

RESEARCH PAPER
**EFFECT OF SOME AGRONOMIC PRACTICES TO
INCREASE MAIZE YIELD IN GHANA**

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ABSTRACT

Low plant densities of maize are often observed in fields of farmers practising no-till agriculture which causes low grain yield in Ghana. With the increasing population and consumption of maize in the country, research must be directed to solve this problem to enhance maize production. In this paper, a 2x3 factorial experiment in randomized complete block design with 4 replications was carried out at Wioso in the Atwima-Nwabiagya District in the Ashanti Region of Ghana during the major season of 2007 in order to come out with the best practices in maize production. The objectives of the study were to determine the right period of refilling maize field and the comparative effect of refilling with seed and seedling on the growth, optimum population density, and yield of maize. The factors were material for refill, which was either seeds or seedlings, and time of refilling either at 5, 10, and 15 days after planting. The results showed that refilling with seedlings produced the greatest positive effect in the number of leaves per plant, leaf length, leaf diameter, plant height and stem girth. Furthermore, refilling with seedlings contributed more to the optimum plant population density. Total grain yield when seedlings were used as refill was 967kg per hectare more than when seeds were used as refill material. On the other hand, plants from seeds refill were weak, lodged more and allowed much solar radiation penetration to the ground. Grain yield from seed refill plants was 6%, whilst seedling refill plants contributed 34% to the total grain yield. Refilling at 5 days after planting induced greater growth than 10 or 15 days after planting. The results indicate that it is possible to do refilling in maize field by using seedling as this contributes more than the traditional method of using seeds.

Keywords: grain yield, refill material, sun fleck, time of refilling

INTRODUCTION

Maize is considered to be the most important cereal in Ghana accounting for 74% of the total cereals (maize, rice, sorghum and millet) produced in 2005 (MOFA, 2005). The total area under maize cultivation in 2005 was about

740,000 ha and production was estimated as 1, 171,000 metric tons (MOFA, 2006). The ever-increasing human population together with practices such as slash and burn, and the recent proliferation of surface mining has endangered shifting cultivation as practiced in the past by

most farmers, as a means of conserving the soil and maintaining productivity (Ekboir *et al.*, 2002). Due to the above reasons, farmers continue to grow maize on the same piece of land season after season, in addition to practicing the slash and burn method that had contributed to the increasing land degradation. There is therefore the need to provide safe interventions for farmers to produce sustainably.

The use of no-till technology conserves moisture by reducing evaporation and runoff, increases infiltration of water and decreases soil temperature fluctuations. It also supplies nutrients and organic matter from decomposing mulch and improve soil faunal activity (Goddard *et al.*, 2008). Boahen *et al.* (2007) stated that the no-till concept is for resource-saving agricultural production that strives to achieve an acceptable profit together with high and sustained production levels while concurrently conserving the environment. Bonsu (2001) stated that residues left on the field during no-till serve as mulch which protects the soil from soil erosion and limit weed growth throughout the growing season.

Farmers traditionally attempt to replace the ungerminated maize by re-seeding at the same spot or hill of dead plant(s). However, these late germinated plants suffer a number of unfavorable growth conditions (Asiedu *et al.*, 2001; Van Gassel *et al.*, 1996). Attempts by some individuals and institutions to improve plant population density in No-till fields have been done using date of planting, refilling with seed maize, planting depth, insecticide and fungicide treatment, firming planting spot and planting through mulch. These were developed to protect planting spot from the rodents, yet farmers continue to encounter loss of plant stands in their maize fields including through destruction of seeds by rodents and seed borne pathogens.

The objectives of this study were to determine comparative effect of refilling with seed and seedling as well as time of refilling on the growth, optimum population density, and grain

yield of maize.

MATERIALS AND METHODS

The experiment was conducted at Nkawie-Wioso in the Atwima Nwabiagya District of Ashanti Region. General soil characteristics in the study area vary from well drained with high organic matter content to poor drained with low organic matter content. The soil is a well drained loamy soil of density ranging from 1.38-1.6 and porosity from 0.39-0.48. The annual precipitation ranges between 1400mm and 1800mm (Atwima Nwabiagya District Assembly 1996).

Land preparation

The experiment was 2x3 factorial with treatments arranged in a randomized complete block design. Refilling materials were seeds and seedlings and time of refilling at 5, 10 and 15 days after initial planting. A post germination herbicide (Glyphosate) was used to spray the weeds, with the use of knapsack sprayer fitted with a low volume nozzle at the rate of 300 ml per 15 litres of water. The plant residues were left on the soil surface without burning for 7 days before planting.

Planting

The experimental plot was planted on 28th April, 2007 at the spacing of 80cm x 40cm with 2 seeds per hill; seeds were planted directly through the mulch. Maize seed was protected from predators by using seed plus (Imidacloprid 20%, *Metalaxyl* 20% and *Anthraquinone* 4%) for seed treatment at the rate of 10g active ingredient per 1kg seed. Each plot had 6 rows with 12 hills, giving a total of 144 plants per plot.

Five days after planting 25% losses of the germinated plants were deliberately created through randomly uprooting 36 plants out of 144 plants. A plot in each replication was refilled with seed and another plot with seedlings. The seeds for seedlings to be used were planted the same day as the experimental plot to enable the use of seedlings of the same age to mini-

mize competition among growing plants. Seedlings were planted with a ball-of-earth at the base, a condition meant to reduce stress at transplanting. The refilling process using maize seeds and seedlings were repeated at 10 days (8th May) and 15 days (13th May) after initial planting of the experiment.

According to GGDP (1998) maize can tolerate moisture stress better during the early period of plant growth than later growth. Thus 15 days period for refilling particularly with maize seedling, was chosen for this experiment.

Starter fertilizer (NPK) 125 kg/ha was applied at planting and Urea fertilizer was also applied 4 weeks after planting at 62.5 kg/ha. Pre-emergence herbicide (Atrazine WP) was applied on the second day after planting. Hand picking of secondary weeds mostly *Panicum maximum* was done 7 days after planting.

Data collection and analyses

Parameters measured were number of leaves per plant, leaf length, leaf width, Sun fleck using ceptometer, plant height, stem girth, and refilled plants establishment; these were measured at tasseling. Others were plants population, grain yield and percentage contribution of grain yield from refilled plants, all of which were measured at harvesting. The data was analyzed using the Analysis of Variance technique and the MSTATC statistical package. The least significant difference at 5% probability was used to determine treatment differences.

RESULTS AND DISCUSSIONS

Number, length and width of leaves

Table 1 shows the effect of refilled material and refilling on the number of leaves, leaf length and leaf width of the maize plants. The results showed that refilling with seedlings produced the greater number of leaves per plant (12.58), which was significantly higher than that produced with seeds as refill material. Time of refilling significantly affected ($P < 0.05$) leaf production. Refilling at 5 days after planting resulted in plants producing the largest number

of leaves, which was significantly higher than when refilling was done at 10 and 15 days. Plants refilled at 10 days also produced significantly greater number of leaves than when refilling was done at 15 DAP.

Refilling with seedlings produced significantly ($P < 0.05$) longer leaf (94.0cm) than when seed were used to do refill (Table 1). Time of refill also significantly ($P < 0.05$) affected maize leaf length with the treatment effect of refilling at 5 days being significantly higher than all other treatment means. However, treatment effects between refilling at 10 and 15 DAP showed no statistical differences.

Leaf width was greatest (9.52cm) when refilling was done using seedlings, and this effect was significantly higher than using seeds (Table 1). Leaf width of plants was also significantly affected by time of refilling. Refilling at 5 DAP produced greater effect than all other treatments, whilst refilling at 10 DAP also produced significantly higher leaf width than for the 15 DAP.

Sun fleck, plant height and stem girth

Table 2 shows the effect of refilled material and refilling time on sun fleck, plant height and stem girth of the maize plants. Results of material used on sun flecks (potential of allowing sunlight to pass through canopy) showed that using seeds as refill material led to significant loss of solar radiation than using seedlings. Indeed, 40% of sunlight that could have been used by the plants was lost. Time of refilling did not, however, significantly affect ($P > 0.05$) sun fleck measurement.

Mean height of plants when seedlings were used as refill material was significantly higher ($P < 0.05$) than when seeds were used as refill material. Time of refill significantly affected maize plant height. The tallest plants (151.0cm) were measured following refilling at 5 DAP, which statistically was similar to that at 10 DAP treatment effect, but either effect was significantly higher ($P < 0.05$) than that of refill-

Table 1: Effect of refilled material and refilling time on number of leaves, leaf length and leaf diameter of maize plants.

Treatment	Leaf Number Plant ⁻¹	Leaf Length (cm)	Leaf Width (cm)
Refill material			
Seed	9.67	78.6	6.83
Seedling	12.58	94.0	9.29
LSD (5%)	0.67	7.36	0.69
Time of Refilling			
5 days	12.25	94.1	9.52
10 days	11.12	84.2	7.93
15 days	10.00	80.6	6.73
LSD (5%)	0.85	9.0	0.85
CV (%)	7.0	9.8	9.90

Table 2: Effect of refilled material and refilling time on Sun flecks, plant height and stem girth of maize plants.

Treatment	Sun fleck	Plant Height (cm)	Stem Girth (cm)
Refill material			
Seed	12.47	95.2	1.41
Seedling	7.01	154.6	2.00
LSD (5%)	3.79	14.5	0.2
Time of Refilling			
5 days	8.56	151.0	1.98
10 days	10.11	146.0	1.66
15 days	10.54	109.1	1.48
LSD (5%)	NS	17.8	0.25
CV (%)	44.8	13.4	14.1

ing at 15 DAP.

Girth of plants from seedlings refill was significantly higher ($P < 0.05$) than that from seeds. Stem girth was also significantly affected by time of refilling with the treatment effect of refill at 5 DAP being significantly higher than all other treatment effects. Treatment differences between refilling at 10 and 15 DAP were, however, not significant.

Plant establishment, lodging and plant population

Table 3 shows the effect of refilled material and refilled time on plant establishment, lodging and plant population of the maize plants. Refilled plant established with seedling was significantly higher than using seeds. Difference was about 30% greater than when refilling was done with seeds. Time of refilling did not significantly ($P > 0.05$) affect plant establishment.

Table 3: Effect of refilled material and refilling time on plant establishment, lodging and plant population of maize plants

Treatment	Plants established (ha ⁻¹)	Plants lodged (ha ⁻¹)	Plant population (ha ⁻¹)
Refill material			
Seed	10938	294	53438
Seedling	14354	132	58229
LSD (5%)	1715.1	0.02	2355
Time of Refilling			
5 days	13375	190	57812
10 days	13125	204	53906
15 days	11438	196	55781
LSD (5%)	NS	0.03	NS
CV (%)	15.6	12,0	4.8

Plant lodging was significantly higher when seeds were used to do refilling. Time of refill also significantly affected plants lodging. The greatest effect was recorded when refilling was done at 10 DAP, and this was significantly higher than all other treatment effects. Lodging was also significantly greater at refilling at 15 DAP than at 5 DAP.

Refilling with seedlings resulted in a significantly higher plants population (58229.0 plants/ha) than using seeds (53438.0 plants/ha). Time of refilling did not significantly affect plant population, although the greatest effect 57812.0 plants/ha, was recorded when refilling was done at 5 DAP.

Grain yield

Table 4 shows the effect of refilled material and time of refilling on total grain yield of the maize plants. Total grain yield difference between refill with seedling and seed was significant, and this was about 30% or nearly 1t/ha. However, time of refilling did not significantly affect maize grain yield.

Both material and time of refilling did not significantly affect ($P>0.05$) grain yield from refilled plants, but while 34% of the grain was produced from refilling with seedlings, only 6% was contributed when refilling was done with seeds.

DISCUSSION

Effect of refilling material on maize growth

The response of maize growth to the type of refilling material, either with seed or with seedlings showed that in the majority of the parameters measured, refilling with seedlings gave a significantly greater response than using seeds as the refilling material. Results showed that the number of leaves from plants refilled with seedlings was 30% greater than when seeds were used as refilling material (Table 1). In addition, leaf length of plants from seedling refill was 20% greater than when refilling was done with seeds. Furthermore, leaf diameter from seedling refill was about 30% greater than using seeds as refilled material. The ability to support greater leaf production is an indication that if growth resources are available through-

Table 4: Effect of refilled material and time of refilling on total grain yield and grain yield from refilled material

Treatment	Total Grain Yield (kg/ha)	Grain Yield from refilled material (%)
Refilled material		
Seed	7,469	6.6
Seedling	8,436	34.3
LSD (5%)	712	NS
Time of Refilling		
5 days	7,820	16.4
10 days	8,037	36.5
15 days	8,001	8.5
LSD (5%)	NS	NS
CV (%)	10.3	86.9

out the growing season, growth and yield would be enhanced. This is because photosynthesis in such plants would be greater (Gardner *et al.*, 1985; Agyei-Wiredu, 1996; Hopkins, 1993).

Penetration of light through the plants, as measured by sun fleck (Table 2) was greater in plants from refilling with seeds than those from seedling. This is not surprising since plants from seed refill were smaller with less leaf area or source capacity than those from seedlings used as refill. In crop production, this is a set back, as much solar energy would be lost in such conditions, and consequently grain yield would be reduced (Gardner *et al.*, 1985; Hopkins, 1999).

Plant height and stem girth of plants from seedling refill were 62% and 43% greater than those from seed refill, respectively. Taller plants can compete well with weeds and other crops for solar radiation. In the peasant farming system, where mixed cropping is the most common crop production system, this would be an advantage for higher maize production. Normally, in such a system, several crops are grown and maize is harvested early to offset

any hunger, pending the maturity of the other crops, especially plantain and the root and tuber crops.

The greater stem girth of plants from seedling refill (Table 2) presumably reduced plant lodging (Table 3). Lodging was greater, indeed more than 100%, in plants using seeds as refilling than using seedlings. Despite the taller plants produced from the latter treatment (Table 2), lodging was still lower. The importance of reduced lodging in maize yields cannot be over-emphasized. Lodging reduced plants ability to absorb solar radiation and photosynthates production and results in lower grain yield. Furthermore, greater lodging means carrying out farming operations as weed and pest control and fertilizer application can be dangerous and expensive (Boa-Amponsem, 2000).

Plant survival was also significantly affected by refilling materials (Tables 3). Refilling with seedlings contributed more than 40% to the total plant population compared with when refilling was done with seeds. In crop yield, the contribution of each individual plant counts. Thus, without much effort and probably at no extra cost, if doing refilling in maize product-

ion with seedlings can be so advantageous, adopting it would increase farmers' yield.

Effect of refilling material on maize yield

Total maize grain yield was significantly affected by the refill materials (Table 4). Using seedlings as refill material supported significantly greater ($P < 0.05$) grain yield than using seed. Indeed grain production in the former treatment was almost 1000kg greater than in the latter treatment per hectare. Furthermore, seedlings used to refill contributed more than 34% to the total grain yield.

Statistic on maize cultivation in Ghana indicated that total land area sown to maize in 2005 was 740 000 ha. The estimated yield for that year was 1,710,000 metric tons (SRID, MOFA, 2005). The present result showed that if farmers would use seedlings to do refilling instead of seed, which is the current practice, yield per hectare would increase by about 1000 kg ha⁻¹.

Effect of time refilling on maize growth and yield

Maize growth and yield were affected by the time when refilling was done whether with seedlings or seeds. In all the growth parameters measured, result indicated that, doing refilling at 5 days after planting showed the greatest response. In a similar pattern, better responses were recorded in doing refilling at 10 days rather than at 15 days after planting. Indeed, delay in refilling resulted in weak plants, reduced leaf length, diameter and stem girth. Delayed refilling resulted in overshadowing by established plants, as a result sun fleck measurements were higher and such plants recorded greater rates of lodging. Grain yield results were, however, not consistent with the growth measurement.

The general practice of peasant farmers had been to refill with seeds following planting of their crop. Commonly, plants from such refill are weak and become less competitive with established plants and weeds. Many times yield recorded by such plants is uneconomical, and at

times no grains are produced from such plants. The present study has demonstrated that refilling in maize production can be achieved by using seedlings, and that such plants are vigorous, grow better, lodge less and ultimately would produce acceptable economic yield rather than doing refilling with seeds.

CONCLUSION

Results showed that it is possible to use maize seedlings to fill vacancies created in maize farms from failure of germination or destruction of seedlings by pests. This practice appears more profitable than the traditional method of using seeds, as plants from such practice competed well with established plants and contributed significantly to total grain yield. The results also showed that refilled plants demonstrated greater growth when refilling was done at 5 days after planting.

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