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Review Article

Vermicompost a Sustainable Bio-Stimulant and Control for Agricultural Enhancement in Africa

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ABSTRACT

Agricultural productivity is characterized by soil, landform and climate change. Only 3% of the soil is fertile in South Africa which necessitates the need for improvement in agricultural practices. Several agricultural practices involve cropping systems, conventional ploughing, and hillside farming which tend to threaten the ecosystem due to frequent cropping, erosion, and leaching. Nutrients are frequently depleted from the soil, organic matter content is depleted, and the activities of microbes are hindered. A valuable biotechnological technique produced through a process called vermicomposting was discovered to improve soil characteristics. It involves combining various agricultural wastes, ranging from plant residue to animal droppings, to produce a harmless and odourless substance. This was found useful because composting waste with worms reduces greenhouse gas emissions. This product helps to control a wide range of pests and diseases of plants. In addition, the activities of invasive plants are suppressed which helps to restore nutrients into the soil. Vermicompost is efficient at stimulating germination, plant growth, and significantly increasing crop yield.

Keywords: Vermicompost; Bio-stimulant; Agriculture; Greenhouse gas

INTRODUCTION

South Africa is country of diversity, rich in culture and biodiversity. Efficient agriculture is a foundation for any economic development. It ensures a beneficial farming business that contributes to the nation's aggregate local production, food safety measures, communal well-being, employment, and ecotourism whilst heightening the worth of crude resources. Several writers such as Thirtle, et al. [1] as well as over the years, reported on quantifying farm efficiency in South Africa. Tracing back agricultural production from 1910 to present, an increase in the production of horticultural crops and high-value commodities was noticed Goldblatt. These findings indicate that South Africa operates contemporary profit-making agriculture in addition to agro-processing subdivision Agriseta. Commercial production must have been zoned into the different agro-climatic areas Agriseta. DAFF stated that farming comprises crop husbandry, horticulture, and animal production sectors which can be scaled from medium to large in their respective zone, either as commercial or subsistence farming.

AGRICULTURAL PRODUCTIVITY AND CLIMATIC INFLUENCE

The productivity in the various zones is characterized by soil type, landform and climate. This implies that the production method, techniques, varieties of crops, and their cultivation are well adapted to these zones [1]. The productivity in the various zones is characterized by soil type, landform and climate. This implies that the production method, techniques, varieties of crops, and their cultivation are well adapted to these zones. The agro-ecological zone varies with agricultural movements as from intensive food production in winter raindrop and extreme summer raindrop regions, to cow ranching in the bushveld and pastoral agriculture in the extra arid area. Out of 12% of the area available for agricultural productivity, only 3% is considered fertile. The majority of the country's terrestrial plane (69%) supports agriculture. Rainfall starting from the east is (>800 mm) and to the west is (<200 mm). The proportion of farmland that gets up to 600 mm per annum is limited and approximately one-fifth of the farmland receives below 200 mm annually. Soil

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structure and nature of rainfall significantly determine different agricultural practices in the various zones. Drought and the limited amount of water have been considered to have influenced agricultural production in South Africa.

INFLUENCE OF ECOLOGICAL ZONING ON AGRICULTURAL PRACTICE

Climate variability in the various agro-ecological zones substantiates the need for conventional farming methods to adopt different farming systems. Conventional or commercial farm practice maximizes yield per output. This practice involves growing more than one crop using innovative technologies and improved varieties. This practice includes monoculture, continuous cropping, conventional tillage, and hillside cultivation. Frequent cropping has been reported to threaten the ecosystem, through erosion and leaching, soil nutrient and organic matter depletion as well as the hindering of microbial activities. Climatic variability, which is also a challenge on conventional farm practice, can be resolved by integrating organic farming. Organic farming preserves the environment and conserves bypassing agro-climatic limitations across the country (Wall). This sustainable farming method includes the integration of vermicompost into the conventional farming system. This practice should assist crop management and support conventional farming methods. There is an urgent need to understand and appreciate the concept of vermicomposting so that the technique can be better adopted into existing farming. Vermicompost has been identified as a sustainable medium for organic farming. It is a mesophilic process that supports the breakdown of agricultural waste in the gut of earthworms to enhance productivity [2].

EARTHWORMS AND VERMICOMPOST DEVELOPMENT

The intensive interaction of earthworm populations with the microbial community promotes the stability of carbon-based material over a bio-oxidative activity, modifying the physical and chemical characteristics of the earth. The fast succession of microbial populations under aerobic conditions provides a well-stabilized product through the biological transformation of organic matter. This support microbial activity over enzymatic breakdown, enriched nitrogen manure as well as transportation of natural and mineral constituents. Earthworms have coexisted on the planet longer than 20 million years and feed on decay organic material (Gajalakshmi), consistently keeping the cycle of life. Earthworms support the recycling of organic nutrients from dead tissue. Based on ancient findings from Greece and Egypt, earthworms played a significant role in Nile valley croplands after the annual flood [3]. After a series of research, Charles Darwin concluded that 'earthworms are important in the history of the world'. Their feeding mode supports the passage of undigested materials in the digestive tract thereby transforming untreated garbage into eco-friendly fertilizer. In this process, the gut of the earthworm stimulates the conversion of organic waste into deodorized and neutralized compound. Nevertheless, the management of bio-solid waste enhances primary productivity through soil quality improvement while providing a clean and healthy environment. The process of recycling organic waste is generally regarded as composting which may likely prevent toxicity and pathogenic growth. Earthworms help maintain the ventilation and nutrient composition of the soil. The bioactive substance imparts and enhances biological uptake, germination, and development. Vermicomposting is gradually becoming a sustainable means for agricultural production.

VERMICOMPOST A BETTER INTERVENTION FOR CONVENTIONAL FARMING

The practice of farming using vermicompost may become an inevitable system in the future instead of green agricultural production through the activity of inorganic farming. It has been noted that the slow release of nutrients by vermicompost allows simple adsorption through vegetative growth, in addition to increasing the wetness of the soil [4]. The recycling of organic waste is obtained from different sources which include agriculture, animal waste, urban solid, or agro-industry. A major valuable resource through which organic fertilizer is fabricated is animal waste. Relatively, large amounts of macronutrients and micronutrients are provided through the application of animal waste into vermicomposting. This supports the provision of an environmentally friendly alternative to replacing mineral fertilizers as an intervention to the conventional farming method. Since 1960, food productivity was increased at the expense of the environment and society through the heavy application of agrochemicals. It destroyed natural fertility and killed the beneficial soil organisms, weakening the biological resisting power of crops. Plants subjected to agrochemicals became vulnerable to pests and diseases. The devastating effects of agrochemicals introduced the use of vermicompost as an intervention for revitalizing the soil and improving crop productivity. The recuperation of plant growth, yield, and maintenance can be enhanced through vermicompost practices and has been emphasized as a favorable channel where the general structure of the soil and fertility is improved by organic matter. Inorganic farming is not as economically viable and beneficial as organic farming. Pests and diseases are controlled by organic farming with no damage to the ecosystem. This, however, put off contamination and amplifies nutrient availability in the soil. Crops produced under these conditions are nutritionally valuable and are obtainable at good market prices. This investigation drives at benefiting farmers and improving their knowledge on how vermicomposting can enhance the value of harvest, augment the richness of the earth, and ease the expense necessary for procuring man-made manure for development. Furthermore, it promotes the well-being of the surroundings by easing the number of greenhouse gasses and subsequently allows the rundown of left-over matter as a substrate for increasing earth abundance. Green gardening performs a key function in food production days. The green garden could secure a huge and valuable worth of harvests through the application of vermicompost.

EARTHWORM TYPE AND CHARACTERISTICS

The earthworm species worldwide are estimated to be 1800. Earthworms are round body organisms that have pointed heads with slightly flattened posteriors. Since earthworms have no backbone, the softness and the ring-like body structure allow twisting and turning in moist soil. The earthworm has no true legs but they can move their body back and forth with bristles (setae) which allows crawling. The skin of earthworms supports infiltration of air into the body. Food is taken in *via* the oral cavity into the abdomen (crop) (Amir and Nasroallah; Appelhof) and gorges *via* the gizzard, where it is crushed off by ingested stones. By products are removed from the intestine through a process called excretion. Earthworms belong to the group of animals called hermaphrodites which have both male and female sex organs but need a different worm to copulate. The broad ensemble (clitellum) that encircles a full-grown procreating earth worm discharges secretion (albumin) after mating [5]. Sperm from a different worm is laid up in sacs. As the secretion glides over the worm, it sheathes the sperm and eggs. After sloping uninhibited from the worm, individual points are sealed, and develop into a lemon-shaped cocoon almost 1/8 inches (approximately ½cm) long. At about 3 weeks, two or more baby worms will hatch from each end of the cocoon. The ingestion and metabolizing of organic detritus complex mechanism by earthworms is a process achieved through vermicomposting. It is associated with calcium neutralization of excreting from the inner wall of the esophagus which allows softening of residues by saliva having ground the particles in the muscular gizzard. The stomach enzymes produce proteolytic compounds for the digestion of organic mass. Pulped material is broken down through protease, amylase, lipase, and others. These results in a biochemical substance excreted as vermicompost [6]. Vermicompost contains a hydrophilic group (-OH, -COOH, and SH among others). The humid particles often work together reacting on the clay surface. It establishes complicated and steady arrangements due to improved matters of argillaceous minerals in vermicompost. This supports changes in the structure of humic compounds found in soils sediments as well as clays. However, a notable decrease in hydrogen concentrations and quantities of aliphatic structures, as well as polypeptide and carbohydrate components, extensively verify the maturation of cattle manure after vermicomposting. An extractable amount of organic water matter is produced during vermicompost of cattle dung which is considerably enriched and stable throughout the humid acid fraction. The organic fraction of municipal solid waste tends to be better compared to composting. This is because of the low emission of pollutant gases such as methane (CH_4) and ammonia (NH_3), among other volatile compounds present during the production of vermicompost.

CHARACTERISTICS OF VERMICOMPOST AS A NON-VOLATILE GAS

Environmental pollutants to the atmosphere are mainly from gaseous emissions; CH_4, NH_3, and nitrous oxide (N_2O). These gases are obtained as a result of poor management of waste discharge from raising ruminant animals extensively in a confined or localized area. This waste is leached into the atmosphere as nitrate, (NO_3^-) into surface water. Both organic and inorganic bound N species and P particulate are lost from the waste as nitrogen (N) into groundwater. The main gaseous form of nitrogen in the air are (NH_3, N_2, N_2O, and NO) and their reactive state can either as organic or inorganic compound (NO_3^-, NH_4^+, DOC) and as particulate matter through surface washing away of the topsoil. Carbon is released from manure into the atmosphere in a gaseous form such as CO_2 and CH_4; when these compounds are dissolved as organic and inorganic substrate, they form (HCO_3, DOC) and often as particulate matter (through washing away of the topsoil). Likewise, sulphur escapes into the air as sulphides (H_2S) also sulphur dioxides (SO_2). Sulphur is often leached in the form of sulphate (SO_4^{2-}) and as a particulate matter [7]. This is associated with the need for a better understanding of flow analysis among farmers and agronomists and information on a management approach of vermicomposting. Functionality and efficiency of waste depend largely on particulate matter put in the system, and that undergoes the oxidative process. In order to better understand the vermicompost technique, a critical investigation was carried out using cow dung with vegetable waste. The parameters measured in that analysis were the physico-chemical and gaseous emissions. Results showed a 20% decrease in pH during vermicomposting of cow dung. This can be likened to the mineralization process in natural environments. The breakdown of phosphorus and nitrogen compounds may result in fulvic and humic acids. This can be attributed to a 60% reduction in the C/N ratio. The mineralization process cuts down the organic carbon to 41% and increases the nitrogen content because it is the major source of energy for both earthworms and microorganisms. A continuous increase in nitrogen obtained at the beginning of vermicomposting was attributed to the activity of earthworms. Worm activity produced mucilage substances, growth hormones, nitrogenous discharges, and microbes from digestion which facilitated transformation of the substrate. Similarly, the phosphatase in the earthworm gut and phosphorous solubilizing micro-organisms action in the worm casts augment the release of phosphorus in various forms which justify 120% of the total phosphorous found in the vermicompost system. Also, the large population of micro-flora present in the gut of an earthworm could enrich the discharge of potassium during vermicomposting. The volatile solid content of the system was reduced by 20% due to biological breaking down of organic residue by worms which indicated the extent of reliability of the manure generated. This is in agreement with 41% of the total solid realized in the vermicompost system in another study (Figure 1).

Anaerobic conditions were observed to kindle the occurrence of methanogenic bacteria which yielded CH_4 but which reduced oxygen and increased moisture content. The ammonia (NH_3) content was found not to be efficient at emitting gas. This may be due to changes in temperatures and low pH observed during the investigation. Vermicomposting takes place at the mesophilic process (<30°C) which may have minimized the volatilization of ammonia. Another reason for this may be due to the population of the earthworms in the vermicompost system. The burrowing activities of the earthworms reduced the emissions of nitrous oxide (N_2O). The available nitrogen is lower than the fresh organic matter in the gut of the earthworm. In addition, the reduction of anaerobic denitrification processes and the population of worms inside the composting units may have been responsible for the low emissions of N_2O. A reduction in process of biological degradation of waste materials may be a result of insufficient CO_2 at the beginning of the trial. The gradual increase in CO_2 may have been due to the activity of enzymes and microbes that were capable of decomposing waste matter which gave rise to alteration of residues into the organic humic structure. A result of uncertainties (<15%) for all the flow of gas was noted with the MFA but N behaved differently. The emission of nitrogen into the air has a 25.6% uncertainty which can be likened to a few and uncertain magnitude of N emission. Frequent emission measurements on site may lessen uncertainties. Following the total solids introduced into the vermicompost system, 72% vermicompost was produced, 28% of the output was adsorbed into the air and 0.2% biomass was obtained from bio-oxidation. Water vapour lost into the air was about 89% by weight. Nitrogen (approximately 18%) was lost to the atmosphere during composting of vegetable waste and cattle manure. It was concluded that vermicomposting with cattle manure can potentially retain more nutrients than composting, stockpiling, anaerobic digestion and other manure management methods. It was recommended that environmental sustainability can be upheld by adopting vermicomposting because it is economically viable and can be produced at minimum cost.

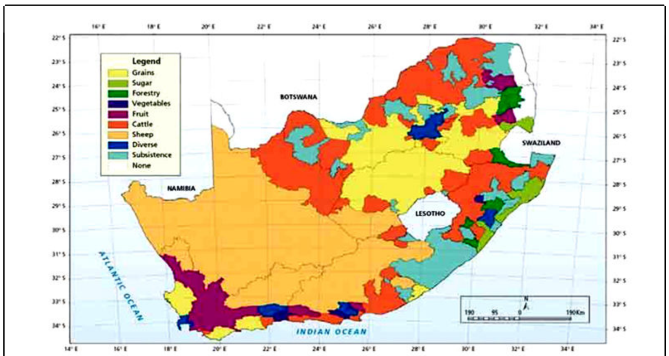

Figure 1: Agricultural area in South Africa.

FACTORS THAT DETERMINE SUCCESSFUL PRODUCTION OF VERMICOMPOST

Factors that determine the production of vermicompost include the bedding which is characterized by high absorbency. The environment where the earthworm is groomed must also be moist. The bedding must contain sufficient moisture since worms breathe through their skin. If the worms are to thrive well, the bedding must fairly retain and absorb moisture. The bedding material must have a good bulk potential. The overall porosity of the bedding through a variety of factors such as the range of particle size and shape, the texture, the strength, and rigidity of its structure are affected for different materials. Materials used as bedding must not be too dense or tightly packed so that the flow of air will not be reduced or eliminated. Since the bedding materials are often broken down, they can be consumed by the worms (Table 1). The process by which this bedding is broken must be slow. Materials used as bedding must not be too high in protein or nitrogen to facilitate rapid degradation. Excessive heat generated in the system can create unfriendly fatal conditions. Heating in the food layers of the vermiculture or vermicomposting system can occur safely, however not in the bedding. Nevertheless, earthworms were discovered to consume any organic material (originated from plant or animal). Worm feedstock commonly used with dairy and beef manures are generally considered the best natural food for Eisenia except for rabbit manure. Since earthworms breathe through their skins, the moisture content in the bedding of compost must be not less than 50%. Extreme heat or cold does not kill worms except when the moisture is inadequate. The ideal moisture-content for conventional composting systems varies between 45%-60% for materials. In contrast, vermicomposting or vermiculture is processed between 70%-90% which is considered the ideal moisture-content. Worms cannot survive anaerobic conditions because they are oxygen breathers. The areas of the warm bed, or even the entire system, can become anaerobic when factors such as high levels of grease in the feedstock or excessive moisture combined with poor aeration may prevent oxygen supplies. The pH at which worms can survive ranges from 5 to 9. Generally, the pH of worm beds tends to drop when the bedding material is suitable and moderate. Likewise, the food sources are expected to be alkaline. The pH of both bedding and food source is usually neutral or slightly alkaline. If the pH of the bedding drops below 7, the food source or bedding is acidic (coffee grounds, peat moss). The preferred salt contents must be less than 0.5% because worms are very sensitive to salt. If seaweed from the sea is used as a feed then it should be rinsed first and washed thoroughly to get rid of the salt on the surface (because worms do not like all forms of seaweed). In line with this, an investigation was conducted to evaluate earthworm reproduction on different beds and waste feeds and the nature of vermicompost produced as a fertilizer. It was reported that the growth performance of earthworms was affected by the earthworm species and feedstock types provided to them. The earthworm population and size increased during the incubation. Maize straw is a preferable source of waste most suitable manure in contrast to soybean (Glycine max) straw, wheat straw, chickpea (*Cicer arientinum*) straw, and urban leftover for the tropical epigeic earthworm, Perionyx excavates. Feeding maize stalk to earthworm produces the highest cast (13.3 units) but the lowest cast was produced (9.3 unit) from fresh food scraps fed to the worms. Lower cast production in the fresh food scraps might be due to the creation of unfavorable environment related to suffocation, which may cause the death of worms.

Parameter	Garden compost	Vermicompost
pH	6.80	7.80
EC (mmhos/cm)	3.60	11.70
Total Kjeldahl nitrogen (%)	0.80	1.94
Nitrate nitrogen (ppm)	156.50	902.20
Phosphorous (%)	0.35	0.47
Potassium (%)	0.48	0.70
Calcium (%)	2.27	4.40
Sodium (%)	<.01	0.02
Magnesium (%)	0.57	0.46
Iron (ppm)	11690.00	7563.00
Zinc (ppm)	128.00	278.00
Manganese (ppm)	414.00	475.00
Copper (ppm)	17.00	27.00
Boron (ppm)	25.00	34.00
Aluminum (ppm)	7380.00	7012.00

Table 1: Chemical characteristics of garden compost and vermicompost.

SIGNIFICANT OF EARTHWORM IN MINERALIZATION OF WASTE

The rates of conversion of ammonium-nitrogen into nitrate are increased when vermicomposting which enhances nitrogen mineralization. Earthworms help lower the C/N ratio *via* respiratory activities and microorganisms. In this process, microbial mineralization of organic matter is supported through the excretion of nitrogenous waste. A higher level of Nitrogen in vermicompost was as a result of discharge waste materials mixed with mucus, body fluid, enzymatic and deteriorating materials of the collapsed worms. Wheat straw, millet straw, pulse brawn, and mustard straw are some of the various organic wastes used in an experiment as substrates for composting in which Eisenia fetida was used in the preparation of vermicompost. In that experiment, 1 kg of waste of the various waste substrates was mixed with cow dung in the ratio (1:5). The percent of potassium was found to be maximum with mustard straw and minimum with beef waste in the course of composting manure. A four-fold increase was recorded in the potassium content of the vermicompost. This may be due to enhanced activities of microbial enzymes in the gut of the worms. An increase in nitrogen contents and a lower C/N ratio was observed during the waste management of temple flora by vermicomposting. Mineralization of the organic matter sustains the production of proteins due to organic carbon loss and decreases in pH. Similarly, the conversion of ammonium compound into nitrate is enhanced. Agricultural waste has a great impact on nitrogen transformation in manure. Mineralization takes place to retain nitrogen in nitrate form. It was also observed that earthworms can potentially convert insoluble phosphorus into soluble forms.

Significant growth in tomato was observed with vermicompost from yard leaf, sewage sludge with rice hull, sewage sludge with raw dairy manure, tobacco residue, when compared to raw dairy manure as a control, that vermicompost from kitchen waste was thermo compost in 9 days and was converted fully within 2.5 months. Lokeshwari and Swamy also reported that the mixture of household and market vegetable waste were mixed aerobically and were decomposed after adding sewage sludge at 0, 10, 20, and 30% within 20 days. The result obtained after 30 days, was far better compared to windrow composting obtained for (80 days). In this experiment, different ratios were used to prepare the vermi-bed from agriculture waste and cattle manure. Sheep manure (1:2) with an equal weight of (Penniseum typhoides and Sorghum vulgare) with sheep manure (1:2 ratio), Cow dung (1:1:2 ratio)$^+$Vignaradiata$^+$Triticumaestivum, the ratio of all plant mixture$^+$cow dung (1:1 ratio) vermicompost were enriched with cattle shed manure for energy renewal. All the compost showed a decrease in organic Carbon (20.4% to 29.0%) and were enriched with N (97.3% to 155%), P (67.5% to 123.5%), K (38.3% to 112.9%), and Ca (23.3% to 53.2%). Furthermore, Gurav and Pathade reported that accumulated organic wastes had decomposed in 30 days at 30°C using cow dung and a biogas digester slurry. The pH 8.0 of the organic waste and moisture content (80%) obtained optimum for a high nutrient yield of vermicompost having been digested by E. eugeniae at 25°C [8-12].

INFLUENCE OF VERMICOMPOST ON SOIL PROPERTIES

Agarian sustainability is crucial for the accumulation of domestic wealth. Nowadays, soaring social unease regarding nourishment scarcity, around inhabitants, ecological well-being as well as soil management has led to a notable rise in the value of organic farm practices. This has reduced the excessive application of inorganic manures. The utilization of carbon-based fertilizers is useful for sustainable farming and productivity. Earthworms have the potential to slash the holding of noxious waste and plant required metals in the organic horizons by putrifying organic matter. Porosity, aeration, drainage, resistance to corrosion, and infiltration which has been identified as the physical characteristics of the soil, could be improved by vermicompost to create a suitable condition for root growth. Increased growth, yield, and quality of beans could be produced by improving the physical properties of soil through the use of vermicompost. Previous studies revealed that the application of vermicompost to the soil is enriched with polysaccharides. Polysaccharides serve as a rooting component. Soil aeration, water retention, drainage, and the aerobic condition causes aggregate stability and maintain the soil structure for crop establishment. Root enlargement and nourishment accessibility to plants are very important through consistent maintenance of soil structure. The mucus secretion from the earthworm's gut and activities of microorganisms enhance soil aggregate stability. The water holding capacity of the soil is strengthened by the absorbent feature of organic matter in vermicompost. The available amount of water is mainly required by the plant to support the rooting system of the plant. The bulk density of vermicompost enhances the soil and influences the physical aggregates of the soil, and as a result, increases soil porosity. In this case, the particle and bulk densities are decreased. This may happen because of the improved population of microorganisms and their engagement in the soil. Vermicompost has been reported to possess a higher Base Exchange capacity and a larger increase in oxidation potential. Vermicompost, a natural nutrient source with a gradual release and a good amendment potential has shown a great increase in plant dry weight and nitrogen uptake. Nitrates, exchangeable phosphorus, and soluble potassium, calcium, and magnesium, with most of the nitrogen in the nitrate (NO_3^-) form, rather than the ammonia, are contained in vermicompost. These nutrients are readily taken up by plants. The dosage as well as plant species and genotype often play a significant role in the effect of vermicompost on plants. Additionally, the appropriate level of chemical fertilizer and/or vermicompost in one specific plant is primarily to ensure the best supply of nutrients to the plant. This is observed in the growth of corn, where the proportionate application of both 3% vermicompost+sulfate and 3% vermicompost treatments increased yield. Also, the plant is less susceptible to pest attack due to the slow release of nutrients such as organic nitrogen from vermicomposts [13].

INFLUENCE OF VERMICOMPOST ON THE MINERAL CONSTITUENT OF THE SOIL

Soil salinity is one of the major problems in agriculture where plant growth is inhibited by the accumulation of salts in the soil. The dominant counter ion that influences soil complexity is Na^+ causing unusual dispersion in the soil. The sustainable production and physical characteristics of the soil can be amended by applying organic matter, particularly in arid and semi-arid regions, where there is low input of organic matters. The use of manure, compost municipal biosolid, and other organic waste as a soil amendment could have a significant influence on the soil, together with water treatment residue (WTR). This amendment action can completely eradicate saline-sodic conditions through worm composting. Animal waste with rice straw and earthworm species Eisenia fetida and Dendrobaena veneta can be successfully applied to amend soil. Increased levels of vermicompost lower the value of soil aeration and crop growth in response to excess water. The addition of the soil amendments, may support soil microorganisms and stimulate chemical reactions necessary for optimal plant growth. This may be due to the beneficial effects of increasing organic matter in the soil. The mixture of vermicompost with water treatment residuals on soil properties and barley grown in research findings indicated that higher content of available N and K was found in the pots treated with 10 g vermicompost. Moreover, the soil content (%) of organic matter and CEC was increased significantly following the soil treated by different ratios of vermicompost alone and its combination with WTR. Different applications of vermicompost, when used alone or in combination with WTR, reduced significantly the soil content (meq/l) of Cl^- and Na+. The reduction of soil salinity with vermicompost and its mixture with WTR may be due to vermicompost and WTR which allows a continuous supply of Ca^{++}, Mg^{++}, and other cations, in addition to Al^{3+}which exists in the WTR.

VERMICOMPOST A CONTROL FOR INVASIVE PLANTS

Alien plants not only alter the dynamics of species arrangement and biodiversity but also hinder the structural efficiency and efficacy in the attacked area. They are species that are not indigenous to the flora and fauna in the concerned environment. As well as swiftly taking over the region, changing the indigenous plant life, alien plants trigger several human health predicaments, ecological deprivation causing danger to service sector actions. They are initiated by humans into localities beyond their native scope of spreading, where they grow conventionally and scattered, causing undesirable influence on the indigenous ecological unit and species. These invasive genus establishments are often liable to set off financial or ecological destruction or detriment to individual well-being. Some alien plants cause water asset reductions, and result in the dispersal of parasites which are vectors of several disorders. They are harmful to financial and ecological development in various nations, due to their rapid spread which can destroy pumps and hamper the use of irrigation systems. One of the control interventions of these weeds is using it as a source of feed in the production of valuable products such as stable and mature vermicompost. Feeding water hyacinth to Californian Red Worms caused an increase in the percentage of the weed in the mixture. This may cause an increase in the mortality of earthworms but pre-compost is a good practice to avoid mortality. Low germination rates in some crops grown with vermicompost obtained from water hyacinth indicated that phytotoxic compounds were present. However, vermicompost produced from water hyacinth contains important metals and salts which may likely be efficient at growing some crops. Nevertheless, care must be taken with handling vermicompost produced from water hyacinth because it is not completely safe and can cause stomach diseases in susceptible individuals by consuming crops produced from them.

INFLUENCE OF VERMICOMPOST ON PLANT EMERGENT

Seed soaking is significant to germination. It softens a hard seed coat and removes all possible inhibitors that may likely prevent germination of seeds. Different concentrations of vermicompost tea from chicken manure and food waste were used in the germination of lettuce and tomatoes. The researchers found that a decrease in percent germination rates at higher concentrations of vermicompost teas (10% and 20%). An increase in leachate concentration, however, supported a positive linear response to germination. These attributes may be as a result of the non-nutritional source, though a better germination rate was observed in seeds soaked in lower concentrations of vermicompost tea (1% and 5%). The effectiveness of lower concentrations may be due to water-soluble bioactive substances such as humic acids, phytohormones, or other microbial metabolites present in the vermicompost extract. For example, the presence of auxin promotes plant height, root length, and density.

INFLUENCE OF VERMICOMPOST ON PHYSIOLOGICAL GROWTH

Vermicompost is used as a plant regulator through foliar sprayer in comparison to plant regulator (Gibberellic Acid and Indole Acetic Acid). A better yield of Capsicum annum, Hepper was obtained with vermicompost than the plant regulator. The effectiveness of the vermicompost was likely due to the consortium of nutrients in the mixture. These nutrients increase the possibility of microbial growth which in turn improves the biochemical characteristics of the soil. Vermicompost likely regulates the moisture content of the soil. Similarly, in a different experiment, microbial inoculant enriched with vermicompost positively affected the growth of Abelmoschus esculentus. This microbial inoculant included Azospirillum brasilense, Bacillus megaterium, and Pseudomonas fluorescens. Seed growth, time of flowering, gender of flowers, senescence of leaves, and fruits were significantly enhanced. This may be a result of micro and macronutrients and plant hormones released from the organic compound. Also, the activities of the inoculant changed the concentration of the plant hormone and symbiotic N_2 fixation leading to the solubilization of mineral phosphate. Enriched vermicompost with inoculant supports the accumulation of earth carbon-based substance and conserves earth productiveness. Thus, vermicompost increases the growth and nutrient content of the plant. It is however not compulsory that the practice of biofertilizer along with vermicompost would be helpful to the ecosystem as it would cut down the application of inorganic manures and stimulate green agriculture. Several amounts of inorganic manures and vermicompost with and with no bio-fertilizer on plant evolution, characteristics, and harvest of sweet corn (Zea mays L. saccharata) were studied. The results revealed that a significant increase was obtained in number of cobs per plant, cob length, cob girth, test weight, green cob yield, and green fodder yield with vermicompost compared to inorganic fertilizer. The result obtained might be as a result of the timely availability of nitrogen and phosphorous in the vermicompost. Plant growth is often supported by the available amount of nitrogen and phosphorous for the development of cob and fodder. Nitrogen is a major nutrient for plant nutrients and growth. It supports the formation of proteins. It absorbs light energy into the inner part of the plant through photosynthesis in the presence of chlorophyll for chemical energy formation in the plant. Vermicompost may also possess a higher nutrient supply than inorganic fertilizers and gradual release of nutrients over time which improves the overall growth and development of plants. Research using vermicompost on lettuce cultivars showed an increase in yield. The use of 20% vermicompost concentration was most effective. In addition, leaf gas exchange and chlorophyll concentration, root and shoot biomass were significantly higher at 20% vermicompost. This may be because of the presence of the phytochormone auxin which may result in the proliferation and elongation of secondary roots increasing the total length and root surface area. Nitrate accumulation was much lower in the vermicompost treatments compare to the inorganic treatment. However, the use of vermicompost as an alternative to inorganic fertilizer may be a better option at reducing the nitrate accumulation in leafy vegetables, which may be detrimental to health. Similarly, the effects of increasing doses of vermicompost on some nutrient element content and some agronomic properties of lettuce (Lactuca sativa L. var. crispa) revealed that there was a significant increase in the plant width, the number of leaves, leaf size, leaf width, and the plant fresh weight. However, no significant increase was recorded in the amount N, P, K, Ca, and Mg contents of the plant upon increasing the vermicompost concentration. Fresh and dry plant weight and shoot-root ratio were significantly influenced by the availability of N, P, Ca, Fe, and B in the soil.

INFLUENCE OF VERMICOMPOST ON INSECT PESTS AND DISEASES

Vermicompost performs a wide range of functions such as suppression of a broad variety of infectious disorders, and plant-parasitic insects. The application of vermicompost extract suppresses fungal diseases in ornamental plant species. It was observed that the growth of pathogens such as Botrytis cinerea, Sclerotinia sclerotiorum, Corticium rolfsii, Rhizoctonia solani, and Fusarium oxysporum were hindered with the use of an aqueous extract of vermicompost. The infection caused by Fusarium lycopersici (Szczech and Smolinska,) and Phytophthora nicotianae were significantly reduced by the accumulation of solid vermicompost to the earth. Vermicompost does not reduce the degree of plant infestation but also the populations of plant-parasitic insects. Two species of beetles in the soil (Acalymma vittatum and Diabotrica undecimpunctata) can be significantly controlled in comparison to the use of inorganic fertilizer. The populations of spider mites (Tetranychus urticae), mealybugs (Pseudococcus sp.), and aphids (Myzus persicae) were significantly reduced in vegetable farms after the use of vermicompost obtained from kitchen garbage. The addition of a large dose of vermicompost significantly reduces the incidence of nematode and plant-parasitic growth.The mechanism responsible for the suppression of diseases may be through competition, antibiosis, and parasitism.

Foliar spray of vermicompost extracts successfully decreased the occurrence of mycological disorders on crops caused by fungi, which include Phytophthora infestans [7]. Erysiphe pisi, and Erysiphe cichoracearum. The production of defense substances by the plant is a result of systemic resistance by vermicompost which supports disease reduction. Vermicompost performs a major function in the microbiological function of potting media. Vermicomposting has a strong effect on the microbial community of wastes because it not only lowers biomass accumulation but enhances metabolic diversity.

CONCLUSION

Agriculture is not effective in most regions of South Africa since most of the land is not fertile. Conventional farming methods and the use of inorganic fertilizer are not sustainable to help agricultural productivity. Soil inefficiency can be alleviated by introducing vermicompost. Vermicompost is obtained from activities of worms and microorganisms. The efficiency of the worms during composting requires conditions such as bedding material, temperature, composting of waste material. Additionally, it involves the recycling of biosolid waste which might pose threat to the environment. Vermicompost can be regarded as a stable product that could help restore the nutrients into the soil. Vermicomposting is also effective at reducing greenhouse emissions through mineralization. Furthermore, vermicomposting can reduce the C: N ratio and as a result increase the availability of nitrogen for plant growth and development. Through vermicomposting, municipal sewage sludge can be converted into a usable organic matter. It can be used to correct plant disorders and suppress the activities of pests and diseases.

RECOMMENDATION

Vermicompost is good manure alternative that can help boost the soil characteristics but the overall efficiency depends on the species of worms and waste material. In addition, poor management of the vermicompost system may affect the efficiency of the worms. Vermicompost may prove useful to resource poor farmers because it is cheap to produce and environmentally friendly compared to expensive inorganic fertilizers that pollute the environment.

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