EFFECTS OF STEEL PLANT WASTE SLAG ON BIOMASS AND CROP PRODUCTIVITY OF Vigna radiata

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ABSTRACT
India occupies second position in the metal production after China in the world. Among the seven integrated steel plants in India, one of the major public sector plant is located at Rourkela. It was constructed in collaboration of Federal Republic of Germany in October 1956. Rourkela Steel Plant generates Blast Furnace Slag, Steel making slag, fly ash, BF sludge dust. An integrated Steel Plant produces 2-4 tonnes of wastes (including solid, liquid, gas) for every ton of steel produced. Rourkela Steel Plant reported production of Blast Furnace slag, Granulated slag and Steel Slag at 1,141,810 tonnes, 868,395 tonnes and 772,476 tonnes respectively during the year 2015-2016. In China, investigation was conducted for use of Steel Plant waste slag as fertilizer. Slag was used as fertilizer in rice, wheat and maize crops. The present work is to study the effect of Steel Plant waste slag on Biomass and crop productivity of Moong plant. Slag fertilizer was first used in rice cultivation, wheat cultivation, maize cultivation. Our aim is to check the effect of steel plant waste slag on biomass and crop productivity of Moong plant.

KEYWORDS: Rourkela Steel Plant, Steel Slag, Slag cement, Vigna radiata (Green Gram), Crop productivity, Biomass.

INTRODUCTION

Industrial wastes and agricultural byproducts are increasingly used in the crop production as fertilizers, but their impacts on soil carbon (C) sequestration remain poorly understood. Slag based silicate fertilizer has been widely used to improve the crop productivity. Silicon is the second most abundant element in the soil after Oxygen. In the soil solution, silicon improves photosynthetic activity and increase resistance of plants to fungal infection, insects attack, salinity hazard and heavy metal toxicity including rigidity to the plant tissues which positively affects growth and biomass production. Steel slag was considered as an adequate source of Silicon and it was registered in 1955 in Japan as a fertilizer.

A legume is a plant in the family Fabaceae or the fruit or seed of such plant. This Plant has close link with Nitrogen fixing microorganism known as Rhizobium. Leguminous plants are important in agriculture because they are resistance to disease, they are rich in proteins so they require less amount of Nitrogen for growth. Nitrogen fixing bacteria are symbiotically associated in them. These plants are used with food crops to enrich the soil with natural fertilisers are in fact produced by bacteria found in the roots or Rhizosphere of leguminous plant. In different concentration of slags the nodule formation also differs. It is also regulated by internal factors or we can term it as autoregulation. Environmental factors affect number of nodules and nitrate concentration in the growing pot. The effects of different concentrations of Steel slag have not been reported on both growth and noduleation in Green Gram i.e. Vigna radiata and therefore present study was made.

STUDY SITE

This research was conducted in the Garden of Muncipal College, Uditnagar Rourkela. (22°13'-30"N and 84°51'-50.76"E) Odisha, India.

METHODOLOGY

To study the effects of Steel Plant waste slag on biomass and crop productivity of plant Vigna radiata in garden soil “Pot Experiment” was conducted. The experiment was carried using rounded design six pots. Six earthen pots (size r.23cm and h.28.5cm) each containing 7 kg of dried garden soil were taken. The experiment was started on 27\textsuperscript{th}. April,2022, and it was considered as the day zero. After the addition of garden soil in the pot, the waste steel slag was added in each pot (except the control pot) separately slag at the rate of 125g, 250g, 500g,750g and 1000g per pot i.e. 5% slag, 10% slag,
20% slag, 30% slag and 50% slag. One untreated pot was kept as control. On the next day 10 Green Gram (*Vigna radiata*) seeds were sown in each pot. Green gram grows very rapidly and therefore plant height, number of leaves/flowers/fruits in each plant were taken at 7 days intervals.

**RESULTS AND DISCUSSION**

The green gram seeds germinated within 24h of sowing showing plumule and radicle on the next day of sowing. The percent seed germination differed little between control (80%) and treatments (70-100%) suggesting no adverse effects of steel slag on the seed germination.

The plant growth measured in terms of shoot height and dry weight was a little higher than control in 5% treatment but decreased a little at higher concentrations (10-50%) (Fig. 1-2).

Per plant leaves number differed little (33-36/shoot) in both control and treatments of lower concentrations (5-20%) but reduced (27-28/shoot) in the treatments of higher concentrations (30&50%). Almost similar effects were noted on flower and fruit numbers/shoot. Flower numbers in the control and treatments of lower concentrations (5% & 10%) were higher (5/shoot) than that at higher concentrations (20-50%) of slag treatments (3 flowers/shoot). Slag treatments had little effect on the fruit number/shoot, with the exception of 50% treatment showing 70% reduction in fruit setting.

**AFTER 21 DAYS INTERVAL**

![Plant Height Chart](image_url)

- **CONTROL**
- **5% SLAG**
- **10% SLAG**
- **20% SLAG**
- **30% SLAG**
- **50% SLAG**
AFTER 28 DAYS INTERVAL

CONTROL  5% SLAG  10% SLAG

20% SLAG  30% SLAG  50% SLAG

AFTER 35 DAYS INTERVAL

CONTROL  5% SLAG  10% SLAG

20% SLAG  30% SLAG  50% SLAG
Photographs showing shoot growth (also leaves) in the control and treatments at different time intervals
Slag treatments affected root development adversely. The roots were highly branched, fine and longer in the control but poorly branched and thick in the treatments (Photographs). However, nodulation was better (18-21/plants) in the treatments of higher slag concentrations (30\&50\%) than the control and treatments (5\-20\%) of lower concentrations (10-12/plant).

![Control and Slag Treatments](image)

Photographs showing root development in the control and slag treatments
Plant weights (Shoot + Root) were almost similar in the control and 5\% treatment but it decreased a little in the slag treatments of higher concentrations.

![Plant Weight Graph](image)

Steel slag contains trace amounts of heavy metals, certain oxidative limiting factor were evaluated as well. The steel slag improved soil mineral composition and it has also increased aboveground maize biomass by providing Fe, Mn,
Mg, K and partly P and improved the photosynthetic limiting factor. In agriculture, slags can be used as fertilizers and curative of soil acidity. Slags are Calcium and Magnesium Silicates which show dissolution action due to Silicon oxide base. Besides, Steel slags have been used as a low cost source of Si supply to rice plants.

Silicon helps in the promotion of nodule formation which is essential for nitrogen fixation. Nodulation and Nitrogen fixation depend on sufficient supply of both macro and micro nutrients (Smith, 1982). Iron which is a micro nutrient has an important role in nodule formation. Silicon is beneficial not only for plant growth but also favor tolerance to abiotic and biotic stress (Guntzer et al. 2012; Kim et al. 2014, 2016; Jang et al. 2018). In Japan, slag silicate fertilizer is applied to paddy fields to increase silicon uptake to rice plants in the silicon deficient soil (Ma and Takahasi 2002). It is evident that slag is rich minerals and silicon good for plant growth. This explains good growth of green gram compared with control in 5% treatment though it affected plant growth adversely at higher concentrations.

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