
Arun Kumar, Department of Farm Machinery and Power Engineering, College of Technology, G B Pant University of Agriculture and Technology, Pantnagar-263145, U S Nagar Uttarakhand India

Ahmed Hamza Umran, Ex-PhD scholar, , Department of Farm Machinery and Power Engineering, College of Technology, G B Pant University of Agriculture and Technology, Pantnagar-263145, U S Nagar Uttarakhand India

Abstract

Among the most necessary crops of India, rice, wheat, sugarcane, and maize are the major ones cultivated at many parts of the world. Maize is the third world’s most important cereal after Rice and Wheat. A recent study on weed control variants from maize crops reveals that, pre-emergence application of weedicides followed by earthing up at 30 days after emergence would be beneficial for getting good grain yield of maize. In India, maize occupies 8.17 mha area, with production and productivity of 19.37 mt and 2.42 t/ha, respectively. The soil in between the lines should be earthed up at the base of the plants. Earthing-up is an essential operation especially in maize crop. This prevents the plant from lodging and results in better standability. Moreover, it also provides anchorage of the lower whorls of adventitious roots above the soil level which then function as absorbing roots. Earthing-up improves yield but is labour intensive and is done by hand with a hoe, spade etc. by the farmers. Top dressing of fertilizer in maize and other row crops is done by broadcasting method manually which results in low fertilizer use efficiency. Therefore, there is a need to mechanize the earthing up and top dressing of fertilizer application in maize and other row crops which will result in saving of time, labour & fertilizer. Keeping all these points in view, a Fertilizer Band Placement cum Earthing up Machine has been developed and fabricated in the Department of Farm Machinery and Power Engineering, G B Pant University of Ag & Tech, Pantnagar, India. The functional requirement of the machine embodied the development of a tractor drawn machine which can perform the three main functions, (i) loosening of the soil up to 200 mm depth and cutting the weeds, (ii) placement of chemical fertilizers on the surface of the soil near the plant at a distance of 50-100 mm sideways (iii) earthing-up the plant and covering the fertilizer. The machine consists of main frame, fertilizer box with cell type fertilizer metering device, fertilizer tubes, sweep & ridger. Performance of the machine was evaluated at G.B. Pant University of Agriculture and Technology, Pantnagar during 2011 at four forward speeds (2.5, 3.5, 4.5 and 5.5 km/h) and four depths of operation viz. 0.05, 0.10, 0.15 and 0.20 m. Results showed that the good earthing up i.e. uniform heaping up of soil on both the sides at the base of the crop up to 100 mm height was found at the depth of operation of 0.10-0.15 m and tractor forward speed of 4.5 km/h. No damage to crop was observed. The field capacity and the fuel consumption was found as 0.56 ha/h and 7.68 l/ha, respectively. The machine can place the fertilizer (Top dressing) along the crop at the rate ranging from 40 kg/ha to 300 kg/ha as per the requirement of different crops. The average draft ranged from 1056 to 5018 N while the average slip ranged between 4.55 and 7.10%.

Keywords: soil earthing, fertilizer band placement, mechanization, maize
1 Introduction

Maize is the third world’s most important cereal after rice and wheat. This is an important cereal crop of the world and has great economic value. In India, maize occupies 8.17 mha area, with production and productivity of 19.37 mt and 2.42 t/ha, respectively.

Earthing up is an essential operation especially in maize crop. This prevents the plant from lodging with better stand ability. Moreover, it also provides anchorage of the lower whorls of adventitious roots above the soil level which then function as absorbing roots. Earthing up improves yield but is labor intensive and it is done by hand with a hoe, spade etc. by farmers. Top dressing of fertilizer in maize and other row crops is done by broadcasting method manually which results in low fertilizer use efficiency. Broadcasting of fertilizers, especially P and K, results in fixation problems due to more soil contact while applied N is lost due to volatilization. Usman et al. 2002 recommended that earthing up before bud formation is necessary for obtaining higher returns from sun flower with respect to seed yield.

A significant increase in grain and straw yield was reported due to earthing up by Thakur et al. 2003. Earthing up and sowing on ridge may provide better condition for aeration and also require less irrigation water. A recent study on weed control variants on maize crops reveals that, pre-emergence application of weedicides followed by earthing up at 30 days after emergence would be beneficial for getting more grain yield of maize (Sultana et al. 2012). Labour scarcity delays these agricultural operations which has adverse effects on crop production. Therefore, there is a need to, mechanize the first/second top dressing fertilizer dose fertilizer application and earthing up in maize and other crops which will result in saving of time, labor and fertilizer.

2 Materials and methods

2.1 Concept of a Fertilizer Band Placement cum Earthing Machine

The functional requirement of the machine embodied the development of a tractor drawn machine which can perform the three main functions, (i) loosening of the soil up to 200 mm depth and cutting the weeds, (ii) placement of chemical fertilizers on the surface of the soil near the plant at a distance of 50-100 mm sideways (iii) earthing-up the plant and covering the
fertilizer. The mounting of legs on the frame is such that they can be adjusted in horizontal and vertical plane according to row crop spacing and depth of operation.

The machine offers the apparent advantage of timely Earthing, weeding, saving of time, fuel and labour costs and therefore, helps reducing the cost of production besides reducing the drudgery of the task.

Fertilizer band placement and earthing-up machine consisted of a number of components which will be assembled on three main units, viz, (i) sweep unit, (ii) fertilizer metering and placement unit, and (iii) ridger unit. The CAD view of the machine is shown in Figure 1 for ease of understanding.

2.2 Performance evaluation of fertilizer band placement cum earthing machine

2.2.1. Description of the machine

Different components of a fertilizer band placement cum earthing up machine such as sweep tine, ridger tine, Frame, hitching system, fertilizer distribution system were designed/selected using engineering principles. The developed fertilizer band placement cum earthing machine (Umran 2012) consisted of mainly, a rectangular frame, two sweep tines, sweeps, two ridger tines, ridgers, hitching system, fertilizer box with its metering system, two pipes for fertilizer band placement, a ground drive wheel for power transmission, and accessories as shown in Figure 2. The machine has three main units, viz. (i) Soil loosening and weed cutting unit (ii) Fertilizer metering and band placement unit and (iii) Earthing unit.

2.2.2 Laboratory performance test fertilizer metering device

One of the basic functions of a fertilizer band placement and earthing up machine, is the fertilizer band placement, hence, the uniformity in fertilizer application is an important criterion for its performance elevation. Uniformity of fertilizer application depends mainly on the uniformity of distribution and delivery. The uniformity of fertilizer delivery was examined in the laboratory. For application rate twenty revolutions of ground drive wheel were selected and delivered fertilizer from each tube was collected and weighed. The laboratory calibration of machine was done at different combinations of sprocket and hopper height.
2.2.3 Experimental details

The experiment was conducted at G.B. Pant University of Agriculture & Technology, Pantnagar during 2011. The Center is situated at latitude of 29° N and longitude of 79.3° E at 243.84 m above mean sea level and lies in a narrow belt under Tarai region of Uttarakhand in the foot hills of Shivalik ranges of the Himalayas. The soil of the experimental field was sandy loam in texture. The average initial bulk density and moisture content were observed as 1.41 Mg/m³ and 18.00% (d.b), respectively, for the depth of 0-150 mm. The experiment was laid out in RBD with different depths and speeds with three replications during the year 2011. Four depths of 50 (D₁), 100 (D₂), 150 (D₃) and 200 (D₄) mm and four speeds of 2.5 (S₁), 3.5 (S₂), 4.5 (S₃) and 5.5 (S₄) km/h were selected for conducting the experiment. The size of each plot was 25×4 m.

The experiment was carried out with the following treatments as: T₁: D₁ S₁, T₂: D₁ S₂, T₃: D₁ S₃, T₄: D₁ S₄, T₅: D₂ S₁, T₆: D₂ S₂, T₇: D₂ S₃, T₈: D₂ S₄, T₉: D₃ S₁, T₁₀: D₃ S₂, T₁₁: D₃ S₃, T₁₂: D₃ S₄, T₁₃: D₄ S₁, T₁₄: D₄ S₂, T₁₅: D₄ S₃, T₁₆: D₄ S₄

The field planted with maize crop was harvested manually and plant were cut from the height of about 400 mm. The performance of machine was evaluated in terms of soil parameters width of soil throw, height of soil throw on the stem of plant and machine parameters such as wheel slip and draft. Field capacity, field efficiency and fuel consumption of the machine was determined using standard procedure. The condition of field after operation of the machine is shown in Figures 3 and 4.

3 Results and discussion

3.1 Effect of depth of operation and travel speed on wheel slip and draft

The average slip of tractor wheel and draft of machine at different depths and forward speeds was noted and the statistical analysis revealed that the effect of depths and forward speeds on slip and draft was significant (P<0.05).

In general, with increase in depth of operation and speed of tractor, the slip increased. The slip of the tractor tire increased with forward speed of tractor at 50 mm depth of operation. Similar trend was observed at other depths of operations. At 2.5 km/h speed, it was minimum (4.55%) and at 5.5 km/h speed it was maximum (4.62%). The average slip was highest at the depth of 200 mm at forward speed of 5.5 km/h (7.10%) and minimum for the 50 mm depth at 2.5 km/h forward speed
(4.55%). The increase in slip of the tractor rear wheel might be due to increase in draft of the machine with increasing forward speed and depth of operation. The draft of a fertilizer band placement cum earthing machine ranged between 1056 to 5018 N. The draft of machine increased with depth as well as forward speed.

3.2 Field capacity and field efficiency

A fertilizer band placement cum earthing machine was operated in a field to determine the field capacity, field efficiency and fuel consumption. The speed of operation during the field trial was 5.5 km/h. The effective width of operation of the machine was 1.50 m. So, the effective field capacity was found to be 0.56 ha/h. The average of theoretical field capacity was calculated as 0.82 ha/h which resulted in field efficiency of 68.3 %. The average fuel consumption during the operation was 7.68 l/h.

3.3 Effect of depth of operation and forward speed on width of soil throw, height of soil throw on stem and ridge height

The average width of soil throw, height of soil throw on plant stem and ridge height at different depths and forward speeds was observed and the statistical analysis of data indicated that the effect of depths and forward speed on these parameters was significant (P<0.05).

In general with depth of operation and speed the tractor the width of soil throw increased. The average width of soil throw for D1S1 was minimum and maximum for D2S3 as 52.88 cm and 80.55 cm, respectively. At 50 mm depth of operation, the width of soil throw increased with the forward speed of tractor. Similar trend was observed at other depths. The width of soil throw at 100 mm depth was noted as, 70.60, 73.80, 74.33 and 74.88 cm for forward speed of 2.5, 3.5, 4.5 and 5.5 km/h, respectively. Thus, it can be seen that with the increase in forward speed the width of soil throw increased and it was highest at 5.5 km/h speed.

Similarly, at 150 mm depth the width of soil throw increased with increase in speed. It was found minimum (75 cm) at 2.5 km/h speed and highest (78.77 cm) at 5.5 km/h speed. However, at 200 mm depth, the soil throw ranged between 78.88 cm and 80.55 cm. The row to row spacing for maize crop is 75 cm. At 100 mm depth and 5.5 km/h speed the soil throw was 74.88 cm which is very close to the base of the crop and is the requirement of earthing operation.
The average height of soil throw on plant stem was 8.33 cm and 11.44 cm for D1S1 and D3S4, respectively. It follows that at 100 mm depth with 5.5 km/h speed, height of soil throw on plant stem of 10.44 cm was adequate because the height of ear root group of plant is 10 cm. At 150 mm depth with 2.5 km/h speed also the stem of plant can be covered. The average height of ridge ranged between 13.33 cm and 31.33 cm, for different treatments.

5 Conclusions

The draft of a fertilizer band placement cum earthing machine and tractor wheel slip increased with the increase in depth as well as increase in forward speed. The average draft ranged from 1056 to 5018 N. while the slip ranged between 4.55 and 7.10%. The draft and slip were highest at 200 mm depth and forward speed of 5.5 km/h.

For earthing in maize, the optimal soil throw width (74.88 cm) and height of soil on plant stem (10.44 cm) were obtained at 100-150 mm mm depth of operation and 4.5 km/h tractor forward speed. No damage to plant was observed.

Under the lab calibration of fertilizer meetering device, the average delivery of Urea fertilizer ranged between 68 kg/ha and 321 kg/ha. The delivery of Urea fertilizer was highest at the sprocket setting 17 x 27 and 50 mm height of fertilizer box (321 kg/ha) which is sufficient to meet the top dressing fertilizer dose for different row crops.

6 References


Figure 1: View of a Fertilizer Band Placement cum Earthing-Up Machine.

Figure 2: Prototype of Fertilizer Band Placement cum Earthing Machine
Figure 3: Field condition after operation of earthing machine in maize field

Figure 3: Field condition after operation of earthing machine in sugarcane crop at farmers field