Indonesian Journal of Agricultural Science
Vol. 20 No. 2 December 2019: 77–85
DOI: http//dx.doi.org/10.21082/ijas.v.20.n2.2019.p.77–85

FLOWER BUD REMOVAL AND EARTHING UP TIME INCREASED GROWTH AND TUBER YIELD OF POTATO AT EASTERN TIGRAY, ETHIOPIA

Pembuangan Bunga dan Pembumbunan Tanah pada Tanaman Kentang Meningkatkan Pertumbuhan dan Hasil Umbi di Tigray Timur, Ethiopia

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Submitted 7 June 2019; Revised 13 December 2019; Accepted 27 December 2019

ABSTRACT

In Ethiopia, potato is a staple food crop and source of cash income for smallholder farmers, but the national average yield in farmers' field is lower than experimental yields due to poor agronomic activities. The study aimed to determine the effects of flower removal and earthing up time on growth and tuber yield of potato. The experiment comprised of three flower removal stage and five earthing up time treatments, which were laid out in a randomized complete block design of 3x5 factorial arrangements with three replications. Results indicated that plant height, stem number, tuber length and tuber diameter were shown significantly affected ($p < 0.05$) by the main effect of flower removal and earthing up time but not by their interaction. Fresh shoot biomass and physiological maturity were recorded significantly affected ($p < 0.05$) by earthing up time, but not by flower removal stage and its interaction with earthing up time. Total fresh biomass, marketable and unmarketable tuber yield, as well as total tuber yield were significantly affected ($p < 0.05$) by main factors and their interaction effects. The results clearly indicated that the highest total tuber yield (30.96 ton ha^{-1}) was recorded from flower bud removed potato earthed up at 15 days after complete emergence. Therefore, flower bud removed potato earthed up at 15 days after full emergence was better in terms of all yield contributing characters and tuber yield.

[Keywords: *Solanum tuberosum,* agronomic activities, Ethiopia]

ABSTRAK

Di Ethiopia, kentang merupakan tanaman pangan pokok dan sumber pendapatan tunai bagi petani kecil, tetapi hasil rata-rata nasional di ladang petani lebih rendah daripada hasil penelitian karena kegiatan budi daya yang kurang baik. Penelitian bertujuan untuk mengetahui pengaruh pembuangan bunga dan waktu pembumbunan tanah terhadap pertumbuhan dan hasil umbi kentang. Perlakuan terdiri atas tiga perlakuan penghilangan bunga dan lima perlakuan waktu pembumbunan tanah. Percobaan dirancang secara acak kelompok lengkap faktorial 3x5, tiga ulangan. Hasil penelitian menunjukkan perlakuan faktor individu pembuangan bunga dan pembumbunan tanah berpengaruh nyata ($p<0,05$) terhadap tinggi tanaman, jumlah batang, panjang umbi, dan diameter umbi, tetapi interaksinya tidak nyata. Biomassa pucuk segar dan kematangan fisiologis secara signifikan dipengaruhi ($p <0,05$) oleh waktu pembumbunan, tetapi tidak oleh pembuangan bunga dan interaksinya dengan waktu pembumbunan. Total biomassa segar, hasil umbi yang dapat dipasarkan dan tidak dapat dipasarkan, serta total hasil umbi dipengaruhi secara signifikan ($p <0,05$) oleh faktor utama dan efek interaksinya. Penelitian menunjukkan bahwa hasil total umbi tertinggi (30,96 ton ha^{-1}) diperoleh dari perlakuan pembuangan kuncup bunga dan pembumbunan tanah 15 hari setelah kemunculan bunga sempurna. Hasil penelitian mengindikasikan bahwa pembuangan kuncup bunga dan pembumbunan tanah 15 hari setelah kemunculan bunga sempurna dapat dianjurkan untuk meningkatkan hasil umbi kentang.

[**Kata kunci**: *Solanum tuberosum,* budi daya, Ethiopia]

INTRODUCTION

Potato (*Solanum tuberosum* L.) is one of the most important food crops worldwide. It ranks third after rice and wheat in terms of human consumption (FAO 2015). Among root and tuber crops, potato ranks first in volume of production and consumption followed by cassava, sweet potato, and yam. More than a billion people consume it almost daily. Hundreds of millions of people in developing countries depend on potatoes for their survival (FAO 2008).

Potato is the world's leading vegetable crop and grown in 79% of the world's countries (Muhammad et al. 2013). Annual world production of potato is about 330 million metric tons from 18,651,838 ha area coverage and in Africa, total production is about 17,625,680 tons from total area coverage of 1,765,617 ha (Israel et al. 2012). In Ethiopia, total area coverage of potato is nearly 0.18 million hectares from which 1.62 million tons are harvested (CSA 2014). The country has about 70% of the available agricultural land suitable to produce potato (Gebremedhin et al. 2008). It is the fastest-growing staple food crop and source of cash income for smallholder farmers in the country. Despite high

potential production, the national average potato yield in farmers' field in Ethiopia is only 11.1 ton ha^{-1} which is lower than experimental yields of over 38 ton ha^{-1} (CSA 2014). It is also very low compared to the world average (17.6 ton ha^{-1}) (CSA 2014; Israel et al. 2012).

The main contributing factors for under production and utilization of potato are lack of high yielding and disease tolerant varieties, unavailability of quality seed, and poor agronomic practices such as optimum nutrition and irrigation, improper earthing up and flower removal stage. Therefore, the production of potato could be increased through the application of better agronomic practices or management such as applying at the proper stage of flower removal and earthing up time which contributed a substantial amount of the crop yield. Proper earthing up increases tuber yield by creating favorable conditions for tuber initiation and development and prevent the greening of tubers.

Poor earthing up around potato plants could expose the tuber to sunlight, high temperature, diseases and insect damage (Gebremedhin et al. 2008). Removal of potato flower also has a great impact on tuber yield. Flowers and tubers would compete to acquire assimilates and pruning of flowers or berries would increase transferred assimilates into underground structures and increase tuber yield (Almekinders & Struik 1996). Therefore, there is an attempt to increase the yield of potato through providing good tubers of the best varieties accessible, by promoting improved techniques and agronomic practices such as removing flowers at the proper stage and earthing up at appropriate time in the production areas.

Flowers are less valuable economically in potato production as well as it is most photo-assimilate sinker that reduces translocation of food to tubers. However, in the Eastern Tigray, still many farmers who grow potatoes frequently give less regard to the proper time of earthing up and flower removal. Therefore, the objective of this study was to determine the effects of flower removal and earthing up time on growth and tuber yield of potato at Eastern Tigray, Ethiopia.

MATERIALS AND METHODS

Description of the Study Area

The field experiment was conducted on May Megelta, Saesie Tsaeda Emba, Eastern Tigray, Ethiopia during the period of 2018. The site is located at an altitude of 2492 meters above sea level and lies at 14^0 15` to 14$^0$ 30` N latitude and 39^0 30` to 39$^0$ to 45` E longitude (Figure 1). The mean annual rainfall is 475 mm, which ranges from 350 to 600 mm. The texture of the topsoil of the study area is sandy loam with an organic matter of 0.45% and a pH of 6.15.

Experimental Treatments and Design

The experiment was carried out 3x5 factorial arrangements within three replications in a Randomized Complete Block Design (RCBD). The first factor was three flower removal stage: normal growth (*i.e.,* the growth of potato was not disturbed and allowed to flower and set fruits); flower removal (*i.e.,* potato flowers removed when flower bud fully opened); and flower bud removal (potato flowers removed at bud

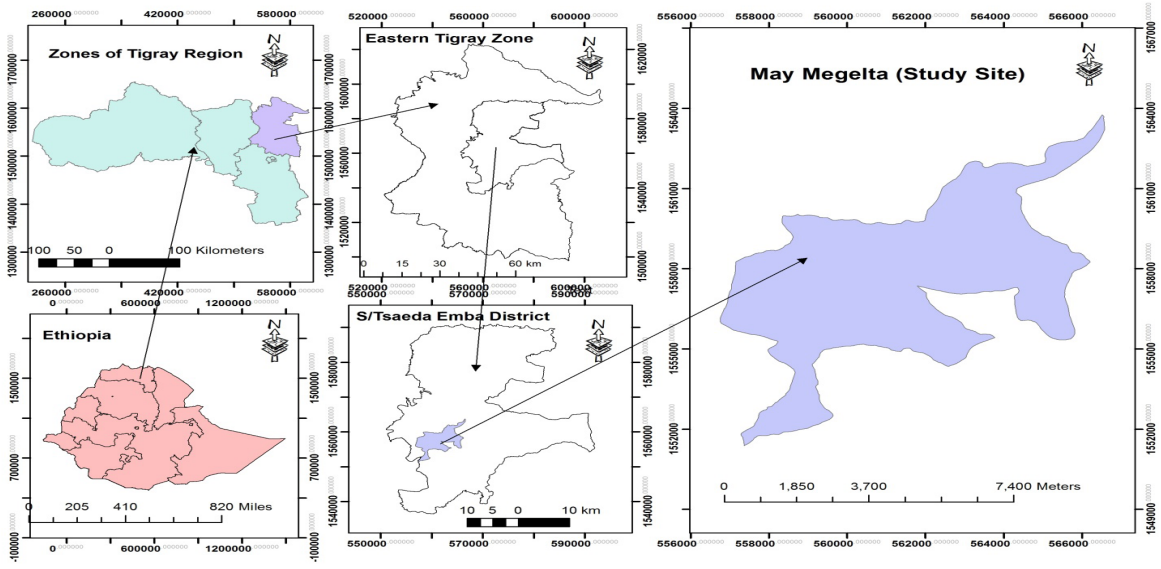

Figure 1. Map of the study area of Eastern Tigray (May Megelta, Saesie Tsaeda Emba district), Ethiopia

stage before opening flower buds). The second factor was five earthing up time including control (no earthing up), earthing up at 15 days, 30 days, 45 days and 60 days after complete emergence of potato. The size of the unit plot was 3 m x 2.4 m and each was accommodated four rows. The good sprout promising local potato seed tuber was planted at a depth of 12 cm and plants were spaced 30 cm apart in each plot. A row distance in plots was 75 cm, and the path between plots within each block was 50 cm wide, and 1 m wide was set between blocks.

Experimental Procedures

The experimental area was plowed and ridge prepared well as per the recommended practices. A promising local variety of potato tuber was prepared and separated. Hand weeding, side dressing and other agronomic practices were applied uniformly to all treatments. For the earthing up treatments before applying treatments first cultivation was applied for all treatments uniformly then the soil was put around the plant up to 20 cm high and 15 cm top width according to earthing up treatments at the different times except control. Phosphorus was applied in the form of diammonium phosphate (DAP) at planting time at a rate of 195 kg ha^{-1} and nitrogen in the form of urea was applied in a split at planting and after full emergence at a rate of 165 kg ha^{-1} (EARO 2004). Initial light irrigation was applied at 5 days after planting. Subsequent irrigation was given at 10 days interval depending upon the climatic condition and soil type. Other than the treatments, uniform field management, disease, insect pest, and weed control were performed to all plots.

Data Collected

Plant height (cm) was measured by taking five plants per plot as a distance in centimeter from the soil surface to the topmost growth point at physiological maturity. A number of main stems was recorded as the average stem count of five hills per plot at maturity. Only stems that emerged independently above the soil as single stems were considered. Days to physiological maturity were recorded when 90% of the potato plants in each plot become ready for harvest as indicated by the senescence of the haulms. The days were counted from planting to maturity of the crops. Fresh shoot mass (g) was taken from five randomly selected plants per hills in each plot from the central rows of the experimental plot. The fresh shoot weight was measured soon after harvest using a sensitive balance. Fresh total biomass (g) was determined as the sum of above ground and below ground (stem, branch, leaves, root, tubers and stolon) fresh mass of five randomly selected plants harvested from each plot using a sensitive balance. Tuber length and diameter (cm) were measured at the matured stage of ten marketable tubers from each plot for each treatment using venire caliper and mean values were taken. Average tuber weight (g) was obtained by dividing the weight of tubers per plant by the number of tubers. Marketable tuber yield (ton ha^{-1}) was free from diseases, insect pests and greater than or equal to 25 g (Lung'aho et al. 2007) in weight. Unmarketable tuber yield (ton ha^{-1}) was determined from the counted number of tubers and weighted that was diseased, insect attack and small-sized (< 25 g). Total tuber yield (ton ha^{-1}) was determined as the sum of the weights of marketable and unmarketable tubers from the net plot area. In the present experimental study, any disease, insect pests and weed data were not recorded but other agronomic and yield parameters were recorded and discussed below.

Data Analysis

Data collected from the experimental plots were subjected to analysis of variances (ANOVA) and computed using the SAS computer software program. Significant treatment means was compared using the least significant difference (LSD) test at $p < 0.05$ probability level.

RESULTS AND DISCUSSION

Plant Height

A significant difference ($p < 0.05$) in plant height was observed due to the main effects of flower removal and earthing up time. However, their interaction effect was not significant.

As indicated in Figure 2, the highest and lowest plant height was recorded from normal growth and flower removed potato respectively. In the case of earthing up, the highest plant height (72.18 cm) was recorded from potato earthed up at 15 days after complete emergence. However, it was a non-significant difference within the result obtained from earthed up at 30 days (68.77 cm). On the contrary, the shortest plant height was found from potato earthed up at 60 days after complete emergence, but it was non-significant differences within earthed up at 45 days and non-earthed potato. Except for control as earthing up delayed, decreasing trend on plant height was shown (Figure 2). This might be due to moisture and nutrient use efficiency at late earthing up the potato.

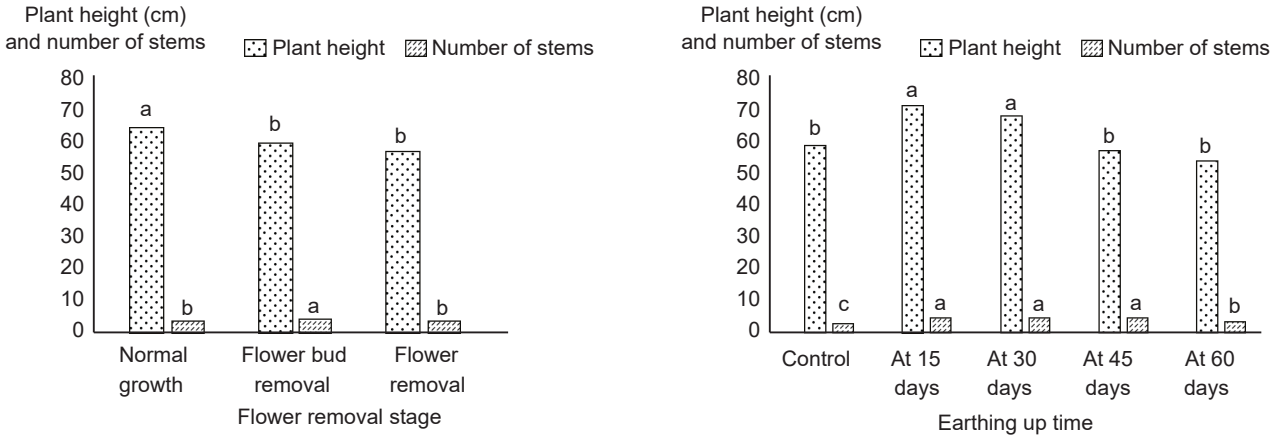

Figure 2. Effects of flower removal and earthing up time on plant height and number of stems of potato grown at Eastern Tigray, Ethiopia

Similarly, Tesfaye et al. (2013) reported that earthing up of potato after 15 days full emergence facilitated nutrient absorption and increased soil aeration.

Stem Number

The number of potato stems was significantly ($p < 0.05$) affected by the main effects of flower removal and earthing up time treatments, but not by their interaction. The highest stem number was recorded from flower bud removed while small stem number was obtained from normal growth potato (Figure 2). Similarly, Nazari (2010) reported that an increase in the number of main stems per plant was obtained due to fluorescence removing of potato. It seems that fluorescence removing decreases apical dominance of stem by destroying an auxin source so that side buds grow and the number of branches and stems of potato plant increases. Lahooti (2003) also presented that apical meristem tissue of aboveground parts such as growing buds, flower buds, and growing fluorescence on the stem are main centers for auxin synthesis. Thus, auxins have an effective role in apical dominance, apical bud is the deterrent factor of other buds' growth, and growth hormones especially auxins, can strongly control the number of side stems. Therefore, removal of apical bud means the removal of auxin source that can increase the number of stems and leaves.

For earthing up, the highest stem number was found from potato earthed up at 30 days after full emergence, but it was a non-significant difference with earthed up at 15 and 45 days (5 and 4), respectively. While small stem numbers (2) were recorded from control or potato without earthed up (Figure 2), this might be due to the face that earthing up, a cultural practice given to the plant during its active growth stage enhanced growth and development of more number of stems. The current results agreed with the work of Qadir et al. (1999) reporting the number of stems per plant was significantly higher for plants earthed up at two weeks after complete emergence. It also strongly agrees to Muhammad et al. (2013) who reported that the minimum number of stems per plant was recorded in plants planted haphazardly on unleveled land, followed by tubers when planted in furrows without ridges. Potato planted on wide plain beds and covered from one side gave the maximum number of stems per plant.

Days to Physiological Maturity

The number of days required by potato to reach physiological maturity was significantly ($p < 0.05$) affected by earthing up time. However, it was not significantly ($p > 0.05$) affected by flower removal and their interaction effects. The potato flower removal was not significantly different to physiological maturity. Longest day to reach maturity was recorded for flower bud removed potato (103 days) while the shortest days was obtained from normal growth potato (Figure 3). The result agreed with the report of Tekalign (2005) that flower removal of potato delayed days to maturity as compared to normal potato plants. Bizuayehu et al. (2008) also reported that the removal of buds and younger leaves may be attributed to prolonged canopy life of potato plant which enabled the plant to produce photoassimilates for an extended time.

In the case of earthing up, the longest day to reach physiological maturity was recorded from earthed up potato at 15 days after complete emergence, but it was no significant difference with earthed up at 45 and 60 days. The shortest days (96) to reach maturity

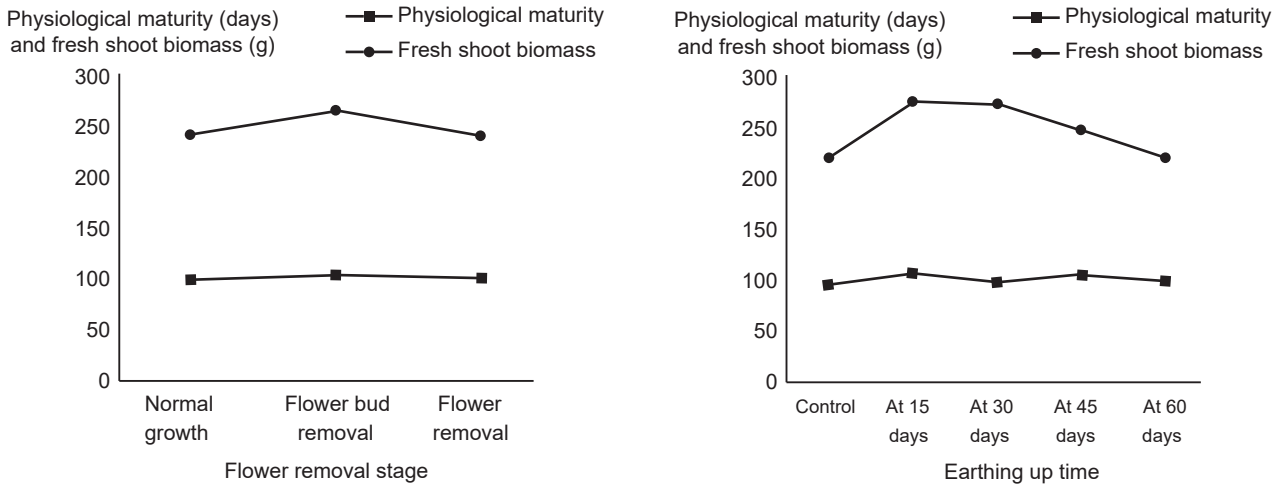

Figure 3. Effects of flower removal and earthing up time on days to physiological maturity and fresh shoot biomass (g) of potato grown at Eastern Tigray, Ethiopia

was obtained from non-earthed up potato (Figure 3). This may be plants extended crop cycle of each growth stage when it is getting favorable conditions. This result lined with Tesfaye et al. (2013) that earthing up potato at 15 days after complete emergence matching with the active growth stage of the plant, created favorable soil environment; and enhanced further vegetative growth that extended days to maturity. The correct choice of time of earthing up is critical as far as crop yields and quality achieved are concerned.

Fresh Shoot Biomass and Total Fresh Biomass

Fresh Shoot Biomass

The fresh shoot biomass of potato was significantly affected ($p < 0.05$) by earthing up time. However, flower removal and its interaction had not. As shown in Figure 3, the highest fresh shoot biomass was found from flower bud removed potato while the lowest value was recorded from flower removed potato (Figure 3). This could be due to more lateral branches and expanded leaves in response to the removal of flower buds. For earthing up time treatment, the highest fresh shoot biomass was recorded from potato earthed up at 15 days after full emergence. However, it was no significant difference within potato earthed up at 30 and 45 days. Whereas, low fresh shoot biomass was recorded from control, but it was no significant difference with earthed up at 60 days after full emergence (Figure 3). Similar results was reported by Qadir et al. (1999) who confirmed that earthing up at 15 days after complete plant emergence resulted in better fresh shoot biomass.

Total Fresh Biomass

Total fresh biomass of potato was highly significantly affected ($p < 0.01$) by flower removal stage and earthing up time as well as their interaction effects had significantly ($p < 0.05$) influenced (Table 1). As indicated in Table 1, the highest total fresh biomass was recorded from flower bud removed potato earthed up at 15 days after complete emergence while the lowest value was found from normal growth potato without earthing up. Generally, flowering had a reduction effect on the growth and development of above and belowground parts of potato. The reduction effect may be attributed at least in part to a higher assimilate demand for reproductive growth since they are strong sinks. Jaggard (1983) reported that the inhibitory effects of reproductive growth over vegetative growth have been found on sugar beet. The research finding of Qadir et al. (1999) also confirmed that earthing up at 15 days after complete emergence resulted in better total biomass of potato.

Average Tuber Weight, Length, and Diameter

Average Tuber Weight

The average tuber weight of potato was significantly ($p < 0.05$) affected by the interaction effects of the flower removal stage and earthing up time (Table 1). The highest average tuber weight (56.75 g) was recorded from the treatment of flower bud removed potato earthed up at 15 days after full emergence. However, it was no significant difference with the treatment of flower bud removed potato earthed up at 30 and 45 days. The lowest average tuber weight (28.94 g) was

Table 1. Interaction effect of flower removal and earthing up time on fresh total biomass per hill and average tuber weight (g) of potato grown at Eastern Tigray, Ethiopia

Treatments		Parameters	
Flower removal stage	Earthing up time	Total fresh biomass (g)	Average tuber weight (g)
Normal growth	Control (No earthing up)	869.37g	28.94f
	At 15 days	1230.53cde	44.95de
	At 30 days	1286.62bcd	53.16abcd
	At 45 days	1352.92abc	53.927abc
	At 60 days	1047.68f	36.25ef
Flower bud removal	Control (No earthing up)	1201.26cd	47.85bcd
	At 15 days	1444.75a	56.75a
	At 30 days	1428.73a	56.27ab
	At 45 days	1384.19ab	55.77ab
	At 60 days	1201.75de	49.7abcd
Flower removal	Control (No earthing up)	1137.58ef	45.48cd
	At 15 days	1339.67abc	46.07cd
	At 30 days	1357.33ab	50.4abcd
	At 45 days	1276.08bcd	53.04abcd
	At 60 days	1131.57ef	52.74abcd
LSD (0.05)		122.71	8.74
Level of significance		*	*
CV (%)		5.84	11.11

Means followed by the same letter were not significantly different at p = 0.05, according to the LSD test; * = significant at 5% level of probability.

also obtained from normal growth potato without earthed up. Hence, it was no significant difference with normal growth potato earthed up at 60 days after full emergence (Table 1). The result was supported with research done by Hassen et al. (2013) on anchote accessions, flower bud removal alone increased root weight per plant as compared with non-removed. Hasani and Karunia (2010) also reported that yam bean tuber fresh weight increased due to the removal of the flower bud.

Tuber Length

Potato tuber length had shown highly significantly affected by flower removal stage and earthing up time, while interaction effect was shown not ($p > 0.05$). The highest tuber length (17.48 cm) was found from flower bud removed potato while the lowest tuber length (7.18 cm) was recorded from normal growth potato (Figure 4). This result was supported with observations of Bizuayehu and Tekalegan (2005) that the existence of flower buds decreased productivity by reducing tuber size. This could be due to high gibberellic acid activity which leads to reduced partitioning of assimilate to tubers while encouraging stolon elongation and reduced tuber size. Hassen et al. (2013) also reported that flower bud removal increased tuberous root length by 5.21% on anchor accessions as compared with non-removed and noted that the absence of reproductive parts contributes to enhanced growth of tuberous root in anchor because assimilates diverted to vegetative parts. In the case of earthing up time treatment, the highest tuber length (13.47 cm) was found from the treatment of potato earthing up at 45 days after full emergence. Hence it was no significant difference with the treatment of potato earthing up at 30 days after full emergence (13.39 cm). While, the lowest tuber length (11.82 cm) was recorded from potato earthing up at 60 days after full emergence, but it was no significant difference with the potato without earthing up (12.15 cm) (Figure 4).

Tuber Diameter

Flower removal stage and earthing up time had shown significantly ($p < 0.05$) affected tuber diameter, but their interaction effects were not shown. Highly significant ($p < 0.01$) variation in tuber diameter was also found among the treatments of the flower removal stage. The highest tuber diameter (14.11 cm) was found from flower bud removed potato, while lower value (5.75

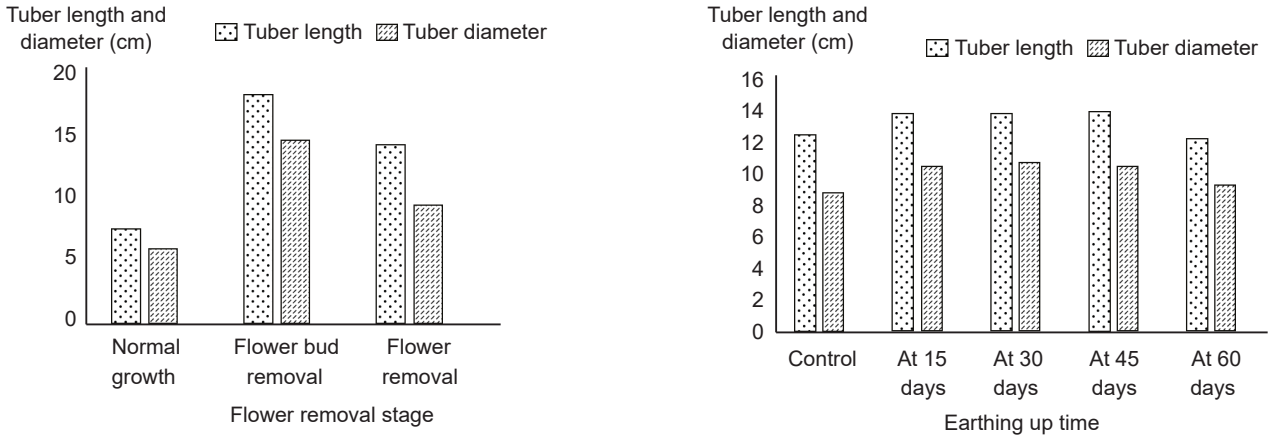

Figure 4. Effects of flower removal and earthing up time on tuber length (cm) and tuber diameter (cm) of potato grown at Eastern Tigray, Ethiopia

cm) was recorded from normal growth potato (Figure 4). The result supported the result of Hassen et al. (2013). The authors reported that flower bud removal on different anchor accessions caused an increment of 7.62% on root diameter as compared to non-removed. Nedunchezhiyan et al. (2007) and Ntawuruhunga and Dixon (2010) who studied sweet potato and cassava plants, respectively, also reported similar result.

Potato tuber diameter was also influenced significantly ($p < 0.05$) by earthing up time. The highest tuber diameter (10.31cm) was found from earthed up potato at 30 days after full emergence. However, statistically it was no significant difference with earthed up potato at 15 days (10.13 cm) and 45 days (10.05 cm). The lowest value of tuber diameter (8.58 cm) was also recorded from the control or potato without earthed up, while it was no significant difference with potato earthed up at 60 days after full emergence (9 cm) (Figure 4).

Marketable, Unmarketable and Total Tuber Yield

Marketable Tuber Yield

Marketable tuber yield of potato was significantly affected ($p < 0.05$) by the interaction effect of flower removal and earthing up time (Table 2). The highest marketable tuber yield was recorded from flower bud removed potato earthed up at 15 days after full emergence. However, it was no significant difference with flower bud removed potato earthed up at 30 days after full emergence. Lowest marketable tuber yield (8.63 ton ha^{-1}) was also obtained from normal growth potato without earthed up, but it was no significant difference with normal growth potato earthed up at 60 days (Table 2). The highest marketable tuber yield achieved because of flower bud removal may be due to the absence of competition for limiting factor between developing flowers and tubers. It was also speculated that in the absence of reproductive parts, presumably since developing tubers were the pre-dominant sinks, a large amount of assimilates was diverted to the tubers which would otherwise be utilized for flower and fruit production (Tekalegan 2005).

Unmarketable Tuber Yield

Unmarketable tuber yield was significantly ($p < 0.05$) affected by the interaction effects of flower removal and earthing up time. It was also highly significantly affected ($p < 0.01$) by the treatments alone (Table 2).

The highest unmarketable tuber yield (2.1 ton ha^{-1}) was recorded from normal growth potato, which was not earthed up, while it was no significant difference with normal growth potato earthed up at 60 days after full emergence (1.83 ton ha^{-1}). The lowest unmarketable tuber yield (0.71 ton ha^{-1}) was obtained from flower bud removed potato earthed up at 15 days after full emergence. It was shown that numerical different, but statistically not significantly different with flower bud removed potato earthed up at 30 days after full emergence (0.83 ton ha^{-1}) (Table 2). Moreover, a higher number of affected tubers by disease, size, malformed and tubers green color and pre-harvest sprouting on tubers was observed within none earthing up combined within normal growth potato. This result agreed with Tafi et al. (2010) reported that soil adding to the plant affects potato product structure. This is due to the appropriate time of soil adding for active physiological growth stages that create a favorable soil environment for plant growth and development.

Table. 2. Interaction effect of flower removal and earthing up time on marketable tuber yield (MTY) , unmarketable tuber yield (UmTY) and total tuber yield (TTY) of potato grown at Eastern Tigray, Ethiopia

Treatments		Parameters		
Flower removal stage	Earthing up time	MTY (ton ha^{-1})	UmTY (ton ha^{-1})	TTY (ton ha^{-1})
Normal growth	Control (No earthing up)	8.63e	2.1a	10.74^{e}
	At 15 days	22.87cd	1.07bcde	23.94^{cd}
	At 30 days	26.56abc	1.21bcd	27.77^{abc}
	At 45 days	26.1abc	1.29bc	27.4^{abc}
	At 60 days	13.54e	1.83a	15.37^{e}
Flower bud removal	Control (No earthing up)	23.62cd	1.01cdef	24.63^{cd}
	At 15 days	30.25a	0.71f	30.96^{a}
	At 30 days	30.1a	0.83ef	30.93^{a}
	At 45 days	29.07ab	0.89def	29.96^{ab}
	At 60 days	23.05cd	1.08bcde	24.13^{cd}
Flower removal	Control (No earthing up)	20.33d	1.13bcde	21.46^{d}
	At 15 days	24.25bcd	0.96def	25.21^{bcd}
	At 30 days	26.36abc	1.03cdef	27.39^{abc}
	At 45 days	24.79bcd	1.15bcde	25.94^{bcd}
	At 60 days	20.57d	1.39b	21.96^{d}
LSD (0.05)		4.94	0.33	4.88
Level of significance		*	*	*
CV (%)		13.1	16.59	12.34

Means followed by the same letter were not significantly different at p = 0.05, according to the LSD test. ; * = significant at 5% level of probability.

Total Tuber Yield

Total tuber yield of potato was significantly ($p < 0.05$) influenced by flower removal stage, earthing up time and their interactions (Table 2). Results revealed that the highest total tuber yield (30.96 ton ha^{-1}) was recorded from flower bud removed potato earthed up at 15 days after complete emergence, but statistically similar with 30 days after full emergence (30.93 ton ha^{-1}). On the contrary, the lowest total tuber yield (10.74 ton ha^{-1}) was collected from normal growth potato without earthed up. However, it was no significant difference with the result found from normal growth potato earthed up at 60 days after full emergence (15.37 ton ha^{-1}) (Table 2). This indicates that flower and fruit development had a depressing effect on tuber development, which may be due to active competition for assimilate among flowers and fruits and developing tubers (Tekalign 2005). Ali (2016) also reported that potato fluorescence removing made an increase of 13% in tuber yield compared to treatment without fluorescence removing. Similarly, Nazari (2010) and Tekalign (2005) also reported that potato tuber yield would be increased to 9% and 18% when the fluorescence was removed as compared to non-removed, respectively. The result also in agreement with research done by Hassen et al. (2013) on anchor accessions; flower bud removal treatment increased root yield by 15.87% as compared to non-removed. This is due to the strong competition existing between the reproductive and root part.

CONCLUSION

The flower removal stage and earthing up time affected plant height, stem number, tuber length and diameter of potato. Earthing up time affected fresh shoot biomass and physiological maturity of potato, but not affected by flower removal stage and its interaction with earthing uptime. The interaction effect of flower removal stage and earthing up time affected average tuber weight, total fresh biomass, marketable tuber yield, unmarketable tuber yields as well as total tuber yield of potato. Therefore, considering the findings of the present experiment, flower bud removed potato earthed up at 15 days after full emergence was better in terms of all yield contributing characters and tuber yield.

ACKNOWLEDGMENT

We want to thank Adigrat University for funding and providing all the necessary materials and facilities required for the research.

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