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Research Paper

Fertilizer band placement-cum-earthing machine effects on growth, productivity and profitability of maize (*Zea mays*) under varying nitrogen levels

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ABSTRACT

A field experiment was conducted during the rainy season (*rabi*) of 2011–12 and 2012–13 at Govind Ballabh Pant University of Agriculture and Technology (GBPUAT), Pantnagar, to study the effect of mechanized earthing, conventional earthing and nitrogen dose on productivity and profitability of maize (*Zea mays* L.). The experiment included 4 earthing treatments in main plots, viz. no earthing, manual earthing, inter-cultivation by cultivator and earthing by Pant fertilizer band placement-cum-earthing machine) and 4 levels of nitrogen, i.e. 90, 120, 150 and 180 kg/ha as subplots was arranged in splitplot design. The Pant fertilizer band placement cum earthing machine was designed and developed at the Department of Farm Machinery and Power Engineering, College of Technology, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Uttarakhand. The machine was designed to perform continuous placement of fertilizer along the row crop, earthing-up and weed cutting operation simultaneously. Significantly higher productivity and monetary advantage was noted under earthing by Pant fertilizer band placement-cum-earthing machine. The average increase in grain yield in mechanized earthing over no-earthing, manual earthing and inter-cultivation by cultivator was 24.5, 6.5 and 14.5%, respectively. The highest monetary advantage of ₹ 46.3 thousands/ha and benefit: cost ratio of 1.22 was obtained in mechanized earthing. Application of nitrogen @ 150 kg/ha was helpful in improving grain yield by 26.2% and net returns by 63.5% over 90 kg/ha.

Key words: Earthing-cum Fertilizer placement, Economics, Maize, Nitrogen, Yield

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 9.426 million ha area, with production and productivity of 24.35 million tonnes and 2.58 t/ha respectively. The adoption of single-cross hybrid in maize led to area and productivity enhancement which provided avenues for more farm mechanization in India (Dass *et al*., 2012). Earthing up is an essential operation in maize crop which 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. Thakur *et al*. (2003) reported significant increase in grain and straw yield owing to earthing up. Earthing up improves yield but is labour intensive and time consuming and it is done by hand with a hoe, spade etc. Earting up and sowing on ridge may provide better condition for aeration and also require less irrigation water. Scarcity of labour delays these agricultural operations that have adverse effect on crop production. Therefore, there is need to, mechanize the first/second top-dressing fertilizer dose and earthing up in maize, sugarcane and other crops which will result in saving of time, labour and fertilizer and reduce drudgery.

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 (Jat *et al*., 2014). Regular supply of nitrogen in adequate amount is necessary to enhance the productivity of maize (Singh *et al*., 2003), particularly in the winter season when low temperature keeps slow growth rate of plants and poor absorption of nutrients. Urea applied by farmers on soil surface is subjected to various losses and causes poor nitrogen use efficiency (Jat *et al*., 2016). Placement of urea below the soil surface may prove an effective way to enhance nitrogen-use efficiency and thus

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may be helpful in reducing nitrogen dose (Jat *et al*., 2014). Therefore, keeping this view, a Pant fertilizer band placement-cum-earthing machine was designed and developed at the Department of Farm machinery and Power Engineering, College of Technology, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar (Umran, 2012) and a field calibration study was conducted for 2 consecutive winter (*rabi*) seasons to find out the effect of mechanized earthing and different doses of nitrogen on maize productivity and profitability.

MATERIALS AND METHODS

The field experiments was conducted during the winter (*rabi*) season of 2011–12 and 2012–13 at Pantnagar. The soil was sandy loam, neutral in reaction (*p*H 7.3), medium in organic carbon (0.65 %), low in available nitrogen (242 kg/ha), medium in available phosphorus (20.2 kg/ha) and potassium (158 kg/ha). The experiment consisted of 4 earthing treatments in main plots, viz. no-earthing, manual earthing, inter-cultivation by cultivator and earthing by the machine and 4 levels of nitrogen, i.e. 90, 120, 150 and 180 kg/ha in subplots was laid out in splitplot design, replicated thrice. The test varieties were 'DHM 117' and 'PEHM 2' during 2011–12 and 2012–13 respectively. The crop was sown on 22 November and 10 November in 2011 and 2012 and harvested on 20 May 2012 and 22 May 2013 respectively. The crop geometry was 75 cm × 20 cm during both years. One-fourth of N and full P_2O_5 (60 kg/ha) and K_2O (40 kg/ha) were applied basal and remaining N was top dressed in 3 splits prior to knee-high, at knee-high and at tasseling stage. Pre-emergence application of atrazine @ 1.0 kg a.i./ha was done 1 day after sowing. Earthing treatments were imposed at knee-high stage. Earthing machine simultaneously placed the urea @ 100 kg/ha (i.e. 46 kg N/ha). In other treatments also urea was applied @ 100 kg/ha manually at knee high stage.

Pant fertilizer band placement-cum-earthing machine is tractor-drawn machine which can perform the 3 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, and (iii) earthing-up the plant and covering the fertilizer (Fig. 1, 2). 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 in reducing the cost of production besides reducing the drudgery. The size of gross and net plots of subplots was 22.5 and 6.9 m^2 respectively. Nutrient-use efficiency in terms of partial factor productivity was obtained by dividing grain yield with nitrogen applied in respective treatment. Cost of cultivation was calculated by taking current market prices of inputs while monetary return was obtained by multiplying grain yield with market price which was ₹15/kg grain. The benefit: cost (B:C) ratio was calculated by dividing the net returns by cost of cultivation. The critical difference at 5% level of probability was calculated for testing the significance of difference between any 2 means and their interactions where ever 'F' test was significant.

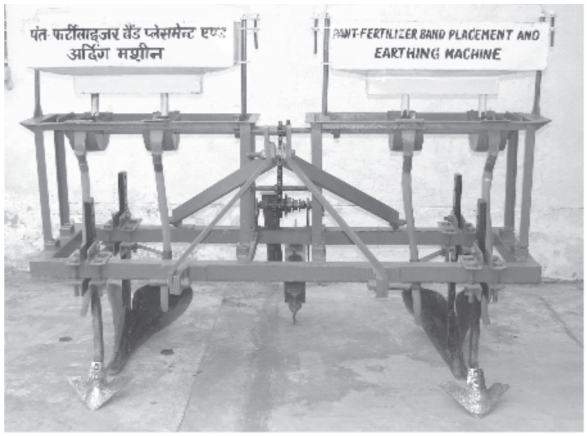

Fig. 1. Pant fertilizer band placement cum earthing machine

Fig. 2. Field condition during operation of machine in maize

RESULTS AND DISCUSSION

Plant growth

The earthing operation in maize remarkably influenced plant height as the crop was grown without earthing attained significantly lowest height (Table 1). Earthing by machine resulted significantly more plant height during both the years, but remained at par with other earthing treatments, viz. manually and by cultivator.

Earthing up ensures better aeration and fine tilth in root zone and thus makes favourable conditions to the development of roots. These conditions might result in higher water and nutrient uptake by roots from soil and favoured shoot growth. This was reflected in more plant height under earthing treatments. Similar findings were reported by Painyuli *et al*. (2013).

Plant height was significantly affected due to nitrogen dose where 180 kg N/ha being at par with 120 and 150 kg/ha recorded more plant height than 90 kg/ha. Poor plant height under 90 kg nitrogen treatment might be due to less availability of nitrogen which decreased vegetative growth. Adequate supply of nitrogen might have helped the maize plants to grow faster. Pal and Bhatnagar (2012) also reported that increased level of nitrogen favoured the growth of maize.

Yield attributes and yield

Earthing operation and nitrogen dose affected yield attributes and yield significantly but interaction between these two treatments was not significant. Plant population and cobs/ha did not vary significantly due to earthing treatments (Table 1). Yield attributes, viz. cob length, cob girth and 100-grains weight, improved significantly with earthing. Earthing in maize showed pronounced effect on cob length as crop grown without earthing obtained significantly lowest cob length. Among various earthing treatments, the maximum cob length was recorded in mechanized earthing that was significantly superior to no-earthing. Cob girth was also influenced significantly with earthing treatments. Crop raised with mechanized earthing attained significantly maximum cob girth. Mechanized earthing 100-grain weight was significantly increased compared to no earthing but remained at par with manual earthing. Better shoot growth under earthing operation owing to favourable soil conditions might helped in improving yield attributes. Mechanized earthing resulted into significantly maximum cob yield. The mechanized earthing resulted 21.5, 5.6 and 12.8% more cob yield than no-earthing, manual earthing and earthing by cultivator respectively (Table 2). Significantly highest grain yield was obtained in mechanized earthing. The increase in grain yield with mechanized earthing over no earthing, manual earthing and earthing by cultivator was 24.6, 6.9 and 14.7 1% respectively. The higher value of yield attributes under mechanized earthing resulted in more yields under this treatment. Painyuli *et al*. (2013) observed significant improvement in cob yield owing to earthing over flat planting. Thakur *et al*. (2003) reported that flat planting followed by earthing up has improved the grain and stover yields of maize. Sharma and Saxena (2012) reported that the earthing up of flat-sown maize showed significant superiority to flat sowing alone.

Variations in nitrogen dose did not affect plant population and number of cobs/ha significantly. An increase in nitrogen dose from 90 to 180 kg/ha increased values of yield attributes but response was not significant beyond 150 kg/ha. Crop fertilized with 180 kg N/ha being at par with 150 kg N /ha recorded significantly more cob length, cob girth and 100-grain weight than 90 and 120 kg N/ha. The yield attributes, viz. cob length, cob girth and 100-grain weight, were significantly lowest in 90 kg N/ha. More supply of nitrogen might have helped in increasing the cob length and cob girth by favoring the metabolic

Table 1. Effect of earthing operation and nitrogen dose on plant height and yield attributes of maize (pooled data of 2 years)

Treatment	Plant height (cm)	Cob length (cm)	Cob girth (cm)	100-grain weight (g)	Plant population ($\times 10^3$/ha)	Cobs ($\times 10^3$/ha)
Earthing						
No-earthing	144.0	14.9	12.4	23.6	60.34	57.91
Manual earthing	151.2	15.6	12.8	24.4	62.62	59.87
cultivator	151.8	15.5	12.8	24.0	62.26	59.10
machine*	154.3	15.8	13.2	24.8	62.44	59.09
SEm±	1.12	0.11	0.09	0.15	1.11	0.86
CD (P=0.05)	3.45	0.33	0.27	0.46	NS	NS
Nitrogen (kg/ha)						
90	142.5	14.7	12.2	23.2	61.84	58.85
120	150.7	15.4	12.8	24.1	61.85	58.88
150	153.7	15.8	13.1	24.7	62.24	59.25
180	154.4	15.9	13.1	24.8	61.74	58.98
SEm±	1.19	0.10	0.10	0.12	0.69	0.61
CD (P=0.05)	3.38	0.28	0.28	0.34	NS	NS

*Pant fertilizer band placement-cum-earthing machine

Table 2. Plant population, number of cob yield, grain yield and economics of maize as influenced by earthing operation and nitrogen dose (pooled data of 2 years)

Treatment	Cob yield (t/ha)	Grain yield (t/ha)	Partial factor productivity for N (kg grain/kg N applied)	Cost of cultivation (× 10^3₹/ha)	Net return (× 10^3₹/ha)	Benefit: cost ratio
Earthing						
No-earthing	5.572	4.233	31.35	37.2	26.3	0.71
Manual earthing	6.702	5.228	38.73	42.9	35.5	0.82
cultivator	6.188	4.788	35.47	38.3	33.5	0.87
machine*	7.096	5.616	41.60	37.9	46.4	1.22
SEm±	0.124	0.074	-	-	1.12	0.03
CD (P=0.05)	0.383	0.229	-	-	3.4	0.09
Nitrogen (kg/ha)						
90	5.501	4.239	47.10	38.5	25.0	0.65
120	6.218	4.855	40.46	38.9	33.9	0.87
150	6.838	5.348	35.65	39.3	40.9	1.04
180	7.001	5.424	30.13	39.6	41.7	1.05
SEm±	0.110	0.078	-	-	1.17	0.03
CD (P=0.05)	0.313	0.221	-	-	3.3	0.08

*Pant fertilizer band placement-cum-earthing machine

activity probably cell-division and elongation. The higher value of 100-grain weight at high level of N may be attributed to better partitioning and translocation of sugars. Pal and Bhatnagar (2012) also reported similar results. Application of nitrogen affected cob and grain yields significantly but response was significant up to 150 kg/ha. Cob yield and grain yield were also significantly higher with 180 kg N/ha than 90 and 120 kg N/ha but was at par with 150 kg N/ha. Crop fertilized with 90 kg N/ha showed significantly lowest cob and grain yields.

The higher yield was owing to more value of yield attributes, viz. cob length, cob girth and 100-grain weight. These results are in the line of findings of Shivay and Singh (2000).

Partial factor productivity for nitrogen

The earthing operation increased partial factor productivity for nitrogen. The highest partial factor productivity was recorded when earthing was done by machine and it was higher by 32.7% over no-earthing treatment, whereas improvement under manual earthing and earthing by cultivator was 23.5 and 13.1%, respectively. A reduction in partial factor productivity for nitrogen was noticed with increase in nitrogen dose from 90 to 180 kg N and varied from 47.10 to 30.13 kg grain/kg N.

Economics

The data on economic parameters (Table 2) revealed that the cost of cultivation was the highest in manual earthing because of additional 25 man-days involved under this treatment for earthing operation and fertilizer application. Crop grown without earthing had the lowest cost of cultivation. Compared to no-earthing treatment, the extra cost incurred on manual earthing, earthing by cultivator and earthing by machine was ₹5,750, 1,125 and 669/ha, respectively. Since machine performs 2 functions simultaneously, earthing and fertilizer application, there was saving of labour and money on these operations. Earthing by machine fetched significantly highest net returns. The net return under earthing by machine was higher by ₹20,071, 10,900 and 12,877/ha over no-earthing, manual earthing and cultivator inter-cultivation, respectively. Benefit: cost ratio was also significantly highest under earthing by machine. The low cost of cultivation and the highest gross return under earthing by machine resulted in the highest net return under this treatment. Nitrogen application @ 180 and 150 kg/ha were statistically same for net return and benefit: cost ratio and remained significantly higher than 90 and 120 kg/ha. Crop grown with 90 kg N/ha showed the poorest economics, as it gave significantly lowest net return and benefit: cost ratio.

Based on the study, it was concluded that mechanized earthing cum band placement of urea amounting 150 kg N/ha found helpful in obtaining higher productivity and profitability of maize in *rabi* season.

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