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Response of Off-season Grown Potato (*Solonum tuberosum* L.) Varieties to Effects of Fertilizer Rates and Harvesting Dates

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ABSTRACT

The experiment was conducted in Bulle, one of the highlands in Southern Ethiopia. Two released varieties viz Menagesha and Tocha were used to study their off-season performance with fertilizer treatments and different harvesting dates. The experiment was laid out in a 3.5 m by 5 m factorial arrangement in RCBD with three replications. Number of tubers/hill, number of stems/hill, marketable and total tuber yield/ha and plant heights were significantly ($p<0.05$) higher in variety Menagesha than Tolcha. Significantly ($p<0.01$) higher number of stems/hill, and tubers/hill were recorded due to application of 55.5/44.85 N/P kg/ha. The number of tubers/hill was significantly ($p<0.01$) higher for Menagesha variety at 135 days after planting (DAP). The numbers of tubers/hill were constant for Tolcha varieties at 105, 120, 135 or 150 DAP. However, the number of marketable tubers and small sized tubers/hill were significantly higher for Menagesha variety when harvested in 135 and 120 DAP, respectively. This study indicates that off season ware potato production using both Tolcha and Menagesha varieties gave better yield at harvesting date of 120 and 135 DAP, and at 105 and 120 days after planting, respectively for seed tuber production purpose with application of 55.5/44.85 N/P kg/ha.

Key Words. Mnagesha, Tolcha, tuber, marketable, potato tuber moth, off-season

INTRODUCTION

The total area under potato production in Ethiopia is well over 120,000 ha with an average yield of 8 t/ha. (Beyene *et al.*, 1998 and Gebremedhin *et al.*, 2003). Southern Ethiopia is one of the main potato growing areas of the country and it has two growing seasons. The first season locally called "*meher*" begins in July/August and ends in October while the second season called "*belg*" extends from February to July. The "*meher*" which is the main season of potato production is characterized by sole cropping and cultivation in large plots of land in rotation with barley, wheat, faba bean or maize mainly for sale in local market. Conventionally, where the main (*meher*) season of potato production falls in rainy periods (e.g August), then late blight incidence was controlled by adjusting the planting dates (planting in the first week of August) and by rotating with maize. Contrary to this, off-season (*Belg*) potato production is manifested by sole cultivation in smaller plots of land and intercropping with cereals like maize with primary purpose of using the harvested tubers for seed purpose in the following season. Moreover, many farmers leave their lands unploughed (fallowed) for six to eight months thinking that off season production might not be economically feasible. Thus, land resources were not optimally utilized and whereas, the productivity of released cultivars under off season production system has not been known and production package for off season potato cultivation has not been developed to utilize existing land resources optimally.

In mid altitude areas of southern Ethiopia, potato is grown during off-seasons were used as source of planting materials in the main season because

of environmental conditions that favor local storage such as heaps (piles) of potato tubers covered by enset leaves in home gardens which intern creates higher temperature and lower humidity there by allowing earlier greening and sprouting than those in higher altitudes. Even though, potato tuber seed production in mid altitude areas like those mentioned above can not be considered as reliable seed source mainly because of late blight infestation owing to higher temperature and humidity. However, farmers of mid altitude areas used to plant all sorts of tubers without any consideration for sprouting, age and size of tubers. In higher altitude areas potato storage conditions actually maintain the physiological health but the existing higher humidity, shorter sunshine hours and lower temperature usually delay greening and sprouting of tubers. On the other hand, poor tuber seed quality has always been a bottle neck in the production of potato in developing countries in general and in Ethiopia in particular lack of proper care during growth period rectifies the losses resulting from poor quality seed.

Differences in harvesting dates cause paramount differences in sprouting ability and its end out put by setting variation in physiological and chronological ages of the crop (Vos, 1999). The use of young seeds caused late emergence, tuberization and maturity, but with high foliage production, greater tuber number and yield was attained, which is actually in direct contrast to physiologically old seed tubers. Tubers of different physiological age will show difference in emergence, crop development, length of growth period and ultimate out put (Wiersema, 1985). Booth *et al.* (1981) also suggested that distribution of harvesting time has been vital as alternative for distribution pattern as plant activity within each of the growth stages can not be independent of previous stages. Salter and Goode (1976) have also shown that the total growth and yield performance of any crop remain the summation of all previous stages. Increasing the application of nitrogen, lowered the starch content of the tubers that subsequently delayed maturity of the crop and thereby making the tubers susceptible to skinning and bruising during harvest, which ultimately lead to poor quality seed tubers (Thompson and Kelly, 1979). Wiersema (1985) also showed that length of dormant period of seed tubers varies based on the nature of variety, soil moisture, soil fertility and storage temperature. The absence of sprouted, healthy and mature potato seed tubers in the Southern region of Ethiopia is mainly due to lack of adequate seed potato package.

Hence, this experiment was initiated with the objectives of evaluating the potential productivity of off-season planted potato varieties, identifying appropriate nitrogen x phosphorus rates and harvesting dates that maximize off season potato production

MATERIALS AND METHODS

The experiment was conducted from 2005-2007 cropping seasons in Bulle, Southern Region of Ethiopia, with an altitude of 2800 m.a.s.l. The treatments included two nationally released and locally adapted cultivars ("Menagehsa" and "Tolcha"), three NP fertilizer rates (0% (0N, 0P), 50% (55.5N, 44.85 P) and 100% (111N, 89.7P) of the nationally recommended 165 kg urea /ha and 195 kg DAP/ha for ware potato in the main season and five levels of harvesting dates (90, 105, 120 , 135 and 150 DAP were arranged factorially in randomized complete block design with three replications. Fertilizer was drilled in a row and planting of uniform sized pre-sprouted tubers was done using spacing of 60 cm x 20 cm in February of 2005, 2006 and 2007. Plants were dehaulmed (removal of vegetative growth) 15 days prior to each harvesting date to prohibit contact of foliage leaf blight pathogens with the soil and tubers, and allow hardening off the tubers.

Plant height and stand count data were collected by measuring plant height from ground to bottom of inflorescence. Yield components such as number of tubers/hill and tuber yield/plot were counted at the spot during harvesting. All tubers obtained from net plot area were grouped into undersized (<30 mm diameter), medium sized (30-60mm diameter) and oversized (>60 mm diameter) in order to know the number of seed

tubers for the storage trial in diffused light store (DLS). At he 3rd and 6th months of storage, data were taken on total tuber number and weight, and number of sprouted and rotten tubers. Finally, percentage weight loss due to sprouting and rotting were calculated. To normalize the data, percentage and count values were transformed and all data were subjected to analysis of variance following the appropriate procedure for 2 X 3 X 5 factors as suggested by Gomez and Gomez (1984).

RESULTS

Yield and yield components

The main effect of variety was significant on number of tubers/m^2($P<0.01$), marketable and total tuber yield /m^2, but not on number of tubers/hill and unmarketable tuber yield ($P<0.01$). Results indicated that Menagesha produced more number of tubers/m^2, higher marketable tuber yields m^2 and greater total tuber yield/m^2 than Tolcha. When averaged across varieties and harvesting dates, the effects of fertilizer rates were significant ($P<0.01$) on number of tubers/hill, marketable tuber yield and total tuber yield/m^2. Consequently, highest number of tubers/hill were recorded from plants that had received 55.5/44.85 N/P kg/ha than either from the control (0/0) or highest rate of N/P fertilizer (111/89.70 N/P kg/ha). Significantly lower number of tubers/hill were recorded from unfertilized plants. The number of tubers/hill increased significantly as fertilizer application was raised to 55.5/44.85 N/P kg/ha, and fallen significantly as fertilizer levels were raised to 111/89.70 N/P kg/ha. Marketable tuber yield/m^2 followed similar patterns to that of number of tubers/hill.

The main effects of harvesting dates were significant on number of tubers/hill, total tuber number/m^2, marketable tuber yield/m^2 and total tuber yield per unit area (Tale 2) while the unmarketable tuber yield was not significant ($p<0.05$>. Harvesting ninety days after planting produced significantly lower number of tubers/hill ($p<0.01$), marketable tuber yield/unit area ($p<0.01$), and total tuber yield/unit area ($p<0.01$) than other levels of harvesting dates. However, the number of tubers/hill were not variable whether harvesting was conducted on 105th, 120th, 135th or 150th days after planting. Delaying harvesting up to 150 days after planting resulted in significantly ($p<0.01$) higher marketable and total tuber yield per unit area than at the rest of the harvesting dates.

Furthermore, harvesting 135 days after planting produced significantly higher ($p<0.05$) marketable and total tuber yield than harvesting at 90, 105 and 120 days after planting (Table 2). However, delaying harvesting beyond 105 -120 days after planting did not result in variable marketable and total tuber yield.

When variety x fertilizer rate (V x F) interactions were considered, significantly higher ($p<0.01$) total and marketable tuber yield/ha was obtained from Menagesha at higher levels of fertilizer application (≥ 55.5/44.85 N/P kg/ha). On the contrary, significantly lowest total and marketable tuber yield was attained in both Menagesha and Tolcha in plots where no fertilizer was applied (Table 4). Variety Tolcha that had received 55.5/44.85 N/P kg/ha produced significantly higher marketable and total tuber yield/ha as compared to the lower fertilizer levels.

When variety x harvesting dates (V x H) interaction was considered, the number of tubers/hill was significantly ($p<0.01$) higher in Menagesha harvested at 135 DAP compared to other V x H interaction levels. Significantly lowest number of tubers/hill was recorded in Menagesha variety when harvesting was conducted at 90 DAP. The number of tubers/hill was constant/invariable in Tolcha variety whether harvesting was conducted in 105, 120, 135 or 150 DAP. Total and marketable tuber yield was significantly higher ($P<0.01$) in Menagesha variety when harvested later than 135 DAP compared to other V x H interaction levels. Earlier harvesting (≤ 105 DAP) produced significantly lower total and marketable tuber yield required for ware potato production compared to other interaction levels in both varieties (Table 4).

Table 1. Mean squares of growth, yield and potato tuber seed quality parameters at Bulle (2004-2006)

Sources of error	Degree of freedom	NSST	WSST	TTN	Total tuber yield	TTWAS	WLP ATM	Stems /hill	Tubers /hill	Plant height
Replication	2	11.6*	0.091*	2813.5*	5.4ns	11.9**	0.001ns	1.491ns	2.420ns	668.9***
Variety	1	6.4ns	0.035ns	11724.8***	25.2*	8.1*	0.458***	7.242**	4.620ns	3893.1***
Year	2	8.23ns	0.121ns	3221.3***	173.7**	0.9ns	0.008ns	2.543***	96.4**	23926.4**
NP	2	30.4*	0.179**	1870.8ns	14.8*	7.6*	0.003ns	68.9**	36.31***	8095.5***
Variety x NP	2	10.6ns	0.012ns	708.8ns	2.9ns	3.5*	0.0029ns	0.857ns	4.08ns	32.1ns
HD	4	944.7***	0.967***	38930.9***	187.2***	94.8***	0.021*	1.456ns	27.02***	145.2ns
Variety x HD	4	146.9***	0.119***	10406.3***	31.1***	12.3**	0.05***	0.547ns	16.08***	549.9***
NP X HD	8	32.5ns	0.021ns	1.0968ns	4.5ns	4.8*	0.011ns	3.709***	5.864*	239.2*
Variety x NP x HD	8	10.9	0.018ns	184.9ns	1.8ns	1.4*	0.013*	2.451**	6.956*	188.8*
Error	58	194.8	0.025	925.1	4.2	1.882	0.006	0.841	3.003	91.6
CV (%)		14.4	19.5	12.3	26.3	19.2	31.9	22.1	24.2	18.8

*,**,***- indicates significant difference at 0.05, 0.01 and 0.001 level of probability and ns-indicates absence of significant difference at 5% level of probability. NP= Nitrogen x phosphorus rate, HD= harvesting dates. NSST= number of seed sized tubers, WSST = weight of seed sized tubers, TTN =total tubers number at harvest/m^2, TTWAS =total tuber weight after 6th month of storage, WLPATM= weight loss percentage after three months of storage

Table 2. Means of growth and yield components of Irish potato grown in off season at Bulie (2004-2006)

	Tubers /hill	Total tubers number (no/m²)	Plant height (cm)	Stems /hill	Total tuber yield (t/ha)	Marketable tuber yield (t/ha)	Unmarketable tuber yield (t/ha)
Year							
2004	7.95	66.22	53.16	4.66	28.24	13.92	4.33
2005	5.96	49.55	33.51	3.12	32.83	29.70	3.13
2006	7.58	63.06	66.05	4.65	41.28	35.10	4.20
SE(±m)	0.19**	4.3**	1.09**	0.11**	5.02**	4.08**	ns
Variety							
Menagesha	7.36	61.3	55.02	4.32	33.44	29.43	4.01
Tolcha	6.95	57.9	46.79	3.97	26.80	23.04	3.76
SE(m±)	ns	3.04*	0.89**	0.08**	0.93**	0.93**	ns
Fertilizer rates							
0N,0P	6.51	54.2	41.20	3.82	22.88	19.36	3.52
55.5N, 44.85 P	7.78	64.8	51.12	4.26	33.28	28.96	4.32
111N, 87.9P	7.19	59.9	60.40	4.35	34.24	30.56	3.68
SE(m±)	0.18**	5.2**	1.02**	0.09**	1.06**	1.07**	ns
Harvesting dates							
90	6.16	51.3	48.51	4.39	18.88	15.20	3.68
105	7.22	60.1	52.34	4.00	24.00	20.80	3.20
120	7.19	59.9	50.35	4.02	26.24	21.60	4.64
135	7.50	62.5	50.64	4.09	38.56	33.92	4.64
150	7.60	63.3	52.69	3.81	43.04	39.68	3.36
SE(m±)	0.24**	2.4**	ns	ns	1.4**	1.33**	ns
CV(%)	24.2	12.3	18.8	22.1	26.2	28.6	29.0

*,** indicates significant difference at 0.05 and 0.01 level of probability and ns- indicates absence of significant difference at 5% level of probability.

Tuber size grades

The effect of variety was significant ($p<0.05$) on number and weight of under sized and medium sized tubers, but not on number and weight of oversized tubers (Table 3). Accordingly, variety Tolcha produced significantly higher number ($p<0.01$) and weight ($p<0.05$) of oversized tubers than variety Menagesha. However, the percentage of small-medium sized tubers was invariable between the two varieties and is well above 74%. The number and weights of medium sized tubers were affected significantly by main effects of fertilizer rates, unlike the numbers of both undersized and oversized tubers. Weights of medium sized tubers were significantly ($p<0.01$) lowest at 0/0 N/P kg/ha, significantly highest at 111/89.70 N/P kg/ha compared to other level of fertilizer rate. Thus, the number of seed sized tubers reached climax due to application of 55.5/44.85 N/P kg/ha. The numbers of over sized tubers increased as days of harvesting were prolonged from 90 to 105, which was increased by 43, 89.2, 93.7 and 94.7% for 105 ,120 ,135 and 150 days of harvesting after planting respectively. Conversely, the numbers of under sized tubers decreased as days of harvesting were prolonged from 90 to 150, which is decrement of 71.4, 75.5, 80.9, 87.9 % in 105 ,120 ,135 and 150 days of harvesting after planting, respectively. Consequently, percentage of seed sized tubers were significantly higher due to earlier harvesting at 90, 105 and 120 days after planting than 135 and 150 days after planting.

When interaction effect was considered, strong significant ($p<0.05$) response was obtained from number and weight of seed sized tubers in response for V x H interaction; however, variety x fertilizer rate interaction resulted in non-significant ($p<0.05$) response on number and weight of all tuber groups considered. Accordingly, the number of seed sized tubers/m^2 was significantly ($p< 0.01$) highest for Menagesha when harvested 120-135 DAP compared to other interaction levels of V x H interaction. Significantly lowest number of seed sized tubers/m^2 was recorded due to harvesting in 90 DAP in both varieties. The number of seed sized tubers/m^2 in Tolcha variety were invariable whether harvesting was conducted at 105, 120, 135 or 150 DAP. The number of oversized tubers/ m^2 were significantly ($p<0.05$) in Menagesha variety due to harvesting of 150 DAP compared to other levels; while the number of oversized tubers/ m^2 was significant so in Tolcha when harvesting was delayed until 135 DAP or more.

Potato tuber quality parameters three months after storage in diffused light store(DLS)

Weight loss percentage after three months of storage in DLS was significantly higher ($P<0.05$)in variety Menagesha (42.2%) than that of variety Tolcha (37.8%) (Table 3). However, sprouting percentage was significantly ($P<0.01$) higher in variety Tolcha (72.6%) than that of Menagesha (24.5%) when measured after three months of storage. Likewise, delayed harvesting ($\geq$ 120 days after planting) also resulted in significantly ($P<0.01$) higher percentage of sprouts than earlier levels of harvesting (<120 days after planting). However, fertilizer rates did not affect significantly ($P<0.05$) weight loss and sprouting percentages within three months of storage.

Potato tuber quality parameters six months after storage in diffused light store(DLS)

Rotted tubers number per unit area were significantly ($P<0.05$) higher in variety Menagesha than that of Tolcha (Table 3). However, sprouted number of tubers was not variable after six months of storage in DLS between Menagesha and Tolcha varieties. Similarly, weight loss, rotting and sprouting percentages were not significant between the two varieties after six month of storage in DLS. Weight loss percentages were significantly ($P<0.05$) higher due to fertilizer application than the unfertilized or zero treatment. Harvesting dates affected tuber seed traits significantly. Accordingly, weight loss and rotting percentages were significantly ($p<0.01$) higher due to delayed harvesting (harvesting at 120,135 and 150 days after planting) than earlier harvesting (harvesting at 90 and 105 days after planting). When sprouting percentages were considered, significantly lower sprouting percentages were recorded due to earlier harvesting at 90 days after

Table 3. Means of seed tuber size categories, sprout, weight loss and rotting percentages as affected by varieties, fertilizer rates and harvesting dates at Bulle (2004-2006)

Treatments	Before storage in DLS									After 3 months storage in DLS		After six months storage in DLS					
	Undersized tubers		Seed sized tubers		Over sized tubers		Total tubers number (no/m^2)	Total tuber weight kgm^2	Seed sized tubers %	Weight loss %	Sprout %	Total tubers weight - kg/m^2	Rotted tuber number (no/m^2)	Sprouted tuber number (no/m^2)	Weight loss %	Rotting %	Sprouting %
	no/m^2	weight kg/m^2	no/m^2	weight kg/m^2	no/m^2	weight kg/m^2											
Variety																	
Menagesha	1.51	0.030	48.39	1.923	11.41	1.391	61.3	3.34	79.7	42.4	24.5	2.34	5.61	55.58	56.40	9.60	90.70
Tolcha	1.07	0.023	42.80	1.654	14.03	1.003	57.9	2.68	73.9	37.8	72.6	1.98	3.72	52.89	57.0	6.4	91.4
SE(m±)	ns	ns	ns	ns	0.61**	0.045*	3.04*	0.093**	ns	1.3*	2.7**	0.093*	0.21*	ns	ns	ns	ns
NP																	
0/0	0.95	0.019	44.54	1.738	8.71	0.531	54.2	2.29	82.2	38.7	42.9	1.393	4.00	49.2	45.1	7.4	90.8
55.5/44.85	1.40	0.029	52.36	2.166	11.04	1.133	64.8	3.33	80.8	42.1	48.6	2.444	4.70	59.1	59.2	7.2	91.2
111/89.70	1.73	0.035	46.67	1.887	11.50	1.502	59.9	3.42	77.9	39.4	49.9	2.530	5.10	54.8	59.9	8.5	91.5
SE(m±)	ns	ns	0.63**	0.045**	ns	0.204*	5.2**	0.106**	1.2*	ns	ns	0.106*	ns	ns	4.6*	ns	ns
Harvesting dates (DAP)																	
90	5.20	0.422	45.12	1.405	0.98	0.061	51.3	1.89	87.9	36.4	36.5	1.132	3.30	42.90	42.10	6.40	83.60
105	1.49	0.029	56.89	2.160	1.72	0.611	60.1	2.40	94.6	39.1	39.8	1.354	4.50	53.00	42.30	7.50	88.20
120	1.27	0.025	56.91	2.446	8.92	0.154	59.9	2.62	95.0	39.5	41.9	1.640	4.91	53.50	47.90	8.20	89.30
135	0.99	0.021	45.92	2.127	15.59	1.708	62.5	3.86	73.5	41.1	64.1	2.575	5.25	56.80	55.30	8.30	90.90
150	0.63	0.013	44.19	2.163	18.48	2.128	63.3	4.30	69.8	44.3	54.5	2.925	5.34	57.50	57.30	8.40	90.80
SE(m±)	0.29**	ns	0.51**	0.051*	0.6**	0.16*	2.4**	0.14**	3.1*	ns	4.3**	0.039**	0.50*	0.63**	4.2*	0.57*	1.2**
CV(%)	**25.1**	**26.4**	**14.4**	**19.5**	**13.9**	**13.8**	**12.3**	**26.2**	**20.4**	**31.9**	**27.3**	**19.2**	**8.5**	**6.8**	**34**	**11.6**	**31.4**

*,** indicates significant difference at 0.05 and 0.01 level of probability and ns-indicates absence of significant difference at 5% level of probability. DAP= days after planting, under sized tuber seed means tuber seed belonging to < 30mm diameter size, seed sized tuber seed means tuber seed belonging to 30mm up to 60mm diameter sized tubers, over sized tuber seed means tuber seed belonging to >60mm diameter size

Table 4. Means of tuber yield and seed size before and after storage in DLS as affected by variety x fertilizer rate and variety x harvesting dates interaction

Variety		FERTILIZER RATE		
	0.0	55.5/44.85		111/89.70
		Total tuber yield (t/ha) before storage		
Menagesha	28.00	38.06		38.09
Tolcha	20.50	29.64		32.79
SE(m±)	1.55**			
		Marketable tuber yield (t/ha) before storage		
Menagesha	23.20	33.77		31.132
Tolcha	17.04	25.23		29.17
SE(m±)		1.52*		
		HARVESTING DATES (DAYS AFTER PLANTINGS)		
	90	105	120	135	150
		number of tubers/hill		
Menagesha	5.93	6.70	7.26	9.11	7.82
Tolcha	6.26	7.71	6.59	7.33	6.93
SE(m±)			0.334**		
		Total tuber yield (t/ha) before storage			
Menagesha	19.6	24.2	28.3	45.7	49.3
Tolcha	21.5	25.1	25.9	30.9	34.8
SE(m±)			1.99**		
		Marketable tuber yield (t/ha) before storage			
Menagesha	16.1	21.2	38.7	40.0	45.5
Tolcha	17.5	21.6	20.9	27.3	31.8
SE(m±)			1.95*		
		Seed sized tubers number /m² before storage			
Menagesha	22.9	38.3	63.6	63.9	55.5
Tolcha	26.2	46.6	48.2	47.5	45.1
SE(m±)			2.55**		
		Over sized tubers number/ m² before storage			
Menagesha	8.36	8.50	10.29	14.35	15.59
Tolcha	11.86	12.25	13.18	17.28	15.77
SE(m±)			0.77*		
		Weight of tubers after six months of storage(t/ha)			
Menagesha	7.43	7.93	18.49	43.26	53.16
Tolcha	7.56	15.91	19.85	25.83	35.59
SE(m±)			3.14**		

*,** indicates significant difference at 0.05 and 0.01 0 level of probability and ns-indicates absence of significant difference at 5% level of probability

planting than other harvesting levels. But, harvesting at 105, 120, 135 and 150 days after planting showed invariably no sprouting percentage difference when observed after six months of storage.

When V x H interaction effects were considered, strong significant ($p<0.05$) response was obtained from total tuber weight and weight loss percentage ($p<0.05$) after storage for six months. Moreover, V x H interaction resulted in significant ($p<0.05$) response on total tuber weight after storage for six months, but weight loss percentages was insignificant. Results further indicated that weight of tubers after six months of storage in DLS was significantly higher ($p<0.01$) in both Menagesha and Tolcha varieties when harvesting was delayed to 150 DAP compared to other V x H interaction levels.

DISCUSSIONS

Menagesha variety produced significantly higher number of tubers/hill, number of tubers/m^2, number of stems/hill and significantly taller plant heights than tolcha variety, due to which in turn significantly higher marketable and total tuber yield/ha were recorded unlike that of variety Menagesha. The amount of seed sized tubers obtained from both varieties is well above 74%. This result is in line with finding of Kaela (1990) who justified off-season production of seed potato on five Zambian varieties with low pest and disease pressure. Variety Tolcha produced significantly higher number ($p<0.01$) and weight ($p<0.05$) of oversized tubers than variety Menagesha. As large sized tubers, mainly large sized ones do not plant wide area of land and could be sold better as ware potato, are generally preferred for consumption than smaller sized ones, tolcha variety suits very well to this end. Sprouting percentage was significantly ($P<0.01$) higher in variety Tolcha (72.6%) than that of Menagesha (24.5%) when measured after three months of storage. This is a manifestation that tolcha variety might be planted after 3rd month of storage in DLS even in the colder part of the country. The result is in agreement with that of Rueda *et al.* (1990) who obtained sufficient sprouts in 33 days from Ndinamagara variety as opposed to Uganda-11 variety which produced sprouts in 131 days after storage. The lower sprouting percentage observed after three months of storage in Menagesha variety was due to possession of higher water content, lower storage temperature and higher storage humidity, which may have not favored adequate media for bud initiation and sprouting. Menagesha is a preferred variety for stew preparation but Tolcha is the preferred for cooking primarily due to its high dry matter content as compared to Menagesha, which is more watery and bulky. However, as the criteria of requirement are different for both varieties, they both were favored in the production.

The effects of fertilizer rates were significant after 6th months storage on most parameters considered in this study with the exception of the no significant weight loss percentage obtained in the 3rd months in the store. This could be due to increased accumulation of tuber weight in fertilized plots earlier in the growth period of the crop which allowed higher moisture loss in later stages and hence manifesting that an increase in fertilizer application during planting can also increase weight loss percentages after six months storage in DLS.

Harvesting dates affected significantly number of seed sized tubers, weight of seed sized tubers, number of tubers/m^2, total tuber yield/ha, total tuber weight after 6th month of storage in the DLS, weight loss percentage after 3rd month of storage and number of tubers/hill. The effects of harvesting dates were insignificant upon number of stems/hill, plant height and unmarketable tuber yield. The insignificant response of number of stems/hill, plant height and unmarketable tuber yield due to the effects of harvesting dates could be attributed to determination of growth components and unmarketable yield earlier in the vegetative phase before tuberization reaches its climax. Delayed harvesting produced significantly ($p<0.01$) higher weight after six months of storage in the DLS than earlier harvesting in both Menagesha and Tolcha varieties. As a result weight loss of 86.0, 85.1, 65.2, 18.6 % and 78.8,

55.3, 44.2, 27.4 % were measured in Menagesha and Tolcha, respectively at harvesting dates made on 90, 105, 120 and 135 DAP as compared to harvesting on 150 DAP. This could be attributed to the fact that tubers accumulate more dry matter in later stages of tuberization than earlier stages in direct contrast to water which potato tubers accumulate more in earlier stages of tuberization than later stages. Weight loss and rotting percentages were significantly ($p<0.01$) higher due to delayed harvesting (harvesting after 120,135 and 150 days after planting) than earlier harvesting (harvesting after 90 and 105 days of planting). This could be due to the phenomenon of senescence that is likely to occur as aging proceeds. The results showed that increase in fertilizer application during planting also increased weight loss percentages after six months storage in DLS. Thus, seed production scheme that endorses earlier harvesting reduces storage losses due to reduction in weight loss (dehydration) rotting and shriveling.

The number of tubers/hill and seed sized tubers/m^2, were constant in Tolcha regardless of harvesting dates that is 105, 120, 135 or 150 DAP. However, the number of tubers/hill and seed sized tubers/m^2 were significantly higher when harvested 135 and 120 DAP, respectively in Menagesha variety. This indicates that yield components and yield were determined 15 days earlier or so in Tolcha compared to that of Menagesha. Accordingly, as measures of marketable yield are indications of ware potato performance, off season production of both Tolcha and Menagesha should follow harvesting after 120 and 135 DAP, respectively and application of 55.5/44.85 N/P kg/ha appeared to be optimal for ware potato production purpose. Conversely, based on V x H interaction, and V x F interaction effects on number of seed sized tubers/m^2, Menagesha variety might be harvested at 120 DAP where as Tolcha variety could be harvested at 105 DAP with the application of 55.5/44.85 N/P kg/ha for seed tuber production purpose. The production of desireable seed size range in earlier harvesting dates could be attributed to restriction of growth period, prevention of late blight infestation and restriction of tubertization, which is in agreement with the findings of Kaela (1990).

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