

Effects of Seedling Types and Their Age on Phenological and Vegetative Growth Parameters of Maize (Zea Mays L.*)* in Burie District, West Gojjam Zone, North Western Ethiopia

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Abstract
The field experiment was conducted during the rainy season of 2018 in Burie District to study effects of seedling types and their growth stages on phonological and vegetative growth parameters of transplanted maize (Zea mays L.). Two types of seedlings (bare rooted and poly bagged); five levels of seedling's growth stage (1, 2, 3, 4 and 5 true leaf) and one control (direct seeded) were laid down in RCBD design with three replications. Phenological and vegetative growth parameters were collected following standard procedures. All data were subjected to analysis of variance and mean separation for significant treatments were done by LSD. Both the main effect affected days to 50% siliking very highly significantly. Types of seedlings affected days to 50% tasseling significantly and days to 90% physiological maturity and plant height highly significantly. Days to 50% tasseling and 90% physiological maturity were affected very highly significantly by seedlings growth stages. Field survival rate and number of leaves were not significantly affected by both the main effects and the interaction. The higher plant height and earliest days to 50% tasseling, siliking and 90% physiological maturity were noticed from transplantation of poly bagged and five true leaf stage seedlings, while delayed phenological events were recorded from the control. Transplanting of poly bagged seedlings at 5 true leave stage was caused to escape the crop from terminal moisture stress. Therefore, transplanting of poly bagged seedlings at 5 true leaf stage is economically feasible and can be recommended tentatively for Burie District, Ethiopia and moisture stressed area. However; it's also advised to repeat the study in areas having terminal moisture stress for maize production.
Keywords: Bare root; Poly bagged; Seedling; Transplanting; Maize; Ethiopia
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1. INTRODUCTION

The performance of crops can be affected by the quality of seed used for sowing, various environmental factors, type of cultivar and cultural practices. Agronomic research on maize has largely focused on maximizing grain yield by investigating on plant nutrients and other agronomic practices (Van-Averbeke, 2008). Sowing of maize is a traditional practice whereas transplantation of maize is a recent technique. Transplanting is an alternative strategy to direct seeding that is commonly used to establish crops when conditions are less favorable for direct seeding. Late sowing leads to delayed germination and then reduced plant growth. Hence, grain yield is reduced due to late sowing as the crop experiences terminal drought with the advancement of growth which reduces the duration for grain filling and dry matter accumulation resulting in small grain size (Biswas *et al.*, 2009). In such cases, grain yield reduction can be compensated by seedling transplantation. Transplantation in maize helped the farmers to harvest a third crop in areas where nothing to do because of late harvest of winter maize; as maize transplantation shortened the crop period by 8-10 days (Basu and Sharma, 2003).

However, age of transplant is one of the factors which affect plant growth and grain yield; but it is ignored to be considered by the farmers during transplantation. The optimum seedling age to be used depends on the edaphic factors, climatic (temperature, moisture), location and cultural practices (Weston, 1988). Hence, knowledge on optimum age of transplant was helpful in understanding the relationship between the physiological state of the transplant, its survival in the field and its growth responses under various cultural systems and environmental factors (Shukla *et al.*, 2011).

Maize could also be established much earlier through transplanting (Dale and Drennan, 1997b). The use of transplants can shorten the growth period in the field and therefore late-maturing and high yielding cultivars can be made to fit in to available growing season as dictated by either rainfall or temperature (Dale and Drennan, 1997a). Depending on the age of transplants, time to harvest of maize was reduced by one to three weeks in the USA and 10 to 12 days in France (Waters *et al.*, 1990).

Besides to this, in Burie District, the onset of rainfall is becoming less predictable and delayed from time to time. As a result, terminal moisture stress and grain yield loss become common challenges in maize production of the study area. Hence, farmers of the study area were forced to shift their crop cultivation to short period crops. Therefore, transplanting of seedling may be an important area of study in Bure district for maize cultivation considering the field duration and early plant establishment under Ethiopian conditions. Unfortunately, there was no previous study carried out on transplanting of maize in Ethiopia as well as in the study area. Therefore, the present field experiment was carried out to study the effect of transplanting maize seedlings; overcome the problem of terminal moisture stress and enhance production and productivity of maize by using appropriate type of planting materials in the study area, Burie District, Ethiopia.

2. MATERIALS AND METHODS

2.1. Description of the Study Area

The present experiment was conducted at the farm of Burie Campus of Debre Markos University, Burie Town Administrative District, West Gojjam Zone of Amhara Region, during the rainy season of 2018 G.C (Figure 2.1). The area is located in the north western part of Ethiopia at a distance of 410 km from Addis Ababa in Northwest direction. Geographically, the experimental site is situated at 10º42'43"N latitude and 37º4'45"E longitude with an altitude of 2,103 m.a.s.l. The agro ecology of the district is varying from *Woyna Dega* (midlands) to *Dega* (highland). The average minimum and maximum temperatures of the area are 10^0c and 25°C, respectively, and its average annual rainfall is 1800 mm. The soil of the experimental site is characteristically Humic Nito and Eutric Vertisols, relatively clay in texture. According to the result of soil analysis conducted by Amhara Designe and Supervision Bureau in 2018 G.C, soil of the study site is non saline (Ec=0.058dS/m), medium in CEC (21.6 cmol kg^{-1}), low in organic carbon (2.11), low in total nitrogen (0.16%), medium in available phosphorus (6.25ppm) and weakly acidic nature with pH of 5.6 as compared to standards of Landon (1991). Major crops grown in the area are maize, wheat, finger millet, pepper, barley and tef.

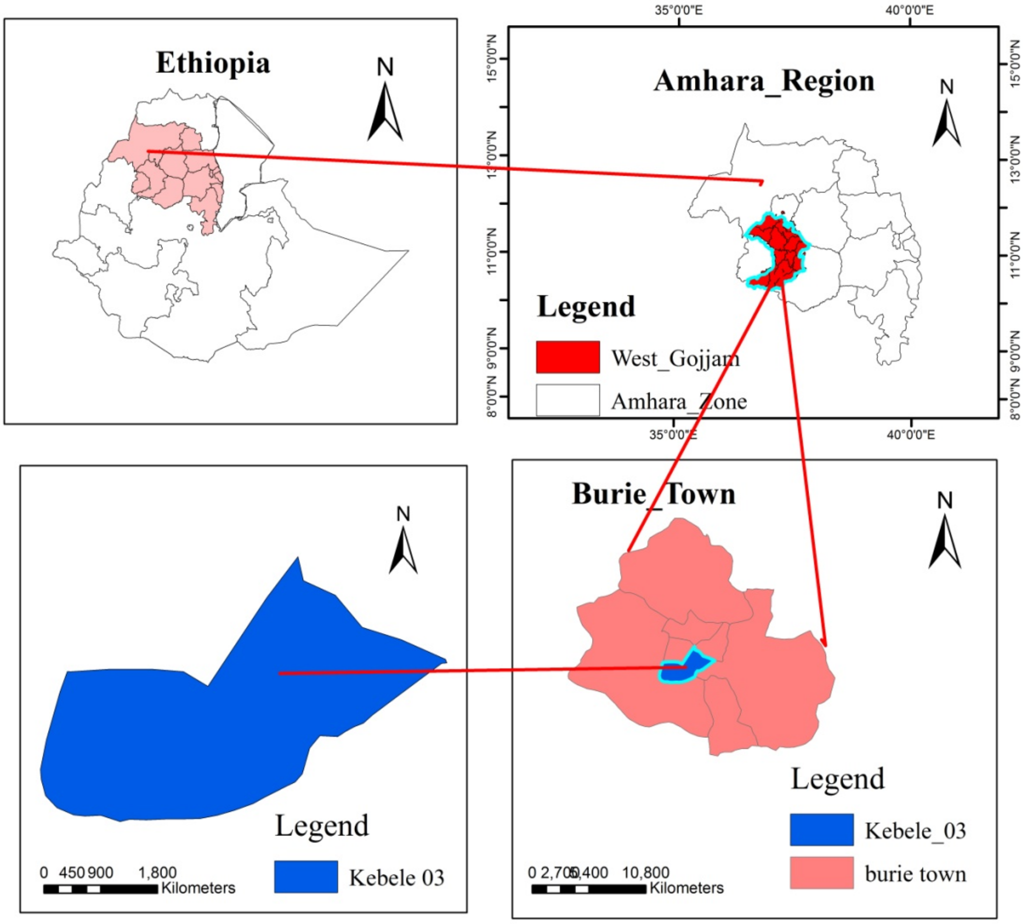

Figure 2.2. Map of the study area

2.2. Experimental Treatments, Design and Procedures

The two factors namely type of seedlings and seedlings growth stage were involved in the study. Combinations of two type of seedlings (bare root and poly bag) and five level of seedling growth stages (seedlings of 1, 2, 3, 4 and 5 true leaf) and with one standard check (direct seeded) having (11) treatments were laid out in randomized complete block design (RCBD) with three replications. An improved maize variety called "BH-660 (Bako Hybrid-660)" was used for the study. This variety was released by the Bako Research Centre and has become one of the most successful hybrid varieties in Ethiopia as well as in Amhara region. It is a three-way cross hybrid and the most prominent variety throughout Ethiopia due to its high productivity (average 7 t ha^{-1}) and coverage

As per the design and treatments, the experimental field was sub-divided into blocks and plots manually. The gross plot size was 3.75m x 3m (11.25m^2). A 1.0 m wide-open path separated the adjacent blocks and plots within a block were separated from one to another adjacent one with 0.5 m wide paths. Experimental treatments were allocated to the experimental plots of each block randomly using lottery method. The seedlings were raised under nursery through two methods which are composted and poly bag nursery. The bare root seedlings were raised on one bed which had 1 m width with 10 m length. The composted nursery was prepared by removing layer of weeds and stubble above the soil surface; and the soil were plowed, pulverized, and mound. A mixture of sand, compost and top soil with the proportion of 1:2:3, respectively; and thick layer of about 10 cm of this growing media was spread all over the bed. The maize seeds were sown in line, maintaining a spacing of 20cm x 5cm and cover with a thin layer of pulverized soil. Proper watering was done after sowing seeds and as necessary to ensure germination of seeds and growth of seedlings. The second method of seedling production was poly bag nursery, in this method poly bags having sizes of 12cm x 8cm were used to raise seedlings. Each poly bag was filled-up with a mixture of sand, compost and top soil with the proportion of 1:2:3, respectively and the poly bag were laid on the falt bed by maintaining 1m width; and a single seed was placed in each bag at 1-1.5 cm depth. Proper watering was done when necessary for proper germination and growth of the seedlings.

Sowing at nursery for raising seedlings was done on May 22/ 2018 G.C and the control was directly sown on one plot in each block on May 27/ 2018 G.C by maintaining a spacing of 75cm x 30cm; and one seed per hill. The seedlings were uprooted carefully by the help of fork to reduce root injury from composted nursery while, in poly bagged seedlings, each poly bag was turned to remove the plastic from the seedling, while keeping the soil volume intact and the long roots were slashed and transplanting was conducted immediately. Transplanting of one and two true leaf seedlings were done on June 3 and 4 of 2018 G.C, respectively, while transplanting of three, four and five true leaf seedlings were done on June 8, 11 and 19 of 2018 G.C, respectively, by maintaining the spacing of 75cm x 30cm and one seedling per hill as the control was done. Thus, there were a total of 5 rows having 10 plants per row and a length of 3m and 50 plants per plot. The net plot size (harvestable area) was 2.25m x 1m (2.25m^2) (i.e. the middle 3 rows from each plot) by excluding one outermost row on both sides of each plot vertically and 1m row segment from both ends of the plot horizontally to avoid possible border effects.

Urea (46% N) and Diammonium phosphate (DAP) (18% N and 46% P_2O_5) fertilizers were used as sources of N and P respectively. The full dose of phosphorous and 1/3rd of nitrogen fertilizer were applied as band placement at the time of sowing and transplanting of the control and seedling transplanting treatments, respectively. The remaining 2/3rd of nitrogen fertilizer was applied as top-dressing at knee height of maize following the second hoeing and weeding time. Experimental plots were kept free from weeds by hand weeding as necessary. All other remaining agronomic practices were applied as per their recommendations for maize in the study area. Harvesting was done carefully from the net plot areas by hand on about at 14% moisture content of grains.

2.3. Data Collection

Some of the data of agronomic parameters of maize were collected as per plot and plant base.

2.3.1. Phenological parameters

Days to 50% tasseling: It was taken when 50% of the plants produced tassels from each net plot area by visual observation and counting.

Days to 50% silking: It was taken when 50% of the plants produced silks from each net plot area by visual observation and counting.

Days to 90% physiological maturity: Days to 90% maturity was recorded as the number of days from transplanting to the date on which about 90% of the plants in the net plot area is matured (90% plants showed browning or drying of cobs husk).

2.3.2. Vegetative growth parameters

Filed survival rate: It was recorded by counting the total number of plants in each plot at 30 days after transplanting was conducted.

Number of leaves per plant: Five plants were randomly selected from three central row of each net plot and their leaves were counted and their average was taken.

Plant height (cm): The average height of five randomly selected plants from the net plot area of each plot was measured in centimeters from the ground to the height of the first tassel branch and average height was taken at dough stage.

2.4 Data Analysis

The data that were collected from the experiment at different growth stages were subjected to statistical analysis as per the experimental designs for each experiment using SAS (Statistical Analysis Software) version 9.1 to analyze ANOVA. Mean separation for significant treatments were carried out using the least significant difference (LSD) test at 1% or 5% level of significance depending on the ANOVA result. Moreover, correlation analysis was also carried out to study the nature and degree of relationship between growth and yield components of maize. A correlation coefficient value ® was calculated and test of significance was analyzed using Pearson correlation procedure using SAS version 9.1.

3. RESULTS AND DISCUSSION

3.1. Phenological Parameters of Maize as Affected by Types of Seedlings and Their Growth Stages

3.1.1. Days to 50% tasseling

The results of analysis of variance indicated that days to 50% tasseling was affected significantly ($p<0.05$) by the main effect of different types of seedlings; and very highly significantly ($p<0.001$) by the main effect of seedlings growth stages. However, the interaction of types of seedlings and seedlings growth stage did not significantly ($P\geq0.05$) affect days to 50% tasseling of maize. (Appendix table 1). Transplanting of poly bagged seedlings leads to earlier (90.8) days to 50% tasseling as compare to transplanting of bare rooted seedlings (93). While the delayed days to 50% tasseling were observed from direct sown (102) of maize which was delayed by more than 11 days from transplanting of poly bagged seedlings (Table 4.1). Early tasseling in transplanting of poly bagged seedlings might be due to the additional nutrients transferred with it, less transplanting shock, which leads the plant to grow fast and switch early from vegetative growth to reproductive phase. Early tasseling due to transplanting of poly bagged seedlings may hence contribute to escape the crop from terminal moisture stress.

In agreement to the present result, Kumar *et al.* (2014) reported that plants raised with plastic cultured seedling took least number of days (50) to attain 50% flowering where as plants grown with sand culture and raised bed seedlings attained 50% flowering 8-10 days later. In harmony with the present result, Biswas *et al.* (2009) also reported that in both of the varieties, direct planting took the maximum duration for tasseling. Among the varieties they tested, BARI maize-6 took 87-89 days and the variety Pacific-11 took 85-89 days for tasseling in the crops grown through planting of seedling. However, direct planting took 101 days and 100 days for BARI maize-6 and Pacific-11, respectively. Additionally, Dale and Drennan (1997b) reported that transplanted maize flowered earlier than direct-seeded maize.

Among the seedling growth stages, the earliest days to 50% tasseling was observed from transplanting of five true leaf seedlings (85.2) followed by transplanting of four true leaf seedlings (90.8), while delayed days to 50% tasseling was observed from the control (direct seeded) and took 102 days to attain 50% tasseling (Table 4.2). Earliest tasseling in transplanting of five true leaf seedlings might be due to the time stayed in the nursery, which helps the plant to shorten periods of vegetative growth and switch early to reproductive phase. Earliest tasseling due to transplanting of five true leaf seedlings might be helpful to escape the crop from terminal moisture stress.

In line with the present findings, Aihole (2012) reported that significantly early flowering of maize was noticed in transplanting of 16 days old seedlings (56.84 days) compared to transplanting of 8 (59.83 days), 20 days old seedlings (62.53 days) and direct sowing (64.34 days). Kumar *et al.* (2014) also supported the present result and reporting that seedlings transplanted at 7 weeks age took 41 days to attain 50% flowering which was 25, 20 and 15 days earlier than that of 4, 5, and 6 weeks old seedlings, respectively. In the contrary to the present study, Olabode *et al.* (2018) reported that directly sown maize plants flowered at 53 days after planting which is significantly earlier than all other transplants. They further elaborated that one- and two-weeks old transplants flowered at the same time (58) days after planting which is significantly faster than three weeks old transplant (60 days).

3.1.2. Days to 50% silking

Very highly significant ($p<0.001$) variation in number of days to 50% silking of maize was observed due to main effects of both seedling types and seedlings growth stages. However, their interaction effect did not show significant ($p>0.05$) variation on days to 50% silking (Appendix table 2). The earliest (93.9) days to 50% silking was observed from transplanting of poly bagged seedling which was faster than by 11 days from the control, whereas the delayed (105) days to 50% silking was noticed from direct sown maize (Table 4.1). In harmony with the present findings, Kumar *et al.* (2014) observed that days to 50% flowering differed significantly due to different methods of nursery raising, as a result plants raised with plastic cultured seedling took least (50 days) number of days to attain 50% flowering, while plants grown with sand culture and raised bed seedlings attained 50% flowering 8-10 days later.

Concerning the seedling growth stages, transplanting of five true leaf seedlings leads to earliest (88.3) days to 50% silking followed by transplanting of four true leaf seedlings (94.7) which was at par with transplanting of three true leaf seedlings. While delayed days to 50% silking were observed from the farmers practice (direct sown) and which took 105 days for 50% silking (Table 4.1). The reason behind from observation of early 50% silking from transplanting of poly bagged and five true leaf seedlings was, similar to that of early 50% tasseling indicated above. This phenomenon due to transplanting of poly bagged and five true leaf seedlings may contribute to escape the crop from terminal moisture stress. Similar to the present results Biswas*et al.* (2009) reported that during direct planting maize took maximum duration for silking, while they took shorter days when planted by transplanting.

Table 3.1. Phenological parameters of maize as affected by the main effect of types of seedlings and their growth stages

Main effects	DFT	DFS	DPM
Type of Seedling			
Bare Rooted	93.0b	97.1b	170.1b
Poly Bagged	90.8c	93.9c	167.5c
Control	102.0a	105.0a	179.0a
Sig. difference	*	***	**
Growth Stage			
1 True Leaf	97.7b	101.0b	174.7b
2 True Leaf	95.2b	99.2c	172.2c
3 True Leaf	90.7c	94.5d	168.2d
4 True Leaf	90.8c	94.7d	167.7d
5 True Leaf	85.2d	88.3e	161.5e
Control	102.0a	105.0a	179.0a
Sig. difference	***	***	***
CV (%)	2.31	1.45	1.21

**** and *** = highly significant and very highly significant respectively; DFT=days to 50% tasseling; DFS=days to 50% silking; DNPM=days to 90% physiological maturity; CV= coefficient of variation; SE ± = standard error**

3.1.3. Days to 90% physiological maturity

The analysis of variance result indicated that days to 90% physiological maturity was highly significantly ($p<0.01$) influenced by the main effect of different types of seedlings and very highly significantly ($p<0.001$) by the main effect of seedling growth stages, while their interaction did not significantly ($P\geq0.05$) affect days to 90% physiological maturity (Appendix table 3). Transplanting of poly bagged seedlings attributed to early days to 90% physiological maturity as a result, transplanting of poly bagged seedling resulted earliest (167.5) days to 90% physiological maturity as compare to transplanting of bare rooted seedlings (170.1), but the latest days to 90% physiological maturity was recorded from the direct sown (179) maize (Table 4.1). The earliest 90% physiological maturity of maize from transplanting of poly bagged seedlings might be due to the additional nutrients transferred with the ball of the seedlings and less transplanting shock, which favors the plant to grow fast and switch early from vegetative growth to reproductive phase. The result of correlation analysis also revealed that the positive and very highly significant association of days to 90% physiological maturity was observed with that of days to 50% tasseling and silking (Table 4.8).

Similarly with the result of the present work Biswas *et al.* (2009) reported that direct planting took maximum duration for maturity. As a result, maize matured 7-8 days earlier when grown through planting of seedlings than direct planting which took 147-149 days for maturity. In partial agreement to the present result Kumar *et al.* (2014) reported that plants grown with sand culture and raised bed seedlings attained 90% physiological maturity 10-12 days earlier than plastic culture raised seedlings, while the direct seeded maize took 162 days to maturity of maize.

The comparison for the seedling growth stages revealed that earliest days to 90% physiological maturity were observed from transplanting of five true leaf seedlings (161.5) followed by transplanting of four true leaf seedlings (167.7) which was at par with transplanting of three true leaf seedlings, while delayed days to 90% physiological maturity of maize was observed from the farmers practices (direct sown) (179) (Table 4.1). Transplanting of five true leaf seedlings attributed to early days to 90% physiological maturity. In similar to tasseling and silking indicated above, early maturity of maize from transplanting of five true leaf seedlings might be due to the time stayed in the nursery, which helps the plant to shorten periods of vegetative growth and switch early to reproductive phase, means that they early tassel and silk, thus eventually had maturity early.

The current result of earliest maturity of maize from transplanting of five true leaf seedlings was in line with the findings of Aihole (2012) who reported that early maturity was recorded in 16 days old seedlings (105.73 days), followed by 20 (107.02 days), 12 (107.42 days) and 8 days old seedlings (109.35 days), whereas, the late maturity was noticed in the direct sowing of maize (109.59 days). Kumar *et al.* (2014) reported also transplanting of seven weeks old seedlings took minimum days while four weeks old seedlings took maximum number of days to maturity.

3.2. Vegetative Growth Parameters of Maize as Affected by Types of Seedlings and Their Growth Stages

3.2.1. Field survival rate

Results of analysis of variance showed that field survival rate of maize was not significantly (p>0.05) affected by different types of seedlings, its growth stages and their interaction (Appendix table 4) (Table 3.2). Adequate moisture content and good care during seedling uprooting and transplanting might had contributed to the same field survival rate across the treatment combinations.

3.2.2. Number of leaves per plant

Results from analysis of variance showed that number of leaves per plant of maize was not significantly (p>0.05) affected by different types of seedlings, their growth stages and their interaction (Appendix table 5) (Table 3.2).

Table 3.2. Vegetative growth parameters of maize as affected by the main effect of types of seedlings and their growth stages

Main effects	FSR	NL (per plant)	PH (cm)
Type of Seedling			
Bare Rooted	97.2	13.9	302.5b
Poly Bagged	98.5	13.9	317.1a
Control	96.4	14.9	321.4a
Sig. difference	**ns**	**ns**	**
Growth Stage			
1 True Leaf	96.3	14.5	303.7
2 True Leaf	98.0	13.9	310.0
3 True Leaf	97.3	14.0	314.5
4 True Leaf	99.0	13.5	308.9
5 True Leaf	98.7	13.8	311.9
Control	96.4	14.9	321.4
Sig. difference	**ns**	**ns**	**ns**
CV (%)	2.33	3.90	3.97

ns and ** = not significant and highly significant respectively; FS=field survival rate; NL=number of leaves per plant; PH=plant height; CV= coefficient of variation; SE ± = standard error

3.2.3. Plant height

The results of analysis of variance reveled that height of maize was highly significantly (P<0.01) influenced by the main effect of different types of seedlings while it was not significantly (p>0.05) affected by seedlings growth stages and the interactions of the two factors (Appendix table 6). The highest value of plant height (317.1cm) was recorded from transplantation of poly bagged seedlings and it was statistically at parity with heights observed from the control (321.4cm) (Table 4.2). While in transplanting of bare rooted seedlings, maize height was 302.5cm. The tallest maize from transplanting of poly bagged seedlings might be due to the additional nutrients transferred with seedling's ball during transplantation and negligible problems of transplanting shock resulted in longer plant height with longer inter node length.

In contrary with the present result Kumar *et al.* (2014) noted that seedlings which were grown on raised bed and sand culture attained more plant height (128.1 cm and 125.4 cm) respectively than those of plastic culture (104.2cm) at 90 days after transplanting. According to the study of Olabode *et al.* (2018) the tallest plant was produced by direct sowing (2.0 m) which was superior only to 3 weeks old transplants (1.63 m) but similar to those of 1 (1.8 m) and 2 week after planting (1.69 m). Adesina *et al.* (2014) also reported that similar height was observed between the direct seeded (74.75) and other seedlings transplanted at 19 (74.82cm) and 14 (74.77cm) days after planting. Based on the finding of Aihole (2012) the lowest plant height of maize was recorded in the direct sowing (166.75 cm) which was on the contrary of the present work.

4. CONCLUSION AND RECOMMENDATIONS

4.1. Conclusion

To attain the highest possible productivity of maize at a particular area, on top of using high yielding and adaptive varieties, alleviating the problem of terminal moisture stress through seedling transplanting is very crucial. Unfortunately, in developing areas much was not done on specific recommendations for most new production technologies including seedling transplanting for maize in most parts of the region including the present study area, Burie District Ethiopia. Hence, the present study was conducted in Bure District, Northwestern Ethiopia, in 2018 G.C main rainy season to assess the effects of seedling transplanting on phonological and vegetative growth parameters of maize, so as to determine appropriate types and growth stages of the seedlings.

From the present result it is possible to conclude that, both types of seedlings and their growth stages affect many of phonological and vegetative growth parameters of maize except field survival rate, number of leaves per plant. Transplantation of poly bagged seedlings were caused for higher plant height and earliest days to 50%

tasseling, siliking and 90% physiological maturity while the delayed phenological events were recorded from the control. Similarly, in case of seedling growth stages, the earliest phenological events were obtained at the transplantation of five true leaf seedlings as compared to other growth stages of seedlings.

a) Recommendations

The agronomic results of the present study showed that, transplanting of five true leaf seedlings which were grown by poly bag gave the highest plant height and earliest phenological events as compared to other treatment combinations. Based on the present study, therefore, transplanting of five true leaf seedlings grown using poly bag is economically feasible and can be recommended tentatively for maize production around the study area and similar agro-ecologies. However; it's also advised to repeat the study in areas having terminal moisture stress for maize production.

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Appendix Tables

Appendix Table 1: ANOVA of days to 50% tassiling

Source	DF	Type I SS	Mean Square	F Value	Pr > F
TS	1	36.3000000	36.3000000	8.05	0.0109
GS	4	551.5333333	137.8833333	30.59	<.0001
TS*GS	4	13.5333333	3.3833333	0.75	0.5704
R	2	18.2000000	9.1000000	2.02	0.1618

Appendix Table 2: ANOVA of days to 50% silking

Source	DF	Type I SS	Mean Square	F Value	Pr > F
TS	1	76.8000000	76.8000000	40.11	<.0001
GS	4	580.4666667	145.1166667	75.79	<.0001
TS*GS	4	14.8666667	3.7166667	1.94	0.1472
R	2	8.8666667	4.4333333	2.32	0.1274

Appendix Table 3: ANOVA of days to 90% physiological maturity

Source	DF	Type I SS	Mean Square	F Value	Pr > F
TS	1	50.7000000	50.7000000	12.23	0.0026
GS	4	604.3333333	151.0833333	36.45	<.0001
TS*GS	4	4.4666667	1.1166667	0.27	0.8938
R	2	6.0666667	3.0333333	0.73	0.4948

Appendix Table 4: ANOVA of field survival rate

Source	DF	Type I SS	Mean Square	F Value	Pr > F
TS	1	13.33333333	13.33333333	2.55	0.1277
GS	4	27.46666667	6.86666667	1.31	0.3028
TS*GS	4	6.66666667	1.66666667	0.32	0.8617
R	2	1.86666667	0.93333333	0.18	0.8380

Appendix Table 5: ANOVA of number of leaves per plant

Source	DF	Type I SS	Mean Square	F Value	Pr > F
TS	1	0.01200000	0.01200000	0.04	0.8426
GS	4	3.17866667	0.79466667	2.69	0.0646
TS*GS	4	3.16800000	0.79200000	2.68	0.0653
R	2	1.20800000	0.60400000	2.04	0.1588

Appendix Table 6: ANOVA of plant height

Source	DF	Type I SS	Mean Square	F Value	Pr > F
TS	1	1613.333333	1613.333333	10.68	0.0043
GS	4	388.573333	97.143333	0.64	0.6387
TS*GS	4	587.160000	146.790000	0.97	0.4471
R	2	73.512000	36.756000	0.24	0.7865