EFFECT OF MATERIAL AND TIME OF REFILLING ON THE GROWTH, PLANT POPULATION AND GRAIN YIELD OF MAIZE UNDER NO-TILLAGE SYSTEM

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BY

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CERTIFICATION

I hereby declare that this project was undertaken by me, and the work submitted as dissertation is the result of my own work under the supervision of Dr J Sarkodie - Addo. The work has not been presented elsewhere for any degree.

……………………………………..   ……………………….

Dr. J Sarkodie-Addo   Patrick Akowuah

(Supervisor)   (Student)

Date ……………………………   ……………………………………..

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DEDICATION

This work is dedicated to my loving wife Faustina Appiah and Children for their moral, spiritual and material support during the research.

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ACKNOWLEDGEMENT

I am most grateful to my supervisor Dr. J Sarkodie-Addo who on several occasions has to attend to me despite his busy schedule until completion of the work.

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I also render my sincere thanks and appreciation to all those who have contributed in various ways to have this work fully completed.

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ABSTRACT

Low plant densities of maize are often observed on maize fields, especially in no-till farmers' field and this may be partly due to low seeding rate or poor seedling emergence.

A 2x3 factorial experiment in randomized complete block design with 4 replications was carried out at Wioso in the Atwima Nwabiagya district during the major season of 2007.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 effect in the number of leaves per plant, leaf length, leaf diameter, and 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 more per hectare 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. Refilled at 5 days after planting induced greater growth than 10 or 15 days after planting, however, this could not be translated into grain yield.

The results indicate that it is possible to do refilling in maize field by using seedling and this contributes more than the traditional method of using seeds.

CHAPTER ONE

1.0 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 at 1,171,000 metric tons (MOFA, 2006). Due to the importance and varied uses, there is a high demand for the crop in the country. It is therefore necessary to research into the production practice that directly or indirectly affects the field establishment, growth, and yield of the crop.

The ever-increasing human populations together with other factors such as slash and burn land preparation, and the recent proliferation of surface mining have 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).

Ghanas population is about 20 million with growth rate of 2.7% per annum (MOFA, 2005), and this has led to severe pressures on the arable lands. As a result most farmers continue to grow maize on the same piece of land season after season. The slash and burn agriculture under the present condition has contributed to the increasing land degradation, thus de-emphasizing the shifting cultivation that contributed to sustainable food crop production in Ghana. Maize yield continue to decline from five tons per hectare to one ton per hectare (MOFA, 2005).

The need for an alternate farming practice evoked no-till farming, which used to be popular decades ago, particularly for cocoa plantations. No-Tillage has gained increasing interest in Ghana (Ekboir *et al*, 2002). Its approach to farming is very attractive particularly to most maize producers. Large number of farmers is practicing no- tillage either knowingly and or unknowingly, by planting through stubble mulched fields.

Maize production under no-tillage systems aims to produce high crop yields while reducing production costs, maintaining soil fertility and conserving water and biodiversity. No- tillage is a way to achieve sustainable agriculture and improve livelihoods. The use of no-till technology conserves moisture by reducing evaporation and runoff, increase infiltration of water and decrease soil temperature fluctuations. It also supply nutrients and organic matter from decomposing mulch and improved soil faunal activity (Goddard *et al*, 2008).

Low plant establishment has been observed by farmers, especially farmers using no till technology in Ghana as very important agronomic constraint to maize production (GGDP, 1998). During Ministry of Food Agriculture's Strategic planning for 2007, a review of the major field problems lowering yield of maize from extension demonstration plots revealed low plant stand as a major problem in maize production. Low plant population contributes to increase in seed size (Asiedu, *et al* 2001), but most often do not increase yield.

A number of attempts to improve plant population density in No- till fields have been by some individuals and institutions using date of planting, refilling with seed maize, planting depth, insecticide and fungicide treatment, firming planting spot and planting through mulch were developed to hide planting spot from the rodents. Farmers continue to encounter loss of plant stands in their maize fields either through picking of seed by rodents' and by seed borne diseases attack.

Farmers traditionally attempt to replace the lost maize plant 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.

The use of planting date (either planted very early or very late than other farmers in the neighborhoods) by seed growers is very crucial to avoid cross -pollination from non pure lines of other neighbors field, but the practice in most cases leads to heavy loss of seeds due to pest (rodents, insects, frogs etc) attack. Farmers attempt to remedy the situation by refilling with seed does not help since the refilled seeds are even more prone to attack. Few farmers use to do refilling with seedling during thinning of their maize farm. This latter practice was the bases of the study.

The objectives of this study were;

1. To determine comparative effect of refilling with seed and seedling on the growth, optimum population density, and grain yield of maize
2. To determine the right period of refilling maize field

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Description of Maize plant

The maize plant has an erect, solid stem, rather than the hollow one of most other grasses. It varies widely in height, some dwarf varieties being little more than 60 cm tall at maturity, whereas other types may reach heights of 6 m or more, the average height is 2.4m, the leaves which grow alternately, are long and narrow. The main stalk terminates in a staminate (male) inflorescence, or tassel. The tassel is made up of many small flowers termed spikelets, and each spikelet bears three small anthers, which produce the pollen grains, or male gametes. The pistillate (female) inflorescence, or ear, is a unique structure with up to 1,000 seeds borne on a hard core called the cob. The ear is enclosed in modified leaves called husks. The individual silk fibers that protrude from the tip of the ear are the elongated styles, each attached to an individual ovary. Pollen from the tassels is carried by the wind and falls on to the silk, where it germinates and grows down through the silk until it reaches the ovary. Each fertilized ovary grows and develops into a kernel.

2.2 Trend of No-Tillage in Ghana

No-tillage is a farming practice that requires planting directly in the sod (plant residues) with the least soil disturbance necessary for proper seed placement, germination and successful crop establishment

No-tillage is a concept for resource –saving agricultural crop production that strives to achieve an acceptable profit together with high and sustained production levels while concurrently conserving the environment (Boahen *et al*, 2007)

In the 1990s, no-till with mulch a sustainable agricultural alternative was introduced to Ghanaian famrers through a joint programme between the Crops Research Institute (CRI) in Kumasi, Ghana, Sasakawa Global 2000 (SG2000) and the Monsanto Company (Ekboir *et al*, 2002).

The earliest research on no-till started in the late 1960 and was boosted by Mensa Bonsu (Ofori, 1973). In 1993, SG 2000, Monsanto and CRI in Kumasi and the Extension Services of the Ministry of Food and Agriculture (MOFA) teamed up to promote no-tillage in the transitional and forest zones of Ghana (Ekboir *et al*, 2002).

Maize production under no-tillage farming has gained increasing interest in Ghana. The number of farmers practicing no-tillage rose from 10,000 in 1996 to 350,000 in 2002 (IIRR, 2005).

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2.3 Influence of no-tillage on maize production

No- tillage aims to produce high crop yields while reducing production costs, maintaining the soil fertility and conserving water. It is a way to achieve sustainable agriculture and improve livelihoods (IIRR, 2005).

Crop residues are left on the field, serve as mulch which protects the soil from erosion and limit weed growth throughout the growing season. The soil cover protects the soil against the impact of rain drop, prevent the loss of water from the soil through evaporation, and also protect the soil from the heating effect of the sun (Bonsu, M, 2001)

The presence of mulch in the maize field smothered weeds, freeing the farmers of backbreaking task of weeding the field. No- tillage prevents hardpans from forming, protects the soil, increases soil moisture, and restores soil fertility, so stabilizing yields and improving production over the long term (IIRR, 2005).

2.4 Causes of low plant density

Plant density (plants per unit of ground area) reveals much about how crops achieve yields. Low plant population density contributes to increase in seed size (Asiedu,*et al* 2001), but most often does not increase yield.

Pest and Diseases;

Most crops are subjected to attack by variety of pest such as viruses, bacteria, fungi, insects, and weeds. Any part of the plant can be subjected to the diseases at any stage: seed, seedling or the growing plant. (Asiedu *et al*, 2001).

Soil Condition;

Germination is the thread of life that assures survival of all plant species. The initial germination requires that the embryo must be alive and capable of germination. The soil condition must be favorable such as availability of moisture, oxygen and adequate soil temperature (GGDP, 1998). Additionally, too much soil cover (residues) impedes the germination and establishment of seed maize.

Sowing dates;

Sowing dates depend mainly on temperature and soil moisture availability. The earliest possible sowing date is usually recommended, however this is associated with lower percentage of plant emergence (Van Gastel *et al*, 1996).

Plant spacing

The appropriate seed rate ensures the optimum plant population density, Poor plant spacing leads to low plant population and usually affects optimum yield (Van Gastel *et al*, 1996). The irregularity of plant distribution which is associated with poor establishment can also depress yield (Harper, 1983).

Presence of Biomass;

In no-tillage maize fields, the presence of biomass on the soil surface harbors most of these organisms and in their attempt to feed from the environment take in the planted seeds or destroy the seedlings in the process. Birds, rats and mice can be very destructive to both seed and seedling

2.5 Plant population density, canopy development and yield

Modern maize varieties do not tiller much, even at low plant densities. They usually produce only one ear per plant. Therefore maize grain yield is much more sensitive to plant density than in sorghum because both the Leaf Area Index (LAI) and the number of ears per acre increase or decrease with density (Gardner *et al*, 1985).

Total dry matter yield is a result of crop canopy efficiency in intercepting and utilizing the solar radiation available during the growing season. The primary plant organs intercepting solar radiation are the leaves. For maximum crop growth rates, enough leaves must be present in the canopy to intercept most of the solar radiation incident on the crop canopy.

All yield factors depend on available food energy to produce yield. If yield is to be increased photosynthesis must be increased. Yield may be increased most effectively if the reasons for each crop production practice are considered in terms of how they affect photosynthesis (Gurevitch *et al*, 2002).

2.6 Plant responses to stand density changes

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Plant density in particular, with its attendant effect on crop competition has been used to influence yield over the years. In maize, adequate planting rates are necessary to give optimum stand at harvest (Asafu-Agyei, 1990).

Grain yield in maize normally increases to a maximum with density and then declines beyond optimum. Maize plant density required for maximum yield in Ghana has been established to be 62 500/ha, that is 80cm by 40cm two seed per hill or 80cm by 20cm single seed per hill (GGDP, 1998).

Donald (1961) presented an explanation of plants responses to stand density changes. He suggested that the greater seed weight and number of seeds per inflorescence at intermediate densities are due to the timing of interplant (between plants) and intra-plant (within a plant) competition. At the widest spacing (lowest plant density), both types of competition are absent during early stages of growth

The major factor determining the distance between plants is plant density; the same factors that affect optimum plant density influences optimum row spacing. Crop plants with high leaf area per plant densities (e.g., maize) respond less to reductions in row spacing than do smaller crop plants grown at higher plant densities (Donald, 1961).

2.7 Timeliness of planting

Boa- Amponsem (2000) reported that, planting maize two weeks earlier or later, relative to the optimum planting date led to 40-55 percent losses in crop yield.

The rate of yield decline is very rapid in delayed planting, and the difference between the yield of the earliest and latest sown crop is approximately 20 percent reduction.

The date of planting can be established for each crop, delays in planting usually result in yield penalty, speed of operation is important in primary and secondary tillage. Farmers must start planting as early as an adequate and healthy stands can be established (Boa- Amponsem, 2000).
The decision on when to sow or plant a crop is an important one. The definition of the precise optimum sowing date is not always of great practical use. Nevertheless, it is important to know the best time to sow various crops so that work programmes can be organized accordingly and high yields achieved.
The primary consideration in the choice of sowing date is its effects on the yields of the production (Findaly and Hutchinson, 1999).

2.8 Plant age and weed competition

Most small-scale farmers in Ghana are unable to clear farm weeds early enough. They often assume that removing the weeds anytime during the growing season will benefit the crop equally well, and as a result weeds compete with crops for light needed for photosynthesis by shading the young crop seedlings. This situation is more serious in the case of seedlings from late planted seeds, which appear to be relatively younger than the earlier ones planted. The crop seedlings thus become weak and sometimes, wither away under the mat of weeds, hence re-sowing of the weedy fields becomes necessary (Gupta, 1998).

It has been established that maximum benefit of compound fertilizer especially the P and K that are relatively immobile, are derived when applied at planting or at very early stage of the crop growth (GGDP, 1998), however most farmers are reluctant to comply with the recommended application schedule for fear of wasting their fertilizer in the case of seedling loss or damage by pest.
Weeds that germinate either before, or at the same time as the crop, offer serious competition to the crop plant since they get the opportunity to establish and accumulate dry matter faster than the crop plants (Gupta, 1998).

In maize for example, it has been found that during the first 2-3 weeks of emergence, weeds put forth 15 –18% of their growth, while the maize crop plants attained 2-3% of it (Gupta, 1998).

Effective no-tillage land preparation usually postpones any meaningful competition from weeds until about 25-30 days later. Hence the choice of no-tillage method for land preparation in this research is one of the opportunities among others to enhance seedling vigor.

2.9 Impact of no-till on the environment

Rainwater infiltration decreased from 200 mn/h under conventional tillage to 45 mn/h under no-tillage, leaching of plant nutrient into the aquifer is reduced compared to conventional arable agriculture (Goddard, *et al*,2008).

The greater production of biomass in no-tillage leaves a protective blanket of leaves, stems and stalks of plants/residues on the soil surface. In this way organic matter can be built up in the soil, which has great influence on the activity and the population of the microorganism (Goddard, *et al*,2008).

Conservation tillage contributes to reduced erosion, less desertification, increased carbon sequestration and less carbon release (less fuel used, less organic matter degradation) and increased biodiversity through diversification (FAO, 2001).

2.10 Impact of no –tillage on human drudgery

Weeding account for more than 60% of the time a peasant farmer spends on the land. Conservation tillage reduces the energy (example fuel for machines and calories for humans and animals) and length of time required for weeding the farm.

Use of pre and post planing herbicides in no-tillage in Ghana require only 15 percent of the time required for seedbed preparation and weed control with a hand hoe, while the reduction in labor days required in rice in Senegal was 53-60 percent (Findaly and Hutchinson, 1999).

Land preparation is the most time-consuming activity for the farmer and farm family (FAO, 2001).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Description of experimental site

The experiment was conducted at Nkawie- Wioso in the Atwima Nwabiagya District of Ashanti Region.

Atwima Nwabiagya District lies between latitudes 5^0 60'and $5^0$62,N and longitudes $1^0$52 and 1^0 9'W and has a total land area of 356.47km^2 which covers 1000 settlements with a population density of 120 persons/km^2 (Atwima Nwabiagya District Assembly, 1996).

The district falls within the wet semi-equatorial zone of Ghana with mean monthly temperature of between 23°C and 33°C. Rainfall is bimodal in both districts with a peak rainy season from the end of March to July and again from September to November. The annual precipitation is ranging between 1400mm and 1800mm (Atwima Nwabiagya District Assembly 1996).

Zschekel *et al*. (1997) reported that in 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 drain loamy soil of density ranging from 1.38-1.6 and porosity and 0.39-0.48.

3.2 Cropping system at experimental site

The predominant land management system at the experimental site is no-tillage, (the use of herbicide for both land preparation and in crop weed control). Most farmers cultivate between 1-2 acres with either mono-crop or mixed and relay crop. The experimental site had been cropped to maize for the past five (5) years in both major and minor seasons.

3.3 Description of experimental materials

The seed maize (Obatanpa) was obtained from Asuoyeboah Seed Bank at Kumasi. Germination of the seed maize was 98 percent.

3.4 Experimental design

The experiment was 2x3 factorial with treatments arranged in a randomized complete block design. There were refilling materials (seed and seedling) and time of refilling at 5, 10 and 15 days after initial planting. The experimental area was 23m x 35m and a distance of 1.0m separating the 4 replications.

(A) Material for refilling

- Seed maize M_1
- Seedling M_2

(B) Time of refilling

- 5 days T_1
- 10 days T_2
- 15 days T_3

3.5 Land preparation

The experimental plot was prepared by slashing the existing vegetation and allowed to re-grow up to about 30 cm high. 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 300mls per 15 litres of water. The plant residues were left on the soil surface without burning for 7days before planting.

3.6 Planting

The experimental plot was planted on 28th April, 2007 at the spacing of 80cm x 40cm at 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 a.i. per 1kg seed. Each plot had 6 rows with 12 hills, given a total of 144 plants per plot.

GGDP (1998) recommended 2 seeds per hill when germination is 85 percent and above, and more than 2 seeds below 85 percent, but below 70 percent it is recommended that better seed should be sought.

Five days after planting 25 percent losses of the germinated plants were consciously created through randomly uprooting 36 plants out of 144 plants. A plot in each replication was refilled with seed and another plot with seedlings. Seedlings used were planted during initial planting of the experimental field in the 1.0m area that separates each experimental treatment. The seedlings were planted the same date as the experimental plot, to enable the use of equal growth age of seedling to minimize competition among growing plants. Seedlings were planted with a ball of earth at the base, a condition meant to reduced stress at transplanting.

The refilled process using maize seed and seedling 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 on 28th April, Urea fertilizer was also applied 4 weeks after planting at 62.5 kg/ha.

3.7 Weed control

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.

3.8 Data collection and Analysis

Parameters measured were number of leaves per plant, leaf length, leaf diameter, Sunfleck, plant height, stem girth, refilled plants establishment, plants population, grain yield and percentage contribution of grain yield from refilled plants. The data was recorded from the four central rows of each plot and analyzed using the MSTATC statistical package. Differences were separated at 5% level of significance using the least significant difference.

Plant height;

The heights of a random sample of four plants were measured from the central row in each plot. The height of each plant was determined by measuring from the base of the plant to the last leaf of the maize plant with measuring tape, and the mean height recorded.

Number of leaves per plant;

The leaves of maize plant were counted in each of the four plants selected randomly from the central row. The mean leaf number per plant recorded.

Leaf length and diameter;

Leaf length and diameter were measured from random sample of four plants from the central row with measuring tape and mean leaf length and diameter calculated. The diameter was taken at the widest portion of each leaf.

Sunfleck;

Sun light penetrating through the canopy to the ground were measured in each plot by the use of Septometer. This instrument automatically recorded the amount of light from sun beneath the plant canopy. Three readings from each plot were taken and the mean calculated as the percentage amount of total light reaching the ground.

Stem girth;

Stem girth of the four random sample plants were measured from the central row in each plot with Caliper. This instrument is graduated and measurements were taken at 5cm height from the base of the plants and the mean stem girth recorded.

Refilled plants establishment;

Refill plants in each plot in the replication were counted and the number of the refill established plant recorded.

Plants population;

Each plant was counted in each treatment plot within the four replications and plant population per hectare computed

Grain yield;

The total weight of the grains of maize cobs harvested from the central row was recorded. Weight of maize from each plot was then extrapolated to total grain yield per hectare at 15% moisture content.

CHAPTER FOUR

4.0 RESULTS

4.1 Leaf number and leaf length

Results of maize leaf number are presented in Table 4.1. The results showed that refilling with seedlings produced the greater number of leaves per plant (12.58), and this was significantly higher than when refilling was done with seeds.

Time of refilling significantly affected (P< 0.05) leaf production. Refilling at 5days 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. Additionally, refilling at 10 days also produced greater leaf number than refilling at 15 days.

Maize leaf length as affected by refilling materials and time of refilling are presented in Table 4.1. Refilling with seedlings produced significantly (P<0.05) longer leaf (94.0cm) than when seed were used to do refill. Time of refill also significantly (P<0.05) affected maize leaf length. Treatment effect at 5 days after planting was significantly higher than those of 10 days and 15 days after planting. Other treatment differences were not significant at 5% level of probability.

Table 4.1 Effect of refilled material and refilling time on maize leaf number and length

Refilled Materials	**Leaf Number/plant**	**Leaf length** (cm)
Seed	9.67	78.6
Seedling	12.58	94.0
Lsd (5%)	**0.67**	**7.36**
Time of Refilling		
5 days	12.25	94.1
10days	11.12	84.2
15 days	10.00	80.6
Lsd (5%)	**0.83**	**9.0**
CV (%)	7.0	9.8

4.2 Leaf diameter and Sunfleck

Maize leaf diameter and Sunflecks results are presented in Table 4.2. Leaf diameter was significantly affected by refilled material. Refilling with seedlings produced wider leaf diameter than when seeds were used as material. Leaf diameter was significantly affected by time of refilling. The greatest effect (9.52cm) was measured when refill was done at 5 days after planting, and this was significantly higher than all other treatment effects. Leaf diameter of plants refilled at 10 days after planting (DAP) was also significantly higher than that at 15 days after planting. Sunflecks measurement when seeds were used as refill was significantly higher ($P < 0.05$) than when seedlings were used as refill. Time of refill did not, however, significantly affect ($P > 0.05$) sun fleck measurement.

Table 4.2 Effect of refilled material and refilling time on maize leaf diameter and sunflecks

Refilled Materials	**Leaf Diameter (cm)**	**Sun flecks**
Seed	6.83	12.47
Seedling	9.29	7.01
Lsd (5%)	0.69	3.79
Time of Refilling		
5 days	9.52	8.56
10days	7.93	10.11
15days	6.73	10.54
Lsd (5%)	0.85	NS
CV (%)	9.9	44.8

4.3 Plant height and Stem Girth

Plant height results are presented in Table 4.3. 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 refill at 5 DAP, which statistically was similar to that at 10 DAP. However, either effect was significantly higher ($P<0.05$) than that of refill at 15 DAP.

Maize stem girth results are presented in Table 4.3. Girth of plants from seedlings refill was significantly higher ($P < 0.05$) than that from seeds. Treatment effect of refill at 5 DAP was significantly higher than all other treatment effects. Treatment differences between refill at 10 DAP and 15 DAP were not however significant ($P>0.05$).

Table 4.3. Effect of refilled material and refilling time on maize plant height and stem girth

Refilled Material	Plant Height (cm)	Stem Girth (cm)
Seed	95.2	1.41
Seedling	154.6	2.00
Lsd (5%)	14.5	0.20
Time of Refilling		
5 days	151.0	1.98
10 days	146.0	1.66
15 days	109.1	1.48
Lsd (5%)	17.8	0.25
CV (%)	13.4	14.1

4.4 Refilled Plants and Plant lodging

Refilled plants established with seedlings recorded significantly higher number than refilling with seeds (Table 4.4). Refilled plant established with seedling was about 30% greater than when refilling was done with seeds. Time of refilling did not significantly ($P>0.05$) affect plant establishment during the experiment (Table 4.4).

Maize plant lodging was significantly higher when maize seed were used to refill. Time of refill also significantly affected plants lodging. Refilling done at 10 DAP resulted in significantly higher plant lodging than other treatment effects at 5% level of probability. Additionally, treatment effect at 15 DAP was also significantly higher than when refilling was done at 5 DAP.

Table 4.4 Effect of refilled material and refilling time on refilled maize plants establishment

Refilled Material	Refilled Plants (plants/Ha)	Plant Lodged (plants/Ha)
Seed	10938	294
Seedling	14354	132
Lsd (5%)	1715.1	0.02
Time of Refilling		
5 days	13375	190
10 days	13125	204
15 days	11438	196
Lsd (5%)	NS	0.03
CV (%)	15.6	12

4.5 Plant population, Total grain yield and Grain yield from refilled materials

Result of plant population at harvest as affected by refill material and time of refilling are presented in Table 4.5. Refilling with seedlings resulted in a significantly higher plants population (58229.0 plants/ha) than when refilling was done with seeds (53438.0 plants/ha). Time of refilling significantly did not affected plant population, the greatest effect 57812.0 plants/ha, was recorded when refilling was done at 5 DAP, which effect was not significant than that resulting from refilling at 10 days only. Treatment differences between refill at 10 DAP and 15 DAP were not statistically different.

Grain yield results as affected by refill material and time of refill are presented in Table 4.5. Grain Yield from treatment where refilling was done with seedlings was significantly higher than when seeds were used for refilling. Yield difference between refill with seedling and refill with seed were about 30% or nearly 1t/ha. Time of refilling did not significantly affect maize grain yield.

The result of percentage (%) grain yield as contributed by refilled plants is presented in Table 4.5. Although grain yield from seedling refill was not significantly higher than that of refilled with seed, yield difference was more than 500%. While 34% of the grain was produced from refilling with seedlings, only 6% was contributed when refilling was done with seeds. Time of refilling did not affect contribution of seed yield from the refill material.

Table 4.5 Effect of refilled material and time of refilling on maize plant population, grain yield and percentage grain yield from refilled material

Refilled Materials	**Plants population** (Plants/Ha)	**Total grain Yield** (Kg/Ha)	**Grain yield from refilled material** (%)
Seed	53438	7469	6.6
Seedling	58229	8436	34.3
Lsd (5%)	2355	712	NS
Time of Refilling			
5 Days	57812	7820	16.4
10 Days	53906	8037	36.5
15 days	55781	8001	8.5
Lsd (5%)	NS	NS	NS
CV	4.8	10.3	86.9

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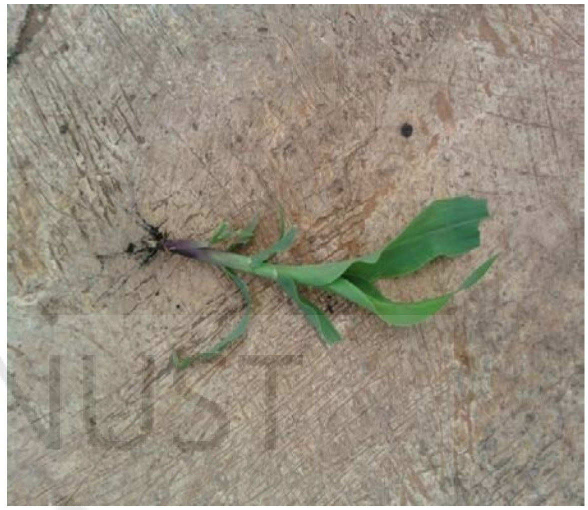

Plate1 . Seedling at 5 DAP

Plate.2 Seedling at 10 DAP

Plate 3. Seedling at 15 DAP

Plate 4. Refill with seed at 5 days

Plate 5. Refill with seed at 15 days

Plate 6. Refill with seedling at 5 days

Plate 7. Refill with seedling at 15 days

5.0 DISCUSSION

5.1 Effect of refilling material on maize growth

The responses of maize growth to the type of refilling material, either with seed or with seedlings have been presented in Table 4.1 - Table 4.4. In majority of the parameters measured, refilling with seedlings gave a significantly greater response than using seeds as the refilling material.

Leaf production of plants refilled with seedlings was more than when seeds were used for refilling.

Results showed that the number of leaves from plants refilled with seedlings was 30% greater than when seeds were used as refilling material (Table 4.1).

In addition, leaf length of plants from seedling refill was 20% greater than when refilling was done with seeds (Table 4.1). The ability to support greater leaf production is an indication that if growth resources are available throughout the growing season, growth and yield would be enhanced. This is because photosynthesis in such plants would be greater (Gardner *et al* 1985; and Agyei Wiredu 1996).

Leaf diameter of plants refilled with seedlings was also significantly higher than those from seeds (Table 4.2). Indeed, leaf diameter of plants refilled with seedlings was 36% greater than those from seeds. These observation show that total leaf area of plants produced from seedling material would be over 30% greater than those from using seeds refilling material. Thus the source capacity in these plants would be larger than those from seeds.

Penetration of light through the plants, as measured by sunfleck (Table 4.2) was greater in plants from refilling with seeds than those from seedling refill. This is not surprising since plants from seed refill were smaller with less leaf area or source capacity than those from seedling refill. Agronomically, this is a set back, as much solar energy would be lost in such conditions, and consequently grain would be reduced (Gardner *et al* 1985; Caesar 1984).

Plant height and stem girth of plants from seedling refill were 62% and 43% greater than those from seed refill, respectively. Taller plants mean that such plants can compete well with others for solar radiation.

In the peasant system where mixed cropping is the most common crop production system, this would be an advantage for higher maize production. Normally, in such system, several crops are grown but importantly, maize is used to subdue hunger, pending the maturity of the other crops, especially plantain and the root and tuber crops. Taller plants and stout stem would give such plants competitive advantage over weeds.

This present observation indicates that if maize refilling in such systems is done with seedlings, grain yield would not suffer as the plants can compete well with others like plantain and cocoyam with their broad leaves. The greater stem girth of plants from seedling refill (Table 4.3) presumably reduced plant lodging (Table 4.4). 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 4.3), lodging was still lower. The importance of reduced lodging in maize farm cannot be over-emphasized. Lodging reduced plants ability to absorb solar radiation and photosynthesize. This always results in lower grain yield. Furthermore, greater lodging means carrying out farming operations as weed control, fertilizer application and pest control can be dangerous and expensive. (Boa-Amponsem, 2000).

Plant survival was also significantly affected by refilling materials (Tables 4.3 and 4.5). Refilling with seedlings contributed more than 40% to the total plant population as compare to when refilling was done with seeds (Table 4.4). In crop yield, the contribution of each individual plants counts. Thus, without much effort and probably at no extra cost, if doing refilling in maize production with seedlings can ensure such occurrence, farmers would increase their grain yield and profitability if this technology is sold to them.

5.2 Effect of refilling material on maize yield.

Total maize grain yield was significantly affected by the refill material (Table 4.5). 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 1000 kg greater than in the latter treatment per hectare. Furthermore, seedlings used to refill contributed more than 34% to the total grain yield. This observation is very significant and the peasant Ghanaian maize farmer can be better off when this technology is adopted

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, 2006). The present result showed that if farmers would use seedlings to do refilling instead of seed, which is the current prevailing practice, yield per hectare would increase by about 1000 kg. Consequently the grain yield obtained by farmers at the present level of 1 t/ha would double, as shown by the results of this research. This would increase the return - to – investment by farmers, and of course, more maize for both human and animal consumption. This increase would be gotten at no extra cost to the farmer.

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5.3 Effect of time of 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 (Tables 4.1 to 4.4). 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 sunfleck measurements were higher and such plants recorded greater rates of lodging.

Grain yield results were, however, not consistent with the growth measurement. This is because the data appears to show that delay in refilling was better than refilling at 5 days after planting. This could only be possible in the cases where water stress was experienced soon after planting. Indeed, this observation was made in the present study as rains that were expected soon after planting delayed. Planting was done on 28th April and from the rainfall data (Appendix 1) no rainfall was recorded during the 5 days after planting. Since refilling at both 10 days and 15 days after planting recorded smaller growth, it was expected that grain yield of plants from refilling at 5 days would be greater. It is difficult to assign agronomic reasons to this observation.

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 yield is produced from such plants. The present study, however, has demonstrated that refilling in maize production can be achieved by using seedlings, and that such plants are vigorous, grows better, lodge less and ultimately would produce acceptable economic yield rather than doing refilling with seeds.

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CHAPTER 6

6.0 CONCLUSION AND RECOMMENDATION

Results reported in this thesis show that it is possible to do refilling in maize by using seedlings. This practice appears more profitable than the traditional method of using seeds, as plants from such practice compete 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 5 days after planting. However, this advantage could not be translated into grain yield under the conditions of this research.

Since this study appears to be the first with maize, it is recommended that further studies be done in all maize production zones to confirm the present observations before the technology is recommended to farmers.

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APPENDICES

2007 Rainfall figures at the experimental site (Wioso, Atwima nwabiagya)

DAYS	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1				16.5					18.0			
2						15.4		2.5	2.9	15.4		9.4
3						**9.0**			7.0			10.0
4						**11.0**					10.0	
5					9.0	55.7		4.8		5.0	24.4	
6					11.0			4.0		10.2		
7										5.2	1.7	
8										10.1		
9		12.1								10.0	1.0	
10		35.3						5.0	40.0	9.1	6.1	
11									13.5			
12						20.0					2.5	
13					**40.7**	22.0				7.4		
14										19.5		
15					**10.2**							
16			16.4	14.6							5.0	
17				10.4		8.6					6.1	
18				14.0		20.0	35.4			9.0	8.5	
19						5.3			15.2	21.0	10.5	
20						34.0			20.2	38.0	16.0	
21									5.3	7.1	4.0	
22									22.2		5.3	
23				5.4			25.0					
24									35.2			
25			11.4			6.0						
26						10.0	40.9			32.0	6.2	
27				27.3		8.2			5.0	10.0	12.5	
28					52.5	10.5	13.4		10.0	3.8	16.2	
29						12.0				10.0		
30	**33.0**		31.0			23.5			15.0	4.9		
31			39.0						20.0			
TOTAL	**33.0**	**45.4**	**97.8**	**77.8**	**113.2**	**269.6**	**114.7**	**16.3**	**274.9**	**244.7**	**106.0**	**19.4**
RAIN Y DAYS	**1**	**2**	**4**	**6**	**4**	**16**	**4**	**4**	**15**	**18**	**16**	**2**

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