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PERFORMANCE EVALUATION OF JAB PLANTERS FOR MAIZE PLANTING AND INORGANIC FERTILIZER APPLICATION

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ABSTRACT

A controlled seeding rate such as seeds per hectare or fertilizer application rate (e.g. kg per hectare) is desired when planting or applying fertilizer in order to obtain the optimum yield of a crop. A study was conducted in 2004 and 2005 at the Department of Agricultural Engineering, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana to evaluate the performance of 30 jab planters randomly selected from a total of 68. These jab planters had been manufactured by a local Ghanaian manufacturer. The objective of the study was to evaluate the performance of jab planters for maize (*Zea mays*, L.) seed and inorganic fertilizer delivery. Five high yielding local maize varieties including *Okomasa*, *Obaatanpa*, *Abeleehi*, *Dorke-SR*, and *Dodzi* were used in 2004. In 2005, four different inorganic fertilizers: NPK 15-15-15, NPK 19-19-19, NPK 20-20-20 and Ammonium Sulphate were used. The experiments were arranged in a completely randomized design. For each of the 30 jab planters, there were 10 replications (jabs) to determine the number of seeds and the quantity of fertilizer delivered. A level of significance of 0.05 was used for all the tests. The results showed significant differences in maize seed and fertilizer delivery rates between jab planters. The poor seed and fertilizer metering of the jab planters showed that there was no control of quality in the manufacture of the metering unit of the jab planters. The study draws attention to the need to consider quality control in the manufacturing of the metering unit of planters and fertilizer application equipment.

Keywords: jab planter, performance evaluation, maize, planting, inorganic fertilizer.

INTRODUCTION

Maize (*Zea mays* L.) is the most important cereal crop produced in Ghana. It is also the most widely consumed staple food in Ghana. The production of maize in Ghana has been increasing since 1965 (FAO Statistical Databases, 2008; Morris *et al*., 1999). Over 750,000 ha of land were harvested to maize in Ghana in 2007 (FAO Statistical Databases, 2008). In Ghana, maize is produced predominantly by smallholder resource poor farmers under rainfed conditions. The crop is planted mainly manually using hand hoes, cutlasses or dibblers depending on local tradition (Adjei *et al*., 2003; Tweneboah, 2000) resulting in high labour requirements and drudgery. Because of the seasonality of rainfed farming, maize planting is often late resulting in considerable losses in crop yield. A need exists for improved maize planting tools that allow farmers to plant in a timely manner in order to increase yield and reduce drudgery. Early planting is one of the most basic requirements for good crop production (Hudson, 1987). Early planting benefits from the higher soil fertility present at the beginning of the rainy season. As the season progresses, nutrients leach below the root zone and are therefore no longer available for uptake. Early planting also benefit from more days of sunshine.

Maize is a major fertilizer consuming crop. Nitrogen is the most limiting essential nutrient for maize production in the humid and sub humid tropics (Sipaseuth *et al*., 2007). Application of nitrogen is essential for sustaining food, feed and fibre production (Bakhsh *et al*., 2000). Fertilizer application is one major farming operation needed to correct deficiencies in the soil in order to ensure proper growth and functioning of crops with the aim of increasing yield of the crop (Srivastava *et al*., 2006; Webster and Wilson, 1992). Proper application of inorganic fertilizers is crucial in successful modern agriculture (Srivastava *et al*., 2006). In Ghana, smallholder resource poor farmers apply fertiliser in maize using their bare hands with or without the help of cutlasses or dibblers. The problems generally associated with this method of fertilizer application include untimely and inconsistent quantity of fertilizer application, drudgery, dehydration of the palm, and palm blisters.

The jab planter appears to be a promising tool that could be used potentially for reducing the drudgery of planting maize, and applying fertilizer in Ghana. A jab planter could enable the small-scale farmer work with improved timeliness and reduced drudgery (Ukatu, 2001). It is an easy-to-operate dibble instrument used in various types of soil, including untilled soil with stubble and tilled soil with or without residues from previous crops. The jab planter comprises a seed hopper and fertilizer hopper mounted on wooden members which terminate in handles at the top and two metal 'beaks', or hole openers at the bottom. The beaks are pushed into the ground with the handles held apart. Once the implement has penetrated the soil, the handles are pushed together and this actuates the sliding seed metering mechanism in the bottom of the seed hopper. The seed falls into a delivery tube and into the hole produced by the seeder beak. The seed slide is attached to a crank on the fertilizer distributor which tips the grooved cylinder in the base of the fertilizer hopper and so delivers a measured dose of fertilizer down its delivery tube and into the fertilizer hole laterally displaced from the seed (Sims, 2003). Since hole-making and seed-dropping are done simultaneously, there is no bending or squatting. In using the jab planter, small holdings of 0.5 ha to 1 ha can be planted in a few days. It can also be used at sloping areas. The jab planter can also be used for fertilizer application.

Under a project for improving smallholder maize planting and fertilizer application, a local Ghanaian manufacturer, KADDAI Engineering Ltd. based in Kumasi, Ghana was engaged to produce 100 jab planters. The major functions of a jab planter are to open a furrow in the soil and to meter the seeds. A controlled seeding rate, such as seeds per hectare is desired when planting in order to obtain the optimum yield (Breece *et al*., 1981). Similarly, a controlled fertilizer application rate, (e.g. kg per hectare) is desired when applying fertilizer in order to obtain the optimum crop growth and yield. The objective of this study was to evaluate the performance of jab planters for maize seed and inorganic fertilizer delivery.

MATERIALS AND METHODS

Experimental location

The experiments were conducted at the Department of Agricultural Engineering, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana. Two experiments were organized. The first experiment was conducted between March and May, 2004 to evaluate the seed delivery of 30 jab planters randomly selected from a total of 68 for five local maize varieties obtained from Crops Research Institute (CRI) of the Council for Scientific and Industrial Research (CSIR), Kumasi, Ghana. Table-1 presents the properties of the varieties of maize used for the experiments. These varieties were selected because they are used by many farmers in the country. It can be seen that all the varieties have white grain colour, are of the dent texture (except for *Dodzi*) and are high yielding.

Table-1. Varieties and properties of maize used for the experiment.

Variety	**Grain colour**	**Plant texture**	**Height** (cm)	**Days to maturity**	**Average yield** (t ha^{-1})
Okomasa	White	Dent	198	120	5.5
Obaatanpa	White	Dent	175	105	4.6
Abeleehi	White	Dent	157	105	4.6
Dorke SR	White	Dent	165	95	3.8
Dodzi	White	Flint	170	80-85	2.5

Source: (Ghana Grains Development Project, 1999; Morris *et al*., 1999)

The second experiment was conducted between March and May, 2005 to evaluate the delivery of 30 jab planters randomly selected from a total of 68 for four different inorganic fertilizers including NPK 15-15-15, NPK 19-19-19, NPK 20-20-20 and Ammonium Sulphate. The fertilizers were purchased from the local agro-chemical market in Kumasi, Ghana and were so selected because they are the popular types of fertilizer used by farmers for maize production.

Experimental design and statistical analyses

The experiments were arranged in a completely randomized design. For each of the 30 jab planters, there were 10 replications (jabs) for each of the five maize varieties to determine the number of seeds delivered. Similarly, for each of the 30 jab planters, there were 10 replications for each of the four different compound fertilizers to determine the mass of fertilizer delivered. The mass of the fertilizer delivered was found using a Sartorius L 2200 S electronic balance made in Germany.

Analysis of variance (ANOVA) was conducted on maize seed and fertilizer delivery for the 30 jab planters using the MINITAB statistical software Release 13.1 (MINITAB Inc., 2000). A significance level of 0.05 was used for all analyses. When the analysis resulted in a significant treatment effect, the means were compared using the least significant difference test.

Wijewardene and Waidyanatha (1984) indicated that in some parts of the world, maize is planted at one seed per hole. In Ghana, the agronomic recommendation for planting maize is 2-3 seeds of good viability per hill (Tweneboah, 2000). Furthermore, the recommended application rates for the following fertilizers in maize in Ghana are: NPK 15-15-15 fertilizer at 250 kg ha^{-1}, NPK 19-19-19 fertilizer at 197 kg ha^{-1}, NPK 20-20-20 fertilizer at 187 kg ha^{-1}, and Ammonium Sulphate fertilizer at 125 kg ha^{-1}.

The study involved testing the following hypotheses: the delivery of the jab planters is two seeds per hill for each of the five maize varieties; the delivery of the jab planters is three seeds per hill for each of the five maize varieties; the delivery rate of the jab planters is 250 kg ha^{-1} of NPK 15-15-15 fertilizer; the delivery of the jab planters is 197 kg ha^{-1} of NPK 19-19-19 fertilizer; the delivery of the jab planters is 187 kg ha^{-1} of NPK 20-20-20 fertilizer, and the delivery of the jab planters is 125 kg ha^{-1} of Ammonium Sulphate fertilizer. The hypotheses were tested using a two-sided Z-test at a level of significance of 0.05, where a true null hypothesis is incorrectly rejected.

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RESULTS AND DISCUSSIONS

Seed delivery of jab planters

Figure-1 illustrates the percentage seed delivery of the jab planters for the five different maize varieties used in the first experiment. Analysis of variance indicated statistical significant differences in the seed delivery of the 30 jab planters for all maize varieties used. In the case of planting two seeds per hill, the results showed that the jab planters consistently significantly delivered less than or greater than two seeds at least 53.3% of the time for all five maize varieties.

In the case of planting three seeds per hill, the results show that the jab planters consistently significantly delivered less than or greater than three seeds at least 70% of the time for all five maize varieties. The results show poor seed metering of the jab planters. This means that there was no control of quality in the manufacture of the seed delivery unit of the jab planters. Seeding maize at rates below the optimum increases the risk of not attaining the maximum yield potential for a given environment. On the other hand, seeding maize at populations above the optimal increases the risk of encountering stress at critical growth stages and suffering yield reductions (Haag, 2008). Seeding maize at populations above the optimal would lead to competition for water, mineral nutrients, space, and sunlight. Additionally, planting excess seed and thinning have become prohibitive for economic and social reasons (Smith *et al.*, 2002).

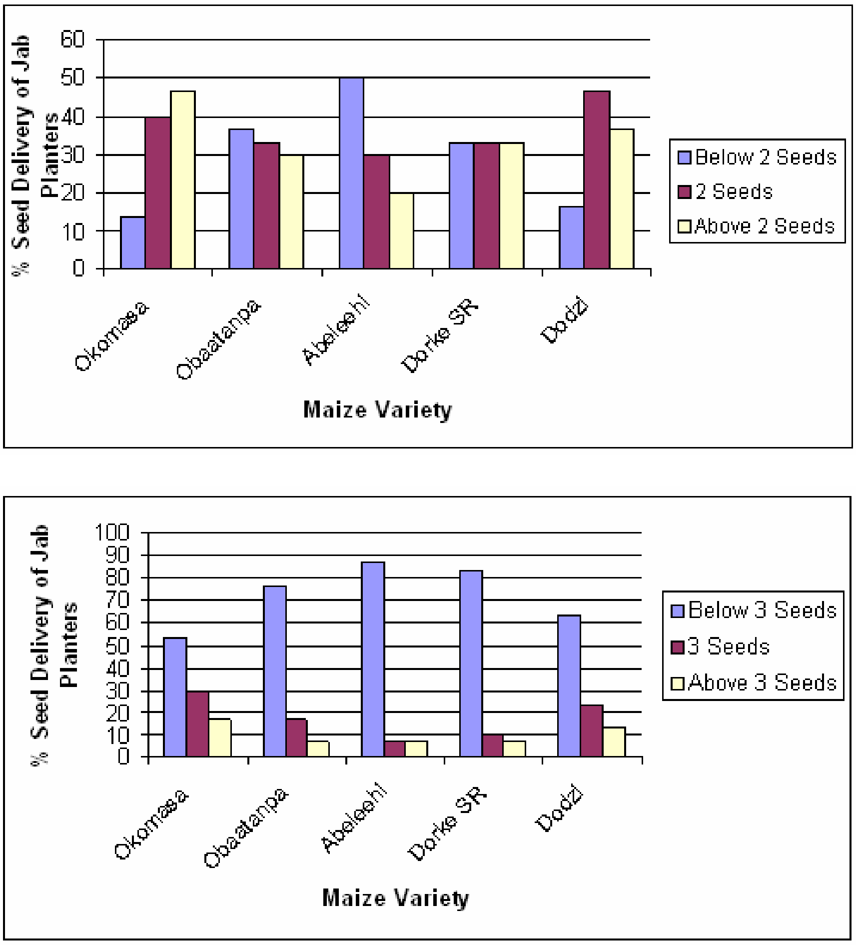

Figure-1. Percentage maize seed delivery of jab planters for five maize varieties.

Table-2 presents the mean and range of seed delivery of the jab planters for the five different local maize varieties. It can be seen that there was high variability in the seed delivery of the jab planters for each maize variety considering the agronomic requirement of two or three seeds per hill.

Table-2. Maize seed delivery for 30 jab planters.

Maize variety	Mean seed delivery rate	Range of seed delivery
Okomasa	2.61	1-11
Obaatanpa	2.04	1-5
Abeleehi	1.95	1-6
Dorke SR	2.10	1 – 6
Dodzi	2.49	1 – 7

Inorganic fertilizer delivery of jab planters

NPK 15-15-15 fertilizer delivery rate of jab planters

Table-3 presents the summary of the delivery rates of the 30 jab planters for the NPK 15-15-15 fertilizer. There were statistical significant differences in the delivery rate of the 30 jab planters. The delivery rate of 36.7% (11) of the jab planters was statistically significantly less than the recommended application rate of 250 kg ha^{-1} while that of 43.3% (13) of the jab planters was significantly greater than the recommended application rate. Only 20% (6) of the jab planters presented delivery rates statistically similar to the recommended application rate of 250 kg ha^{-1}. This means there was no control of quality in the manufacture of the metering unit of the jab planters. Where the fertilizer delivery rate of the jab planter is below the recommended rate, there is negative implication on the growth and development of the crop as well as potential crop yield loss. On the other hand, excess fertilizer application would cause too much vegetative growth, delay crop maturity, result in lodging, and reduce grain yield. In addition, excess fertilizer application can cause fertilizer movement into sources of drinking water (EPA, 2001). Invariably, excess fertilizer application would cause financial loss to the farmer.

Table-3. Delivery rate for the NPK 15-15-15 fertiliser.

Number of jab planters	Mean fertilizer delivery rate (kg ha^{-1})	Range of fertilizer delivery rate (kg ha^{-1})
11	169	67-230
6	257	233-265
13	315	279-410

NPK 19-19-19 fertilizer delivery rate of jab planters

The delivery rates of the 30 jab planters for the NPK 19-19-19 fertilizer is presented in Table-4. As can be seen, the delivery rate of 90% (27) of the jab planters was statistically significantly lower than the recommended application rate of 197 kg ha^{-1} while that of 3.3% (1) of the jab planters was above the recommended delivery rate. Only 6.7% (2) of the jab planters gave delivery rates statistically similar to that of the recommended application rate.

Table-4. Delivery rate for the NPK 19-19-19 fertilizer.

Number of jab planters	Mean fertilizer delivery rate (kg ha^{-1})	Range of fertilizer delivery rate (kg ha^{-1})
27	132	109-161
2	195	188-202
1	226	226

NPK 20-20-20 fertilizer delivery rate of jab planters

The summary of the delivery rates of the 30 jab planters for the NPK 20-20-20 fertilizer is given in Table-5. The delivery rate of 6.6% (2) of the jab planters was significantly lower compared with the recommended fertilizer application rate of 187 kg ha^{-1} while that of 66.7% (20) was greater. Only 26.7% (8) of the jab planters presented delivery rates statistically similar to the recommended application rate. This indicates that there was no control of quality in the manufacture of the metering unit of the jab planters.

Table-5. Delivery rate for the NPK 20-20-20 fertilizer.

Number of jab planters	Mean fertilizer delivery rate (kg ha^{-1})	Range of fertilizer delivery rate (kg ha^{-1})
2	146	140-153
8	186	165-207
20	282	217-476

Ammonium sulphate fertilizer delivery rate of jab planters

Table-6 presents the summary of the delivery rates of the 30 jab planters for the ammonium sulphate fertilizer. The delivery rate of all the jab planters was statistically significantly greater than the recommended application rate of 125 kg ha^{-1}. None of jab planters presented delivery rate similar to the recommended application rate.

Table-6. Delivery rate for the ammonium sulphate fertilizer.

Number of jab planters	Mean fertilizer delivery rate (kg ha^{-1})	Range of fertilizer delivery rate (kg ha^{-1})
30	319	214-477

CONCLUSIONS

The objective of the study was to evaluate the performance of jab planters manufactured by a local Ghanaian manufacturer for maize seed and inorganic fertilizer delivery. Based on the results obtained, it can be concluded that there was statistical significant difference in the seed and fertilizer delivery rate of the jab planters. This means that there was no control of quality in the manufacture of the metering unit of the jab planters for seed and fertilizer delivery. Seeding maize at rates below the optimum increases the risk of not attaining the maximum yield potential for a given environment while seeding maize at populations above the optimal increases the risk of encountering stress at critical growth stages and suffering yield reductions. Furthermore, planting excess seed and thinning is prohibitive for economic and social reasons. Furthermore, applying fertilizer below the recommended rate would result in yield loss while excess fertilizer application would cause too much vegetative growth, delay crop maturity, result in lodging, and reduce grain yield. Additionally, excess fertilizer application can cause fertilizer movement into sources of drinking water. The study draws attention to the need to consider quality control in the manufacturing of the metering unit of planters and fertilizer application equipment.

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