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RESEARCH ARTICLE

PRODUCTIVITY ENHANCEMENT OF MAIZE THROUGH IMPROVED AGRONOMIC PRACTICES AIDED BY GIS

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ABSTRACT

Farmers are cultivating maize crop intensively with huge use of chemical fertilizers, pesticides, and weedicides, etc., because of their better response to applied inputs. Thee huge use of inorganics results in deterioration of natural resources (Viz., land, water and air). A great emphasis is placed to maintain the soil fertility by returning all the waste to it chiefly through compost to maintain the gap between NPK addition and removal from the soil and the main objective is blending organic manure with inorganic fertilizer to minimise the cost of production and improve the soil fertility level. The present paper investigates the effectiveness of different organic sources viz., vermicompost, seaweed extract and pressmud in combination with NPK fertilizer to increase the productivity of maize through balanced fertilization for higher yield aided by GIS and remote sensing in maize crop.

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INTRODUCTION

Maize (Zea mays *L.*) belongs to Gramineae family, maize is considered as the native to the Central America & Mexico where many diverse types of maize are found. Maize is one of most important cereal crop in the world agriculture economy both as food for man and feed for animal. It is a miracle crop with high yield potential. There is no cereal on the earth which has so immense potentiality and that is why it is called "queen of cereals". Maize grain contains about 10% protein, 4% oil, 70% carbohydrate 2.3% crude fiber, 10.4% aluminizes, 1.4% ash. Maize protein 'zein' is in tryptophan and lysine two essential amino acids. In Worldwide, maize is grown over an area of 181.03 million hectares with a production of 1073.93 million tonnes and with the productivity of 5.73 t ha^{-1}. In India, maize occupies an area of 9.50 million hectares with a production of 24.50 million tonnes and the productivity of 2.58 t ha^{-1}. In Tamil Nadu, it is cultivated in an area of 0.22 million hectares with production of 0.81 million tonnes and a productivity of 4.5 t ha^{-1} and also it occupies fourth position in India. For increasing the profitability of maize in only economic view, farmers are cultivating the crop intensively with the huge use of chemical fertilizers, pesticides, weedicides, etc. Maize crop has better yield response to chemical or inorganic fertilizers. Hence heavy doses of these fertilizers are applied to maize. Though these practices are helps to increase the temporary increase the production of crop; deterioration of natural resources (*viz.* land, water and air) is also the another side of such high input intensive cultivation. Over reliance on use of chemical fertilizers has been associated with declines in soil physical and chemical properties and crop yield and significant land problems, such as soil degradation due to over exploitation of land and soil pollution caused by high application rates of fertilizers and pesticide application. The organic sources besides supplying N, P and K also make unavailable sources of elemental nitrogen, bound phosphates, micronutrients, and decomposed plant residues into an available form to facilitate the plant to absorb the nutrients. But, it is also the fact that optimum yield level of maize production can't be achieved by using only organic manures because of their low nutrient content. Efficacy of organic sources to meet the nutrient requirement of crop is not as assured as mineral fertilizers, but the joint use of chemical fertilizers along with various organic sources is capable of improving soil quality and higher crop productivity on long-term basis. Highest productivity of crops in sustainable manner without deteriorating the soil and other natural resources could be achieved only by applying appropriate combination of different organic manures and inorganic fertilizers.

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Traditional agriculture is currently characterized by excessive inputs of chemical fertilizers, pesticides, and herbicides, whilethe insufficient application of organic fertilizers (Li *et al*. 2007; Gill and Garg. 2014). The excess use of chemical fertilizers and pesticides has resulted in numerous negative effects on the environment, including water, soil (Ju*et al*. 2009), and food pollution (Li *et al*. 2007), degradation of soil quality (Ju*et al*. 2009), and losses of agricultural biodiversity (Minuto*et al*. 2006; Gill and Garg. 2014). To solve such problems, more sustainable agricultural practices are urgently required. Compared with chemical agriculture, organic farming has been thoroughly proven as beneficial in maintaining both biodiversity and environmental sustainability (Ahmad *et al*. 2007; Leite*et al*. 2010). Organic farming has been gradually adopted by agriculturalists, particularly in developed countries (Rigby *et al*. 2001; Lobley*et al*. 2009), because of its higher economic and ecological benefits.

Effect of Vermicompost on Maize

Many researchers reported that in an organically managed field activity of earth worm is higher than in inorganic agriculture [Amir and Fouzia, 2011]. In the biodegradation process earthworms and microbes work together and produce vermicompost, which is the worm fecal matter with worm casts. Vermicompost provided macro-elements such as N, P, K, Ca, and Mg and microelements such as Fe, Mo, Zn, and Cu [Pal, 2002]. The vermicompost contained 0.74, 0.97, and 0.45 per cent nitrogen, phosphorus, and potassium, respectively Amir and Fouzia (2011) reported thatagro-economic study of practices of growing maize with compost and liquid manure top dressing in low-potential areas showed significantly better performance than those of current conventional farmer practices of a combined application of manure and mineral fertilizers. Maize grain yields were 11–17 per cent higher than those obtained with conventional practices. Addition of organic amendments and casting of earthworms to soil also proved effective in controlling diseases in pea (*Pisumsativum* L.), mustard (*Brassica juncea* L. Coss.), and chickpea (*Cicer arietinum* L.) during winter season. Nitrogen, phosphorus, potassium, calcium, and magnesium accumulation also increased with increasing doses of vermicompostas well as with fertilizers. The application of vermicompost at 13– 20qha^{-1} increased yield of pea (23.62 q ha^{-1}) and groundnut (*Arachishypogaea* L.) (12.16 q ha^{-1}). (Sangakkara *et al*., 2008) found that the organic matter incorporation increased soil water retention in soil and hence enhanced root growth, culminating in high yields of maize. Minhas and Sood, 1994 also reported that the organic matter after decomposition release macro- and micronutrients to the soil solution, which becomes available to the plants, resulting in higher uptake. Organic farming was capable of sustaining higher crop productivity and improving soil quality and productivity by manipulating the soil properties on long term basis. It was reported that organic and low-input farming practices after 4 years led to an increase in the organic carbon, soluble phosphorus, exchangeable potassium, and pH and also the reserve pool of stored nutrients and maintained relativity stable EC level (Gaur *et al*., 2002). The National Academy of Agricultural Sciences (NAAS) recommended a holistic approach involving integrated nutrient management (INM), integrated pest management (IPM) for enhanced input use efficiency, and adoption of region specific promising cropping systems as an alternative organic farming strategy for India and to begin with the practice of organic farming should value crops like spices, cereals medicinalplants, fruits, and vegetables [Bhattacharya, 2005]. The application of vermicompost helps to improves and conserves the fertility of soil. Vermicompost imparts a dark colour of the soil and thereby help to maintain the temperature of soil. Vermicompost is one of the manure used by the farmer in growing crops because of early availability and presence of almost all the nutrients required by plants. The composition of vermicompost is 0.6-1.2% N, 0.13-0.22% P and 0.40-0.75% K. Vermicompost are organic materials broken down by interactions between microorganism and earthworms in ahemophilic process, to produce fully stabilize organic soil amendments with low C: N ratios.Vermicomposting has been reported to be a cost-effective, viable, and rapid technique for the efficient management of livestock manure (Garg *et al*. 2006). Earthworm activity not only accelerates the decomposition of organicmatter (Atiyeh*et al*. 2001; Lv*et al*. 2013) but also makes nutrients available for plant growth (Tripathi and Bhardwaj 2004; Garg *et al*. 2006). Therefore, the composting of livestock manure could help toreduce the environmental pollution caused by this waste while providing a healthier alternative from chemical fertilizer toorganic farming (Atiyeh*et al*. 2002).

Effect of seaweed extract

Sea weeds are marine algae, saltwater dwelling, and simple organisms that fall into the rather outdated general category of “plants”. Most of them are the red (6000 species), brown (2000 species) or green (1200 species). A wide range of beneficial effects have been reported from the use of liquid seaweed extracts (Blunden, 1991), including increased crop yields, resistance of plants to frost, increased uptake of inorganic constituents from the soil, more resistance to stress conditions and reduction in storage losses of fruit. Sea weeds have proved effective in enhancing yield, pest and frost resistance in vegetables, fruits, flowers, cereals and pulses. Seaweed extracts had beneficial effect on seed germination and plant growth. Tentative determination of plant growth regulators in the seaweed concentrate (SWC) using bioassay systems, indicated the presence of compounds with gibberellin, abscisic acid and auxin like properties. Tentative identification of the auxins present in the SWC and *Ecklonia maxima* using High Performance Liquid Chromatography revealed the presence of tryptophan, indole-3-acetamide, indole-3- acetic acid, indole-3-carboxylic acid and indole-3-acetaldehyde. Any improvement in agricultural system that results in higher production should reduce the negative environmental impact of agriculture and enhance the sustainability of the system. One such approach is the use of biostimulants, which can enhance the effectiveness of conventional mineral fertilizers. Marine bioactive substances extracted from marine algae are used in agricultural and horticultural crops, and many beneficial effects, in the terms of enhancement of yield and quality have been reported (Blunden, 1991; Crouch and VanStaden, 1994). Liquid extracts obtained from seaweeds have recently gained importance as foliar sprays for many crops including various grasses, cereals, flowers and vegetable species (see Crouch and Van Staden, 1994 for a comprehensive list).

Seaweed extracts contains major and minor nutrients, amino acids, vitamins, cytokinins, auxin and abscisic acid like growth promoting substances (Mooney and Van Staden, 1986) and have been reported to stimulate the growth and yield ofplants (Rama Rao, 1991), develop tolerance to environment stress (Zhang and Schmidt, 2000; Zhang *et al*., 2003), increase nutrient uptake from soil (Verkleij, 1992; Turan and Köse, 2004) and enhance antioxidant properties (Verkleij, 1992). The beneficial effect of seaweed extract application is as a result of many components that may work synergistically at different concentrations, although the mode of action still remains unknown (Fornes*et al*., 2002). In recent years, use of seaweed extracts have gained in popularity due to their potential use in organic and sustainable agriculture, especially in rainfed crops, as a means to avoid excessivefertilizer applications and to improve mineral absorption.Unlike, chemical fertilizers, extracts derived from seaweeds are biodegradable, non-toxic, non-polluting and non-hazardous to humans, animals and birds (Dhargalkar and Pereira, 2005). Seaweeds are also called macro-algae. This distinguishes them from micro-algae (Cyanophyceae), which are microscopic in size, often unicellular, and are best known by the blue-green algae that sometimes bloom and contaminate rivers and streams. The growth area in seaweed fertilizers is in the production of liquid seaweed extracts. These can be produced in concentrated form for dilution by the user. Sea weed can be applied directly to plants or they can watered in, around the root areas. It was estimated that about 10000 tonnes of wet seaweed were used to make 1000 tonnes of seaweed extracts. However, the market has probably doubled in the last decade because of the wider recognition of the usefulness of the products and the increasing popularity of organic farming, where they are especially effective in the growing of vegetables and some fruits.

Kaliaperumal (2000) reported that the conjunction of seaweed manure with inorganic fertilizer has been found to be better than the other organic input for growth and development of the plant. Durand *et al.,* (2003) stated that in Cytokinins, auxins and auxin-like compounds and abscisic acid (ABA)-like growth substance after cellular metabolism in treated seaweed plants leading to enhance growth and crop yield. The foliar application of 1 per cent seaweed increased the germination, growth, yield and uptake of the nutrient in maize. Improved productivity and quality of crop without impairing the soil fertility, he also stated that it may be due to the presence of many organic compounds in seaweed liquid fertilizer which acts as a bio-stimulant that can increase the availability of nutrients in the plant system. Norrie *et al*. (2006) noticed that the presence of natural chelating compound (*i.e*.manitol) in seaweed have increased nutrient availability by a better absorption of the leaf levels, the increased root proliferation and establishment, thereby plants were able to mine more nutrients even from distant places and deeper soil horizon, in a balanced Proportion. Zhang and Ervin (2003) reported the seaweed resources are intensively used to improve harvest quantity and quality in agriculture and horticulture also concluded that the beneficial effects of seaweed products on the plants improve the seed germination, seedling development, increase plant tolerance to environmental stresses. Dhargalkar and Pereia (2005) observed that the seaweed extracts are capable of supplying macro and micro nutrients directly to the plant, as well as seaweed manure is also a better option than conventional organic manure (farm yard manure) due to its easy decomposability of carbonaceous matter and presence of micro-nutrient. Studies of Lane *et al.* (2006) and Norrie *et al*. (2006) revealed that a wide range of beneficial effects of seaweed extraction applications on plants, such as early seed germination and establishment, improve crop performing and yield, elevated resistance to biotic and abiotic stress, and enhanced post-harvest shelf-life of perishable products. Mancuso *et al.* (2006) revealed that seaweeds compost have been used for centuries as organic inputs to improve soil health and so to enhance the growth of agricultural crops. Hong *et al*. (2007) stated that several species of seaweeds has been used as manure in agriculture. Craigie (2011) reported that the seaweed contain several hormones which might be responsible for increased nutrient uptake by crop, used extracted red algal polysaccharide, to induce secondary metabolites in maize plants, and observed a significant change in plant height, stem diameter and number of leaves per plant. Subramanian (2011) documented the effect of seaweed on plant growth promotion and tolerance other biotic and abiotic stress factors. Hong *et al*. (2007) noticed that foliar spray of seaweed extract resulted in improved plant growth and yield as compared to control. Seaweed liquid fertilizer (SLF) is a blend of both plant growth regulators and organic nutrient input is ecofriendly, promoting sustainable productivity and maintaining soil health. The seaweed fertilizers are preferred not only due to their nitrogen, phosphorus and potash content but also because of the presence of high amount of water soluble potash.

Effect of Pressmud on Maize

Among the organic sources of nutrition, pressmud occupies unique position as a by-product of sugar industry. Pressmud can serve as a good source of organic matter, an alternate source of crop nutrients and soil ameliorant (Razzaq, 2001). It is also known as filter cake or filter mud, and used as fertilizer in soils (Barry *et al.,* 2001). It contains much of the colloidal organic matter anions that precipitate during clarification, as well as certain non-sugar occluded in these precipitates. It is the residue obtained from sedimentation of the suspended materials such as fiber, sugar, wax, ash, soil and other particles from the cane juice. The organic fraction of pressmud is 15-30% fiber, 5-15% crude protein, 5-15% sugar, 5- 15% crude wax and fats and 10-20% ash comprising oxides of Si, Ca, P, Mg and K (Partha and Sivasubramanian, 2006). This organic matter is highly soluble and readily available to the microbial activity and so to the soil. The weight of wet filter mud (80% water) averages about 3.4% cane. There are many physical, chemicaland biological advantages of pressmud. It improves structure, texture, aeration, water-holding capacity, andporosity and increases stress tolerance. The yields of various crops including maize and millet showed substantial increases with pressmud (PM) applications (Elsayed*et al.,* 2008) that were attributed to the improvement in soil physical, chemical and biological conditions. Maize dry matter yields increased with increasing nitrogen and pressmud rates. (Barry *et al.,* 2001) stated that organic fertilization with pressmud increased the crop yields more in light loamy-sandy soils due to easier soil warming, increase of microbial activity, better air exchange and, as a consequence, a better release of nutrients contained in

organic fertilizers. Industrial waste such as press mud or filter cake a by-product of sugar factories which is a valuable resource of plant nutrient alter the physical, chemical and biological properties of alter the soil (Muhammad and Khattak. 2009). He also stated that the application of Pressmud (PM) on saline-sodic soil increased the maize growth and yield. The benefits of organic fertilization with pressmud in quantity and quality of crop yields. The recycling and the use of nutrients from pressmud based organic manure have been given more consideration for insuring sustainable land use in agriculture production development. Yadav (2011) found that, application of pressmud and lignite fly ash was found to be superior in reducing the weed competition and increasing the growth and yield of maize. The presence of macro and micro nutrients in the pressmud which is essential for silicicolous plants like maize and soil ameliorating source for sustaining crops. Said Ghulam and noticed that application of press mud in increasing the yield of crop.

Effect of poultry manure on maize

Poultry manure has long been recognized the most desirable organic fertilizer. It improves soil fertility by adding both major and essential nutrients as well as soil organic matter which improve moisture and nutrient retention. Poultry manure is a valuable fertilizer and can serve as a suitable alternate to chemical fertilizer. Poultry manure application registered over 53% increases of N level in the soil, from 0.09% to 0.14 % and exchangeable cations increase with manure application (Boateng*et al*., 2006). In agriculture, the main reasons for applying PM include the organic amendment of the soil and the provision of nutrients to crops (Warren *et al*., 2006). (Farhad*et al*., 2011) reported that all parameter recorded including plant height, number of rows per cob, number of grains per row, 1000-grain weight, grain yield, biological yield and harvest index were significantly affected by application of PM. Maximum values for all these parameters were recorded with the application of 12 t ha^{-1} PM.The combine use of the poultry manure and the N sources increase the crop grain yield, water use efficiency and fertilizer use efficiency which shows the synergetic relationship between the organic matter and the N fertilizers [Bocchi, S. and Tano 1994]. Poultry manure treatments produced higher values for maize plant height, leaf area index and biomass. Maize grain yield was significantly higher when the farm yard manure was applied along with the lower level of NPK [Boateng*et al*., 2006]. The application of mineral fertilizers with the organic manures can sustain the crop yield and the cropping systems through better nutrient recycling during thecomplete growing season and also increase the chlorophyll content in maize Mohamed *et al*.,2008.

Effect of NPK on maize

Inorganic fertilizer contains beneficial chemical and mineral deposits and supplies the nutrients necessary to grow plants. This type of fertilizer can be bought at most gardening supply stores. Inorganic fertilizer, which is often reasonably priced, consists of mineral-based nutrients manufactured for immediate application of crops. Like organic, inorganic fertilizer does not take more time to decompose to supply nutrients to plants. Most inorganic fertilizer contains balanced amounts of nitrogen, potassium, and phosphorus to feed plants and to faster growth. These substances often derive from chemical processes such as urea, ammonium sulphate, and calcium nitrate. Overall, the nutrients of inorganic fertilizer help nourish a plant's roots, stems, shoots and leaves. The synergistic effect of combining farm and mineral fertilizers application has been confirmed many times, where the joint application of vermicompost and nitrogen fertilizer increased the rice crop of 15.6 % compared to the only application of nitrogen fertilizer. Prathyusha*et al*. (2013) recorded that application of 150 kg of N + FYM @ 5 t ha^{-1} significantly increased the plant height at harvest and have significantly higher growth attributes with the application of 120 kg nitrogen ha^{-1}.Sanjiv Kumar (2014) noticed that application of inorganic fertilizer N were efficiently used by maize crop for their growth and development and also maintained soil fertility for longer term basis. Studies of Matusso and JossiasMateusMaterusse (2016) revealed that maize growth parameters (plant height, ear height, stem girth, and ear length) increased significantly with increase in nitrogen level. Integration of organic and inorganic sources resulted in higher biological yield in crops that is attributed to more availability of nutrients and their uptake, which increased flowering, LAI, biomass and CGR (Munir*et al*., 2007). The positive effect of potassium on yield components of maize like number of grain cob^{-1}, cob length, grain and biological yield. Hafiz*et al.* (2011).

The interaction between N and P is the single most important nutrient interaction. It affects adsorption and desorption phosphorus capacities in the soils (Bhattacharyya *et al*., 2015). Also stated that phosphorus and potassium fertilization combinations on maize increase the growth and yield parameters of the crop. Shahzad*et al.* (2015) showed that application of 100 per cent chemical fertilizer produced maximum cob length, cob diameter and number of grains row cob^{-1}. Tetarwat*et al*. (2012) reported that the combination of organic and inorganic fertilizer showed higher uptake values of NPK. The increased in nitrogen level resulted increase in nitrogen uptake by winter maize. And increased dry matter with increased level of phosphorusalso stated that application of RDF + FYM 10 t ha^{-1} recorded significantly increased uptake of N, P and K compared to control. Mohamed *et al.* (2008) stated that application of 150 per cent nitrogen recorded the highest plant height, dry matter accumulation and biological yield of maize. The applications of NPK fertilizer significantly increased dry matter accumulation and yield of corn. Application of 250 kg ha^{-1} has been reported as an optimum rate of N for maize under the semiarid environment of Pakistan (Hammad*et al*., 2011). Swati Yadav *et al.* (2011) revealed that application of 60 per cent nitrogen significantly increased the yield, cob length and cob girth and kernel weight of maize. The available nitrogen status in soils increased with increased supply of nitrogen in the form of either fertilizers (or) organic manures which ultimately increased the productivity of maize. Tetarwat*et al*. (2012) stated that application of 150 per cent nitrogen recorded the highest plant height, dry matter accumulation and biological yield of maize. Sanjivkumar (2014) reported the application of inorganic fertilizer N was efficiently used by maize crop for their growth and development and also maintained soil fertility and increased yield of the crop.

Conclusion

Organic farming can provide quality food without adversely affecting the soil's health and the environment. There is need to identify suitable crops/products on regional basis for organic production that has international market demands. The whole region as such cannot afford to go for organic at a time because of its commitments to insure food and nutritional security. This will provide ample opportunity for employment and bring prosperity and peace in theregion.

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