in soil organic matter losses, which have negative implications on soil fertility and sustainability. There are various options to increase soil organic matter content either by application of residues, manure or compost. Compost contain highly degraded organic material compare to residue or manure application (Mylavarapu and Zinati 2009; Zameer et al., 2010) and may therefore have longer lasting effect than the more rapidly decomposing residue and manure. Therefore, due to unavailability of compost in the study area there is need to develop effective compost manure which is suitable for raising non traumatic single rice seedling by SRI practitioners.

3.1 Effect of newly developed compost on raising single rice seedlings

Rice seeds were germinated and grown under healthy condition in the control treatment (100% soil) as well as in all the various compost amended soil as represented by all the five treatments including the control treatment. The result has shown that the attempt to raise rice seedlings using the newly developed compost is not impossible due to presence of healthy and energetic seedlings (Figure 9). Raising rice seedligs without the use of fertilizer especially compost manure allow the seedlings to experience delay in growth and development and it also showed significant reduction in height of the seedlings at 15 days after sowing (DAS) as depicted in Table 2.

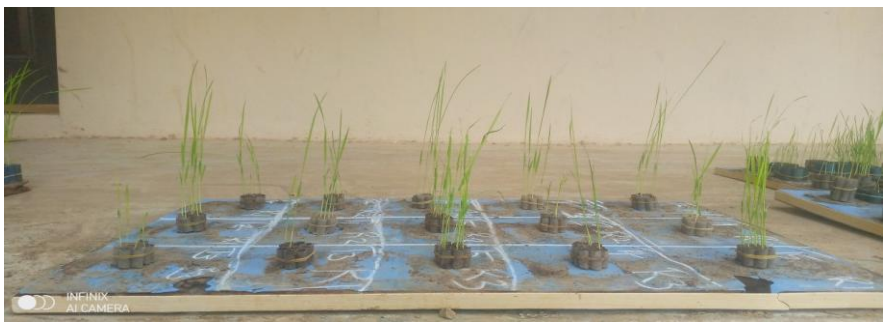

Figure 9: rice seedlings raised using the newly developed compost

Table 2: Heights of rice seedlings raised under various treatments

Treatments	8 DAS	10 DAS	12 DAS	15 DAS
T1	9.37[a]	13.40[a]	14.49[ab]	14.59[b]
T2	9.26[a]	10.38[a]	16.80[a]	21.30[a]
T3	3.60[c]	5.26[b]	10.53[b]	19.20[ab]
T4	6.42[b]	9.54[ab]	10.37[b]	15.27[b]
T5	10.16[a]	11.98[a]	12.51[ab]	14.46[b]

4.0 Conclusion

The study was conducted to develop compost for raising healthy and energetic rice seedlings to be transplanted under system of rice intensification (SRI). Two different compost ingredients were mixed and blended together manually under two varying measurement scales (weight and volume). This means four different mixtures of ingredients were blended and tested in order to come up with the best compost for raising SRI seedlings. The study confirmed the effectiveness of raising rice seedlings using the newly developed compost as a result of suitable growth and development of the rice seedlings raised. This was showed by the germination of rice seeds sown in the isolated cell cavities as well as proper growth and development of rice seedlings for SRI transplanting in paddy field. This revealed that the newly develop compost can be used for raising strong and healthy seedlings under SRI cultural practice. Conclusively, the investigation depicted the suitability of using the newly developed compost for raising rice seedlings under SRI practice. Additional test using on-farm investigation to examine the suitability of the newly developed compost to transplanted rice plants need to be considered. There is also need to test the possibility of raising other crops apart from rice using the newly developed compost.

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