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Growth, Yield, and Production of Khariff Paddy through Variation of Micronutrient(S) with Constant Macronutrient(S) Ratio (N:P:K) of Glass Fertilizers

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ABSTRACT:

We investigated the application of different formulations of Glass Fertilizer (GF) on Khariff Paddy- their growth, yield, and photosynthesis and grain quality as well as soil mineral status. The results revealed that the application of different fertilizers had no evident effect on soil pH and electrical conductivity (EC) except for two GF with or without chemical N supplementation. Two GF showed an improvement on its mineral nutrient concentrations,. The application of GF showed a positive effect on grain mineral, sugar and protein contents. Our findings highlight the important agronomic potential of the selected glass fertilizers particularly in improving yield and grain quality which makes them potential fertilizers for the agriculture sustainability in the future. There are numerous building blocks of life that plants need for healthy and optimum growth, where Nitrogen (N), Phosphorus (P), and Potassium (K) N:P:K= 19: 19: 19.[1]. Taking this ratio constant we have to change the macronutrients ratios for effective paddy production. Application was done by pot culture method using the synthesized GF and comparing with conventional Chemical Fertilizer, with or without Chemical N supplementation.

Key Words: Khariff Paddy, Glass Fertilizer, Micro and Macro Nutrients, Agronomy.

Introduction

At present we are passing through an environmental crisis period. The environment protection is very necessary in an industrial world. Using of fertilizers in agriculture can be very useful to the plant or crops for food production, but on the other hand it may be very dangerous for environment. It may cause soil deterioration, greenhouse gas emissions, and water contamination. Hence only necessary amount of fertilizers can be used for successful vegetation. It means that we must use fertilizers, which are dissolved quickly as is nutrient requirement of plants. In this case it is not a contamination hazard for environment. The main elements for successful plant vegetation are K, Ca, Mg, P and

N. Many types of fertilizers supply these elements, but the velocity of dissolution of fertilizers in an agricultural land is greater than requirement of plants.

In the year 1950 fertilizers comprised only a small percent of the nutrients needed for grain production, most of the supply being provided by the "natural fertility" of the soil and added manure. By 2020, more than 70% of the grain yield will have to depend on fertilizers. In 2030 the world crop surface will increase only 7% respect to nowadays and there will be necessary to increase the use of fertilizers and irrigation water. The worldwide per capita land base for agricultural production has declined dramatically over the past few decades and is expected to continue to decrease. For example, it's estimated that by the year 2025 the land in production per person will be 56 percent less than it was in 1965. The world population in 25 years is expected to be about 8 billion-2 billion more than the current 6 billion. This situation will create a great problem: It will be lacking of food and water. So the world average arable land per capita (ha) gradually decreases in every year.

Glass Fertilizer

Glass fertilizers are new type of advanced and controlled released fertilizer and made of glass matrices with macro elements (K, P, Mg, S, Ca) most useful for plants and also incorporated with micro elements (B, Fe, Mo, Cu, Zn, Mn) which are important to the growth and development of crops or plants(1). The quantity of the microelements incorporated in the glass as oxide in the range 1-5%. The use of glass fertilizers offers lot of advantages: due to low or controlled solubility it avoids underground water pollution; glass can accommodate almost all the elements of the periodic table (secular matrix).

Khariff Paddy Crop: The Khariff (Arabic term means autumn season) Cropping (starts with the onset of the Indian subcontinent's monsoon. Khariff crops are typically sown at the beginning of the first monsoon rains (depending on region to region). Harvesting season begins from the 3rd week of September to October (the exact harvesting dates differ from region to region). Unlike Rabi crops, Khariff crops require good rainfall. The output of these crops depends upon time and amount of rain water. Khariff Paddy is grown in India.

Research Aim and Design

At first GF is to be prepared by weigh them through Analytical Balance, next this was dry mixed for several times by dipping them in an Agate Mortar. Next it was wet mixed by Pestle Ethyl Alcohol , and dried, next it was taken in high Alumina crucible and packed well, at the next stage it was introduced in a programmable temperature controlled Muffle Furnace(3). Temperature of melting and time of melting (Soaking period) was optimised according to the specific cases The GF thus produced completely free from any pore and homogeneous).

The amorphous nature of the product was confirmed by XRD and SEM, leaching study was done under Soxhlet condition for varying period under different chemical environments.

Our country India is based on agriculture as the principal resource. Hence it is the agricultural sector which will be given the first priority. Kharif paddy is one of them. Fertilizer is simply a material added to soils or directly to plant tissue that contains nutrients essential to the growth and health of the plant or crops. Generally, this indicates fertilizer remaining N, P and K .It is in this context one glass fertilizer can take a dual role. In addition as the leach resistance of glass is very high i.e. when applied to a soil the fertilizer will be released very slowly satisfying the optimum level of requirement and no misuse there.

Large scale applications of fertilizer nitrogen (N) have also shown deleterious effects on groundwater quality, especially its nitrate content, which is harmful to health. Furthermore, gaseous losses of N as NH_3 and NO_x resulting from N fertilization have adverse effects on the environment. Therefore, the goal of all agriculture has to be to "increase food-grain production with the minimum and efficient use of chemical fertilizers". This calls for a sincere effort on the part of agricultural scientists including extension workers to increase the efficiency of fertilizers applied in the farm fields.

Glass fertilizers are new type of advanced and controlled released fertilizer and made of glass matrices with macro elements (K, P, Mg, S, Ca) most useful for plants and also incorporated with micro elements (B, Fe, Mo, Cu, Zn, Mn) which are important to the growth and development of corps or plants. The quantity of the microelements incorporated in the glass as oxide in the range 1-5%. The use of glass fertilizers offers lot of advantages: due to low or controlled solubility it avoids underground water pollution; glass can accommodate almost all the elements of the periodic table (secular matrix) ; the soil pH can be regulated by the pH of the glass matrix; do not release acid anions (Cl^-, SO_4^{2-}) which are harmful for plants so there is no risk of soil burning when they are incorrectly dosed; in a single type of fertilizer can be embedded almost all useful elements for plants; the controlled rate of solubility in water can be adjusted easily by changing the composition of glass matrix. With the growing need for efficient utilization of resources, such glass fertilizers (CRF) are most deplorable and call for a radical change in the inorganic fertilizers. Glass fertilizers are such type of slow-releasing or controlled releasing fertilizers. The controlled release fertilizers (CRF) must be, therefore, either slow-releasing or must contain nutrients in exchange sites. Slow- releasing or controlled releasing fertilizers are the latest concept in fertilizer technology.

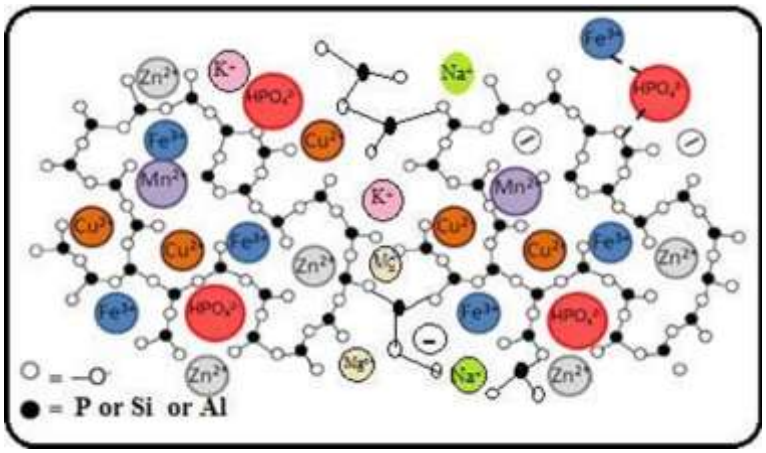
Objectives of the present work

The general objective of this project was to prepare and characterize glass fertilizer and development of a new glass fertilizer (GF) conveniently formulated for application in kharif paddy and a systematic study of potassium phosphate glasses from the viewpoint of their suitability as agricultural fertilizers that includes the solubility.

The thesis contains 05 (five) chapters of which 3 (third) chapters are included the experimental techniques that have been employed for the synthesis and characterization of different types of glasses.

Chapter-I describes an introductory discussion with a brief study of glass fertilizers.

The *Chapter-II* is related to Review of Literature. The theory of glass, properties of glass, different types of fertilizers (inorganic, organic etc.), glass fertilizer etc. and advantages of glass fertilizers which have been discussed in this chapter. The Compositions of different glass fertilizers with various types of nutrients such as AG2, AG3 type which is shown in this chapter. In this section glass formers, intermediates and modifiers have been included which are indispensible in the formation of glass since they form the basis of the random three dimensional networks of glasses. A model Network structure of the glass fertilizers with different corps nutrients is shown below



Materials and Experimental methods which have been discussed in *Chapter-III* .In this chapter the first step is related to preparation of glass batch. In the present work the glasses were melted in the phosphate system and their spectroscopic characterization of different glass fertilizers were studied. To obtain homogeneous, transparent and inclusions/bubbles free glasses, a three-step procedure (calcination, melt quenching, annealing) was used and described in the following section. Specific details of the method of preparation for different glass samples are given in the relevant chapters.

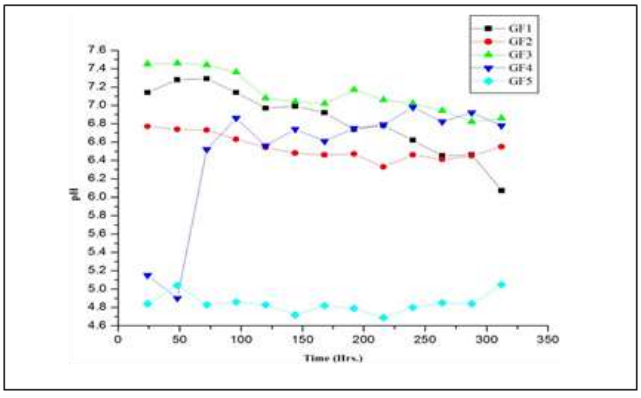
Glass batches of different compositions were synthesized from AR graded ingredients. The powder ready for glass melting was prepared by dry mixing followed by wet mixing in acetone medium using an agate mortar and pestle and repeated thrice each. They are next dried and taken in high alumina crucibles and fired in a muffle furnace fitted with programmer in the range 900–950°C for soaking periods of 30 min.-1hr under ambient condition. In melting operation, the temperature and time of melting are the principal factors are to be monitored. The melting operation was done in a programmable muffle furnace with window and temperature controller. The prepared glass was ground to powder using an agate mortar, then screened through two sieves with a different mesh of 330 and 425 μm B.S. size. The sieve mesh sizes are closer to each other, so the size fraction between them will be less dispersed and average size fraction will be constant from sample to sample and was subjected to Soxhlet distillation taking the powder in a net. The glass batches used in the present study were prepared from the ingredients like ammonium dihydrogen orthophosphate [$(NH_4)H_2PO_4$], magnesium oxide (MgO), potassium dihydrogen phosphate (KH_2PO_4), and calcium oxide (CaO), as raw materials for macro elements. Borax ($Na_2B_4O_7$), ferric oxide (Fe_2O_3), zinc oxide (ZnO), and molybdenum trioxide (MoO_3) were added in order to supply the macro and microelements. The oxides $Na_2B_4O_7$ /B_2O_3 act as the glass former while ZnO act as intermediates and MgO, K_2O, CaO, Fe_2O_3 act as modifiers.

The compositions glasses used in the present work are shown in below. Composition of different glasses prepared (wt %).

Glass ID	$(NH_4)H_2PO_4$	MgO	KH_2PO_4	CaO	$Na_2B_4O_7$	Fe_2O_3	ZnO	MoO_3	Total
GF1	40	16	29	5	10	-	-	-	100
GF2	40	20	30	5	-	5	-	-	100
GF3	40	20	30	5	-	-	5	-	100
GF4	40	20	30	5	-	-	-	5	100
GF5	49	12	-	-	15	10	8	6	100

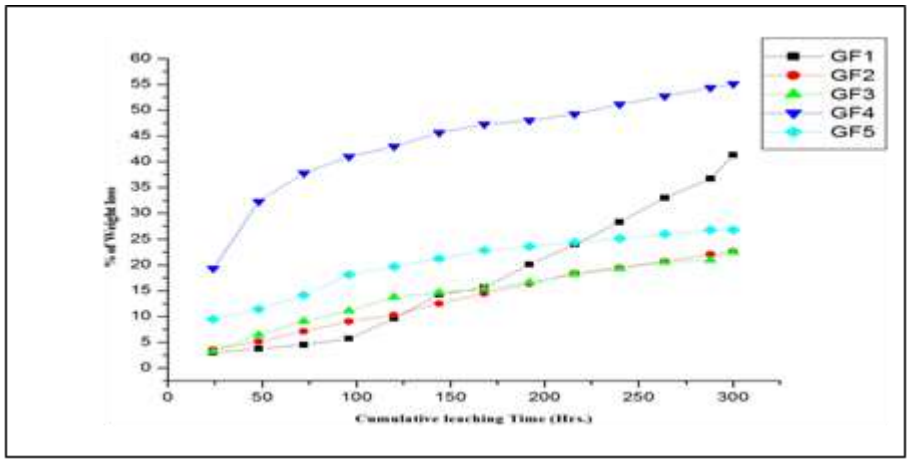
In this chapter, have been discussed the experimental techniques that have been employed for the synthesis and characterization of different types of glasses. The relevant theories and working principles are also described. At first preparation of glasses followed by methods used to characterize them have been described. Thermal properties have been studied DTA, TGA by instruments. The structural characterization of glasses was carried out using XRD, SEM, XRF, Mössbauer and FTIR spectroscopy. The corrosion or leaching studies (weight loss with respect to time) of the different glasses are carried out in different solutions under Soxhlet condition.

The next part is *Chapter-IV* which included Result and Discussion. In the present study we were interested in the characterization and application of our melted glass fertilizers. In case of the phosphate glasses we could melt the glass at the temperature (900 – 950°C) with a soaking period of 30 min to 1 hr. The glasses in the phosphate system acting as slow release fertilizer. In this aspect we could find some interesting results for an example the XRD patterns of the melted glass fertilizers samples showed some hallow pattern which is characteristic of the formation of glassy products. The entire glasses showed a regular and homogeneous surface. SEM micrographs of some of the selected glasses were reported. The homogeneous nature of glass materials was analyzed by SEM. Leaching study of these glasses with a maximum time period of 300 h was conducted under Soxhlet distillation condition with distilled water. pH studies of the leachate solution on selected glasses at different time intervals are shown in this section. There is a definite change in pH of the leachate solution of the phosphate system of glasses with respect to time has been described here. The slightly increasing trend in the pH values of some glasses may be due to the mixed oxide effect of the phosphate system. The observed pH values are in good agreement with the equilibrium pH values of glass system having composition close to present study. The resulting solution increasingly becomes acidic with decreasing the pH of the leachate solution. The increase in pH may be explained by the Na^+ and H^+ exchange corresponding to the hydration of an outer layer of phosphate chains. The plots of variation of pH change with respect to different time intervals are shown below



Weight loss and the leach rates of the glass fertilizer samples were calculated from BET surface area measurements. They were in the range of $6.3x10^{-3}$ to $2.3x10^{-3}$ $g.m^{-2}.h^{-1}$ at 90

°C. The effect of different modifier ions like Na^{+}, Fe^{3+}, Mg^{2+}, Ca^{2+}, and K^{+} in the basic phosphate networks on melting and time of melting has been found to be evident. The plot of cumulative weight loss with respect to time for different glasses are shown below



It was observed that the total weight loss with respect to cumulative time (h) varied as GF4 > GF1 > GF5 > GF2 >GF3.The pH determination ranging from 4.80 up to 7.50 of the leachate solution at ambient temperature under varying time intervals showed interesting and regular variations. FTIR studies show absorptions at 760, 879, 920, 1087, 1110, ~ 2193-2870 and ~3440-3500 cm^{-1}. Thermal study (DTA) shows the glass transition temperature to be in the range 345– 348°C for the glasses. Amorphous nature of glass was confirmed by XRD (X-ray diffraction). The leaching study of such glasses under Soxhlet condition showed Ca^{2+}, Mg^{2+} and K^{+} to be good candidates as modifier towards faster leaching. The findings have been corroborated in terms of ionic size, ionic radius, and hence the ionic potential of the modifier ions incorporated into the glass structure. X-ray Fluorescence (XRF) technique is used for elemental analysis and chemical analysis. Mossbauer spectra of glass fertilizers have been studied. The Mossbauer spectrum for our glass fertilizer sample showed a close similarity with nitroprusside ion in comparison to that of ferrocyanide ion. A doublet in MB spectrum signifies an asymmetric environment around the particular nucleus. The model structure of glasses has been considered taking the role of some glass formers/ modifiers which ultimately has an effect on the chemical durability of these glasses. For GF minimum solubility was measured for the sample containing ferric Oxide (Fe_2O_3) and maximum solubility for base sample and from GF (glass fertilizer) maximum solubility appeared for the sample with molybdenum oxide. The variation of physical and chemical properties were taken into account with the changes in ionic charges and ionic radii and hence ionic potentials of different modifier ions, the source of which are the respective modifier oxides, viz. MgO, CaO, Fe_2O_3, ZnO and MoO_3 for different glass systems.

(a)

Application of the glass fertilizer in pot culture experiment was done on kharif paddy during experiments. The studies on the efficacy of glass fertilizers will be carried out in successive crops and will be ascertained through yield, uptake, and quality of the product. We have applied glass fertilizers on kharif paddy through pot culture which was shown in photograph below. A step by step experiment just like paddy fields have been shown here.

Photographs (a, b, c, d,e etc.) of pot experiment on paddy with glass fertilizer

Photographs of pot experiment on paddy with: (e) Conventional fertilizer (f) without fertilizer

After 8 weeks we observed the growth of paddy which was shown in photographs below:

Photographs of pot experiment on paddy with (g) glass fertilizer (h) without fertilizer

(i) Conventional fertilizer

After 10 weeks we have seen the growth of paddy which was shown in photographs below:

(b)

(c)

Photographs of pot experiment on paddy with: j) glass fertilizer GF3; k) glass fertilizer GF5; l) without any type of fertilizer; m) conventional fertilizer

In *Chapter-V* over all conclusion of the study is presented. It was noted that the prepared vitreous fertilizers, in particular GF1, GF2, GF3 and GF4, showed an increasing effect on paddy growth and yield traits compared to non-amended and NPK treatments, suggesting the importance of considering the use of these fertilizers in large-scale application to improve crop production with no harm to the environment.

It was shown that after the application of the glass fertilizer, the growth and production of the kharif paddy was better than the normal application of the conventional fertilizers.

Preliminary study on the efficacy of glass fertilizers prepared in laboratory to kharif paddy through pot experiment during 2018 revealed that all the glass fertilizers under consideration are very much promising with regards to grain yield and total biomass production. Intensive efficacy studies with regards to uptake of nutrients by crops and soil status after harvest of crops of these glass fertilizers is required prior to acceptable by farmers as a viable option over conventional fertilizers and its production as commercial fertilizers.

Application

The GF thus produced and characterized by DTA, DGA, FTIR, Mossbauer and Raman Spectroscopy will be subjected to Pot Culture method at Soil Chemistry Laboratory, Sriniketan, Visva-Bharati (a collaborative Project). Growth development and production of Khariff Paddy, thus produced will be done. The indigenous know how technology will be applied in large scale Pilot Plant production.

Conclusion:

A preliminary study on the efficacy of glass fertilizers prepared in the laboratory to Kharif paddy through pot experiment during 2018 revealed that all the glass fertilizers under consideration are very much promising with regards to grain yield and total biomass production. Intensive efficacy studies with regards to uptake of nutrients by crops and Soil status after harvest of crops of these glass fertilizers are required prior to acceptance by farmers as a viable option over conventional fertilizers and its production. The as commercial fertilizers.

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