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Original research

EFFECT OF ROTATIONAL SPEED OF A PAN GRANULATOR ON GRANULAR SIZE DISTRIBUTION OF A NEEM-BASED ORGANOMINERAL FERTILIZER

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ABSTRACT

Fertilizers are granulated based on specific grades by mostly specifications of not less than 2 mm and not more than 5 mm. Granular sizes that are below 2 mm and above 5 mm which are called undersize and oversize products, respectively are expected to be recycled. . This recirculation attracts extra production cost which most times results in losses to the manufacturers. Among the major factors affecting granular sizes in pan granulator is the rotational speed (ω) of the pan. In this study, a pan granulator was used to granulate a neem-based organomineral fertilizer for 45 minutes. Each batch was granulated at different speeds from 20 rpm, to 60 rpm after which the materials were separately sundried and screened into 3 grades (<2 mm, 2 mm ≤ 5 mm and > 5 mm). The pattern of granulation in relation to size distribution was observed to vary with speed. The quantity of grade 2 mm≤5mm produced increased with the increase in speed of the granulator from 20 rpm to 40 rpm after which the quantity decreases with further increase in the speed of the granulator to 50 rpm, and further to 60 rpm.

Keywords: Fertilizer, granulator, speed, sizes, production, pan.

INTRODUCTION

The world demand for fertilizer is expected to rise due to the increase in population (Stewart *et al*., 2005). As the global population is increasing, the cultivable area continues to decrease because of human habitation and at the same time food demand is expected to rise, therefore there is need to increase food production per unit area with appropriate technologies, hence the use of fertilizer to boost food production cannot be underrated. To boost food production in our modern day farming, local technology must be adopted to produce an affordable fertilizer to boost crop production. There is the need to improve the efficiency of fertilizer production technology using locally available raw materials and simple equipment that are within the reach of the local fertilizer manufacturers. The process technology also must be simple and able to produce a fertilizer that is safe for the environment and easy to handle by the end users. One of the major considerations in the production of fertilizers is the need to eliminate dust and improve the physical properties of the product, hence granulation is an important process towards achieving this.

Granulation as a process of improving flowability and appearance of fertilizers is one of the major processes involved in fertilizer production which transforms fine powders into granules in order to improve the characteristics of materials used as fertilizers and as a means of protecting the end users from hazards such as dust. Granulation process can be described as the aggregation of mostly small particles into larger assemblies which is conducted in the presence of moistening liquid (Biskupski and Picher, 2008), it involves the production of solid particles with a certain size or shape from a fine material. During this process the particles binds together with any other material, or the bonding forces are transmitted by the material bridges formed with a binder (Gluba and Obraniak 2009; Gluba *et al.*, 2005; Heim *et al.*, 1991). Dissolution rate, bulk density, reduction in caking formation and strength of granules is also improved. It improves handling of powder which is difficult to handle due to their cohesiveness and low flowability (Lister and Ennis, 2004). Granulation therefore is a size enlargement process in which small particles are agglomerated together by spraying a liquid binder on to a dry powder bed (Roy *et al.*, 2009). Agglomerates are formed by the aggregation of particulate solids that are held together by short-range physical or chemical forces acting among particles, by chemical or physical modification of the particles triggered by specific process conditions or by substances that act as binders by adhering physically or chemically to form material bridges among particles (Pietsch, 2003).

During granulation in a pan granulator, size distribution of granules is affected by so many factors, among which is the speed of rotation of the pan (Walker *et al.*, 2000). This study was therefore carried out to evaluate the effect of rotational speed on the size distribution of granules formed in a pan granulator while granulating a neem-based organomineral fertilizer.

MATERIALS AND METHODS

Materials

The powder used in the production of the granules is a neem-based organomineral fertilizer formulated and produced by Dukazer Ltd.

Production of granulated fertilizer

The production for each batch of the neem-based organomineral fertilizer was repeated two times. 150 kg of the powder fertilizer material was fed manually with hand-bowl into the pan granulator which was set to rotate for 45 minutes for each batch. For each batch a varying speed of 20 rpm, 30 rpm, 40 rpm, 50 rpm and 60 rpm was used. 15 litres of gum Arabic solution (500g of gum /10L of water) was sprayed continuously on the powdered material in the pan through a nozzle sprayer while the pan was rotating in an anticlockwise direction until the powder was well moistened and the granules began to form. The diameter of the pan used in this research work was 1000 mm and a depth of 500 mm. The setup is as shown in (Figure 1).

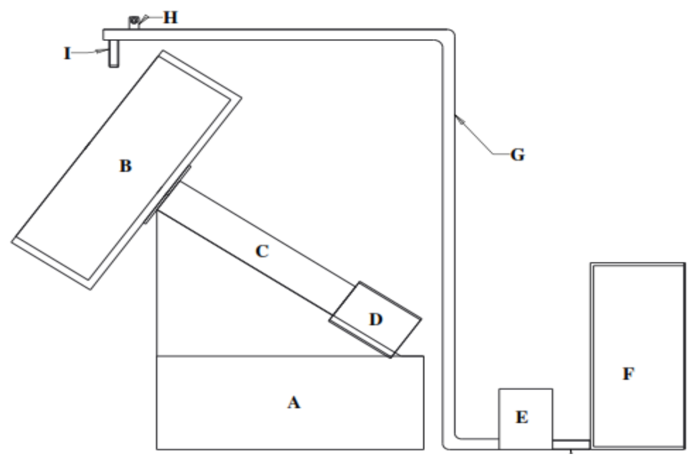

Figure 1: Schematic diagram of the granulating system: Pan (B) is connected to an electric motor with a variable gear (D) with shaft (C). Pan (B), Shaft (C) and gear electric motor (D) was supported by stand (A). A Solution of binder was pumped through pipe (G) with a surface pressure pump (I) from reservoir (F) and binding solution was sprayed on to the materials through nozzle (G) which was being regulated with valve (H).

The critical rotational speed within pan is the speed at which material can be just carried around the pan by centrifugal action. In terms of the Froude number describing the ratio of inertial to gravitational forces, the critical rotational speed can be defined as:

$$\omega = \frac{(42.4)}{1}\left(\sqrt{D}\right) \quad (1)$$

where ω = critical rotational speed (rev/min) and D = diameter of the pan (metre).

After 45 minutes, the materials were collected and sundried. The sundried materials were screened to 3 grades (< 2 mm, 2 ≤5 mm and > 5 mm.) using 5 mm and 2 mm manual sieves. Each grade was thereafter weighed separately with a scale balance.

The efficiency of the process, Ɛ, is defined as the percentage of the product which meets the size requirement (Mangwandi *et al.*, 2012):

$$\mathcal{E} = \left(\frac{\text{MNormal}}{\text{MTotal}}\right) 100 \qquad (2)$$

RESULTS AND DISCUSSION

The result of granulation efficiency is depicted in Figure 2. As the speed increases from 20 rpm to 30 rpm, the quantity of granules within the range of 2mm-5mm also increases (fig. 2) until 40 rpm when the quantity of grade 2≤5 mm produced continues to decrease with further increases in rotational speed of the pan.

More of the < 2 mm granules were produced initially at 20 rpm but decreases at 30 rpm and further at 40 rpm, but increased at 50 rpm to 60 rpm. The larger quantity of <2mm produced at a lower speed and higher speed shows that material did not granulate much at a lower speed and at a much higher speed of 50 rpm and 60 rpm, the material stuck to the wall of the pan due to centrifugal forces which is in line with the work of Sherrington and Oliver (1981), on the effect of rotational speed of the drum on physical properties of granulated compost fertilizer.

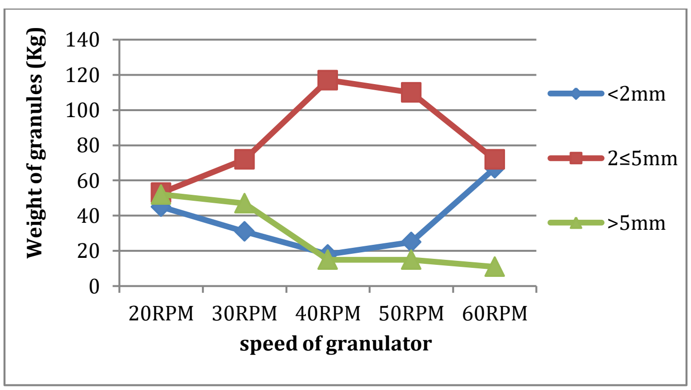

Fig.2. Effect of rotational speed on size distribution of granules formed.

At a low rotation speed, the granulate slides about the bottom of the pan with little agitation of the granules, and with increasing pan speed the granule begins to roll, cascading occurs and the probability of agglomeration increases. It has been suggested that the optimum rotational speed is half the critical speed, where the critical speed is defined as the speed at which the dry material will be carried around the drum by centrifugal force (Walker, 2007).

CONCLUSION

In present study on the effect of pan rotational speed (ω) on production of normal grade (2≤5 mm) of neem-based organomineral fertilizer granules, the result indicated that when the rotational speed increased from 20 to 40 rev min^{-1}, the percentage of the produced normal size (2≤5 mm) also increased, and further increases in the speed of rotation resulted in reduction of the percentage of normal granules produced. The optimal efficiency of the granulator was at 40 rev min^{-1}. The findings in this study may be useful in determining the optimal operational condition for the production of granulated fertilizers using similar technology.

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CONFLICT OF INTEREST

No conflict of interest.

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