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Research Report

Research Experience *and* Recommended Technologies *for* Potato Production *in* Western Oromiya

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Introduction

Among the root and tuber crops the production coverage of potato stands next to enset (*Ensete ventircosum* L.). Potato production and utilization has been established better than other root and tuber crops. Its demand is rising because it is processed into different products and served as snacks in restaurants especially in big towns.

Potato is efficient in converting resources such as labor and capital into a high-energy food. Its efficiency of protein production is also higher than commonly realized. If carefully managed, it gives the highest yield of nourishment per hectare of all basic foodstuffs in tropical and subtropical countries. Further more, the growing period is only 90-125 days, enabling multiple cropping for optimum use of the available land and moisture. Hence, it is noted that in potato producing areas double cropping is possible (Solomon, 1985). It is one of the major food crops widely grown in high and mid altitude areas of western Ethiopia. It is mainly produced as food and income security. It is a reliable crop during short and erratic rainfalls. However, the average national yield for Ethiopia is 8 t ha^{-1} and for western region could be lower than that of the national. The national average yield is low when compared with other African. Several biotic and abiotic constraints contribute to the very low yield of potato production in high and mid altitudes of Ethiopia. Among the important ones are shortage of good quality seed tubers, lack of high yielding disease resistant/tolerant varieties, use of sub-optimal management practices, pre and post harvest losses from insect and disease; poor storage facilities and marketing infrastructures, and inadequate technology transfer efforts.

To address some of potato production constraints of western Ethiopia, research has been carried out on potato for more than two decades at Bako Agricultural Research Center and recently at its sub-sites, Arjo and Shambu. Thus, on this paper we presented potato research achievements on variety improvement and agronomic management practices, and indicated future research and development direction for sustainable contribution of potato as food and income security crop to smallholder potato farmers of the region.

Research Achievements

Breeding

At Bako Agricultural Research Center, potato research began in 1971. However; in collaboration with the Coordinating Centers of Potato National Improvement Program, Alemaya University of Agriculture and Holetta Agricultural Research Center; a well-planned and designed experiments have been started since 1981.

In 1985 cropping season, 86 potato genotypes were evaluated at Bako Agricultural Research Center in non-replicated plot to select the best adaptable varieties, which are high yielding and disease resistant/tolerant. Accordingly, 35 the top performing potato genotypes with respect to yield, maturity, and tuber quality and disease reaction were advanced for the next season evaluation step.

In 1986 cropping season, similar screening activity of potato genotypes were made for desirable horticultural characteristics and attributes. The study was undertaken on 35 potato genotypes promoted from 1985 cropping season evaluation. Out of these, 26 potato genotypes, which gave better tuber yield as well, better in disease reaction over the standard check, were promoted for further study. All the genotypes under study except CIP378501-10 and AL-264 were well germinated and had performed better than 1985 cropping season. The probably reason reported for the poor performance of the above two genotypes were sprout breakage and damage of tuber during transportation and physiological aging. Except AL-252 and CIP378328-8, all the potato genotypes were attacked by late blight disease. In fact, all the CIP series potato genotypes showed good relative resistance to late blight disease.

Variety Trial

As Bako Agricultural Research Center is one of the multi-locations in Potato Improvement Program of the country, 21 potato genotypes were evaluated in 1981 and 1982 cropping seasons along with local check for their adaptability disease reaction, yield and quality of tubers The study was employed using randomized complete block design with three replications. Analysis of variance showed that there were significant differences among potato genotypes with regard to marketable and total tuber yield in 1981 and non-significant difference in 1982 cropping season. AL-646 gave the highest total and marketable tuber yield followed by AL-601 and AL-634.

Among potato genotypes marketable and total tuber yield ranges from 98.5 to 369.9 q ha^{-1} and from 114.6 to 388.1 q ha^{-1}, respectively in 1981, and 53.3 to 263.4 q ha^{-1} and 95.2 to 419.8 q ha^{-1}, respectively in 1982 cropping seasons, among the genotypes under study. This study indicated that there are huge variations in tuber yield potential among potato genotypes tested. This probably explains the inclusion of diverse potato genotypes with varied yield potential and adaptation under different environments.

Similarly, in 1983 cropping season 21 potato genotypes were evaluated at Bako Agricultural Research Center in randomized complete block design with three replications, to identify and develop late blight resistant genotypes with high tuber yield to the area. The analysis of variance indicated that there were highly significant differences among potato genotypes in number of tuber per plant and marketable and total tuber yield, while weight of tuber per plant was non-significantly different. The top yielding genotypes identified were AL-556, AL-578, AL-100, AL-517, AL-615 and AL-601. Late blight disease scoring was made since the onset of the disease. Disease symptom was observed at early vegetative growth stage on AL-404, AL-528 and AL-646 as compared to the other genotypes under evaluation.

In 1985 cropping season, 26 potato genotypes were evaluated including the local check for their tuber yield and quality, disease reaction, and adaptability over locations. Analysis of variance showed that there were highly significant differences among potato genotypes with regard to marketable and total tuber yield. AL-531 gave the highest marketable tuber yield followed by AL-624 and AL-517, respectively. While AL-517 gave the highest total tuber yield followed by AL- 531 and AL- 624. More than 50% of the cultivars gave more tuber yield over the standard check, AL-100. During the growing period all genotypes except CIP378367.4, were attacked by late blight disease.

Similarly, during 1987 to 1989 cropping seasons, 11 potato genotypes were evaluated at Bako Agricultural Research Center for yield and yield components. The study was under taken using randomized complete block design with four replications. Analysis of variance showed significant differences among potato genotypes with regard to total and marketable tuber yield in all the study years. The genotypes, CIP378329.7, K-59 (A) 26 and AL-107 outsmarted the other potato genotypes under evaluation in total and marketable tuber yield (Table 1). Even though the infestation degrees differ, all the genotypes under evaluation were attacked by late blight disease.

Table 1. Tuber yield of potato as affected by genotypes at Bako in 1987-1989 cropping seasons

Genotypes	Marketable tuber yield (q ha^{-1})			Total tuber yield (q ha^{-1})		
	1987	1988	1989	1987	1988	1989
CIP378367.4	37.78	179.03	169.45	145.93	184.86	186.95
CIP378501.16	41.48	101.67	170.15	121.34	128.96	174.17
CIP378371.5	145.93	130.70	104.17	186.67	157.92	117.64
AL-107	142.22	219.93	118.06	202.96	228.27	126.53
CIP378329.8	53.33	83.40	97.22	97.04	113.96	155.56
AL-119	73.19	99.17	125.00	178.37	100.49	134.24
K-59(A)26	186.67	207.78	131.95	279.26	214.24	161.88
CIP378329.7	109.63	133.13	149.31	166.67	214.24	210.35
CIP378501.3	30.37	128.33	190.97	100.74	181.74	202.64
AL-624	144.45	-	-	218.67	136.46	-
Local	17.69	24.45	-	37.15	27.08	-

*Key: F = probability value, ** = significant (p< 0.01) and NS = non-significant (p< 0.05).*

In 1990 and 1992 cropping seasons, 10 potato genotypes were evaluated at Bako Agricultural Research Center using randomized complete block design with four replications. Analysis of variance has shown highly significant differences among genotypes with regard to marketable and total tuber yield. The genotypes CIP573268, CIP380479.6, UK-80.3 and CIP374080.5 gave high marketable and total tuber yield in 1990, while Krolisa and CIP380479.6 gave high marketable and total tuber yield in 1992 cropping season. The genotype, CIP 380479.6 produced consistent tuber yield over the two study years (Table 2). Hence these genotypes were recommended for production in Bako and similar areas.

Table 2. Tubers yield and yield components of potato as influenced by genotypes at Bako in 1990 and 1992 cropping seasons

Genotypes	Marketable tuber yield (q ha^{-1})			Total tuber yield (q ha^{-1})		
	1990	1992	Mean	1990	1992	Mean
CIP676171	194.44	100.69	147.57	224.62	105.70	165.16
CIP573268	298.61	128.47	213.54	329.12	130.69	229.91
CIP374080.5	218.75	142.36	180.56	292.71	136.60	214.66
CIP380479.6	288.20	163.07	225.64	309.74	164.79	237.27
Uk-80-3	256.94	128.47	192.71	286.75	132.78	209.77
CIP573272	190.97	86.81	138.89	201.94	91.18	146.56
CIP575051	222.22	114.58	168.40	254.92	118.20	186.56
Sisay	194.44	136.88	165.66	208.79	192.36	175.58
Krolisa	201.39	163.07	182.23	235.70	177.29	206.50
Local	48.62	38.19	43.41	51.94	42.91	47.43
F	**	**		**	**	
CV (5%)	24.45	16.87		22.57	17.00	
LSD (5%)	75.07	28.78		77.44	30.50	

*Key: F = probability value, ** = significant (p< 0.01) and NS = non-significant (p< 0.05.*

In the same fashion in 1993 and 1994 cropping seasons, eight potato genotypes were evaluated at Bako Agricultural Research Center in randomized complete block design with four replications. There were highly significant variations among potato genotypes in total and marketable tuber yield over both study years. The genotypes, CIP384321.3 and CIP384821.16 outsmarted all the other potato clones under study in total and marketable tuber yields (Table 3). In addition to better vegetative growth performance and yielding potential, CIP 384321.3 was tolerant to late blight disease. Thus, these genotypes were recommended for production in Bako areas.

Table 3. Tuber yield of potato as influenced by genotypes at Bako in 1993 and 1994 cropping seasons

Genotypes	Marketable tuber yield (q ha^{-1})			Total tuber yield (q ha^{-1})		
	1993	1994	Mean	1993	1994	Mean
CIP384327.42	99.99	102.80	101.40	169.43	158.80	164.10
CIP384321.3	49.14	176.40	112.77	195.17	279.60	237.40
CIP383121.14	64.58	85.40	75.00	98.06	136.30	117.20
CIP384821.16	154.18	151.40	152.80	178.92	173.90	176.40
CIP384229.56	113.17	128.50	120.80	156.92	158.80	157.40
AL-204	21.85	-	21.85	49.05	-	49.18
CIP378501.3	22.57	142.40	82.50	109.16	159.00	134.10
CIP2384376.3	68.50	163.20	115.90	191.71	277.20	234.45
F	**	**		**	**	
CV (%)	41.83	22.00		20.69	17.86	
LSD (5%)	45.45	55.47		43.65	55.93	

*Key: F = probability value, ** = significant (p< 0.01) and NS = non-significant (p< 0.05).*

In 1996 and 1997, seven potato genotypes were evaluated at Bako Research Center. Highly significant variations among potato genotypes in marketable and total tuber yield in both study years were observed. The mean yield ranged from 116 to 286.5 q ha^{-1} for total yield; while it was 99.4 to 262 q ha^{-1} for marketable tuber yield (Table 4). All CIP potato genotypes gave higher total and marketable tuber yield over the standard check, Awash, due to their high resistance to late blight disease. The superior genotype, CIP381376.15 high yielded all the other genotypes followed by CIP380479.6 in total and marketable tuber yield. Based on the results of this experiment, the top performed and late blight resistant genotypes, CIP381376.15 and CIP380479.6 can be recommended for production for food and income security to sub-humid mid-altitude areas of western Ethiopia.

Table 4. Tuber yield of potato as affected by genotypes at Bako in 1996 and 1997 cropping seasons

Genotypes	Marketable tuber yield (q ha^{-1})			Total tuber yield (q ha^{-1})		
	1996	1997	Mean	1996	1997	Mean
CIP380479.6	248.27	246.53	262.08	275.89	326.39	286.46
CIP382173.12	243.06	211.81	227.44	254.44	239.14	246.79
CIP381376.15	263.89	229.16	246.53	278.16	268.14	273.15
CIP383715.2	215.28	200.69	207.99	226.19	215.59	220.89
CIP382121.5	236.11	204.16	220.14	243.77	226.15	234.96
CIP383032.15	229.17	82.64	205.91	237.89	205.13	221.51
Awash	111.11	84.72	99.41	122.25	109.13	115.69
F	**	**		**	**	
CV (%)	12.15	23.27		11.17	19.34	
LSD (5%)	41.29	54.01		40.49	56.78	

*Key: F = probability value, ** = significant (p< 0.01) and NS = non-significant (p< 0.05).*

In 1998 cropping season, eight potato genotypes were evaluated for their adaptability; vegetative growth performance, disease reaction and tuber yield against the standard check, Tolcha. Randomized complete block design was employed for this study with four replications. Analysis of variance showed highly significant variation among varieties with regard to all the parameters investigated. It was noted that only one variety called Red flower is inferior to Tolcha with regard to tuber yield (Table 5). The severity of late blight disease was also highly significant among potato varieties studied.

Table 5. Tuber yield of potato as affected by genotypes at Bako (1998)

Variety	TTY (q ha^{-1})	MTY (q ha^{-1})	TN	TW (kg)	LBS (%)
Red flower	111.11	83.33	26.25	0.24	47.80
CIP381169.16	274.66	250.35	39.50	0.49	38.96
CIP 387028.1	277.78	256.95	51.00	0.56	60.00
CIP 384321.9	284.73	250.348	48.25	0.48	40.33
CIP 386029.18	222.22	201.39	31.00	0.45	57.25
CIP 387224.25	277.78	251.04	57.50	0.56	42.50
CIP 386031.4	243.06	159.13	35.00	0.46	63.05
Tolcha (Stand. Check)	121.52	97.22	30.50	0.38	47.60
CV (%)	11.06	21.4	18.87	19.05	10.91
LSD (0.05)	36.93****	60.95****	11.07****	0.126***	7.97****

Key: TTY= total tuber yield; MTY= Marketable tuber yield; TN= Tuber number; TW= Tuber weight; LBS= Late blight score.

In 1999 cropping season potato genotypes were evaluated in two sets for their adaptability, vegetative growth performance, disease reaction and tuber yield against the standard check (Awash and Tolcha) and local check varieties. The majority of the varieties evaluated under set-I during this cropping season are from that of 1998's, including few others (Table 6). Tuber yield (marketable and total) and tuber number were found significantly varied among set-I and set-II potato varieties under study (Tables 6 and 7). The varieties CIP 384321.19 and CIP 387792.5 were found tremendously superior over others that perhaps attributed to large number and weight of tuber production, respectively. In overall consideration most of varieties under set-I were superior over varieties under set-II.

Table 6. Tuber yield of potato as affected by genotypes at Bako (1999 (Set-I)

Variety	TTY (q ha^{-1})	MTY (q ha^{-1})	TN	TW (kg)
CIP 387792.5	339.25	333.35	10.00	0.56
CIP 386029.18	127.80	121.53	7.70	0.43
CIP 381169.16	201.38	188.89	11.10	0.65
CIP 386031.4	187.48	179.03	9.00	0.57
Red flower	120.13	114.58	7.70	0.38
CIP 387224.25	302.80	295.13	10.85	0.56
CIP 387028.1	256.25	250.00	12.50	0.51
CIP 381381.13	279.18	267.38	9.85	0.70
CIP 384321.19	417.35	399.25	16.10	0.43
CIP 382146.27	288.08	270.83	10.95	0.43
CIP 384321.9	324.28	315.95	10.80	0.49
Tolcha (Stand. check)	163.23	156.25	9.00	0.51
CV (%)	24.8	25.17	19.18	29.46
LSD (0.05)	89.42****	87.28****	2.89***	NS

Key: TTY= total tuber yield; MTY= Marketable tuber yield; TN= Tuber number; TW= Tuber weight.

Table 7. Tuber yield of potato as affected by genotypes at Bako (1999 (Set-II,)

Variety	TTY (q ha^{-1})	MTY (q ha^{-1})	TN	TW (kg)
CIP 387315.2	288.23	263.90	11.75	0.90
CIP 384311.3	263.23	246.53	8.55	0.84
CIP 380479.6	270.18	253.48	13.60	0.78
CIP 382121.5	279.88	260.43	11.55	0.62
CIP 384298.56	201.25	174.88	12.00	0.59
CIP 384321.16	57.70	142.38	13.45	0.84
CIP 383032.15	148.65	131.95	7.750	0.59
CIP 382173.12	286.25	270.85	11.45	0.86
Local	176.35	166.68	12.30	0.95
CV (%)	10.64	11.52	18.24	20.58
LSD (0.05)	35.74****	35.71****	3.03**	0.232*

Key: TTY= total tuber yield; MTY= Marketable tuber yield; TN= Tuber number; TW= Tuber weight.

Similarly in 2000, potato varieties including the standard check and local check were evaluated for yield and yield attributes under set-I and set-II each having 12 varieties, at Bako Agricultural Research Center. All agronomic parameters investigated tuber yield (marketable and total), tuber number and weight per plant and disease severity were significantly varied among potato varieties. The disease infestation was clearly reflected on the yield potential of the varieties i.e. the higher the disease infestation the poorer tuber yield was recorded and the vice versa (Tables 8 and 9). The vegetative growth performance and adaptation of the varieties showed their potential for further evaluation and production under wider agro-ecologies of the western Ethiopia for conclusive recommendation.

Table 8. Tuber yield of potato as affected by genotypes at Bako (2000 (Set-I)

Variety	TTY (q ha^{-1})	MTY (q ha^{-1})	TN	TW (kg)	LBS (%)
KP90134.2	237.44	228.33	9.35	0.85	13.75
CIP389701.3	153.39	132.23	11.40	0.58	21.56
CIP387676.24	161.94	132.22	10.85	0.78	18.13
KP90143.5	183.61	161.11	8.65	0.70	35.31
KP90138.12	231.56	216.67	9.35	0.87	13.13
KP90108.5	187.22	166.67	7.20	0.69	12.50
CIP387675.20	144.17	127.78	6.55	0.63	19.69
CIP386423.13	233.39	211.11	9.30	0.71	20.63
KP90134.5	265.55	255.55	9.35	1.03	21.25
CIP387675.8	178.61	150.00	11.65	0.63	31.56
Tolcha (Stand. check)	120.29	105.56	8.40	0.56	35.94
Local	41.640	37.21	5.80	0.22	66.75
CV (%)	*17.29*	*19.46*	*23.04*	*17.95*	19.01
LSD (0.05)	*44.34*****	*44.89*****	*2.98***	*0.18*****	*7.07*****

Key: TTY= total tuber yield; MTY= Marketable tuber yield; TN= Tuber number; TW= Tuber weight; LBS= Late blight score.

Table 9. Tuber yield of potato as affected by genotypes at Bako (2000 (Set-II)

Variety	TTY (q ha^{-1})	MTY (q ha^{-1})	TN	TW (kg)	LBS (%)
CIP392640.516	240.74	222.22	7.73	0.73	24.17
CIP381049.518	275.56	244.44	8.00	0.77	23.75
CIP392627.512	155.56	6.8540	6.73	0.17	65.42
CIP392650.516	219.26	207.41	11.53	0.67	18.33
CIP391058.546	193.33	185.19	6.27	0.54	21.25
CIP391058.500	140.74	118.52	10.67	0.52	32.50
CIP392650.505	284.45	266.66	11.93	0.81	20.00
CIP391058.553	122.96	125.93	8.40	0.61	18.33
CIP391058.559	150.37	133.33	6.87	0.55	25.42
Tolcha (Stand. check)	121.63	103.70	6.00	0.46	34.58
Awash (Stand. check)	97.04	74.08	6.60	0.39	55.42
Local	9.6340	4.33	6.07	0.15	61.667
CV (%)	11.57	16.06	21.26	19.84	17.80
LSD (0.05)	30.56****	38.36****	2.904**	0.18****	10.32****

Key: TTY= total tuber yield; MTY= Marketable tuber yield; TN= Tuber number; TW= Tuber weight; LBS= Late blight score.

In 2001 and 2002 cropping seasons, different potato varieties progressed from preliminary studies were evaluated under Set–I and Set-II. Randomized complete block design was used for the studies with four replications. Significant variation was noted among potato varieties with regard to tuber yield (marketable and total) in both study years in each set. Analysis of variance also showed significant differences among varieties with regard to the most important yield components, number and weight of tubers per plant (Tables 10-13). The varieties under set-II evaluation in 2002 were tremendously exceeding the highest yielding and widely adaptable variety *Wechecha* (Table 13). Therefore, these materials are supposed to be verified under different agro-ecologies of western Ethiopia for recommendation to be produced in wider areas.

Table 10. Tuber yield of potato as affected by genotypes at Bako (2001 (Set-I)

Variety	TTY (q ha^{-1})	MTY (q ha^{-1})	TN	TW (kg)
KP90134.2	226.400	220.150	8.100	0.47
CIP389701.3	165.975	156.275	7.850	0.2
CIP387676.24	204.180	186.130	8.400	0.41
KP90143.5	214.580	197.930	9.650	0.480
KP90138.12	188.875	179.875	6.650	0.410
KP90108.5	199.325	179.875	5.950	0.450
CIP386423.13	236.105	220.155	8.000	0.422
KP90134.5	264.632	259.033	7.150	0.525
Tolcha (Stand. Check)	126.425	120.150	6.250	0.325
CV (%)	24.38	24.47	19.19	22.61
LSD (0.05)	72.196*	68.230*	2.116 *	NS

Key: TTY= total tuber yield; MTY= Marketable tuber yield; TN= Tuber number; TW= Tuber weight.

Table 11. Tuber yield of potato as affected by genotypes at Bako (2001(Set-II)

Variety	TTY (q ha^{-1})	MTY (q ha^{-1})	TN	TW (kg)
CIP392640.516	212.93	197.93	8.60	0.56
CIP392627.512	190.98	178.48	9.15	0.49
CIP392650.516	227.30	215.30	8.90	0.55
CIP391058.546	129.30	121.55	7.30	0.40
CIP391058.500	131.53	121.53	6.35	0.35
CIP391058.553	96.10	92.35	7.10	0.40
CIP391058.559	194.31	184.06	8.40	0.52
Tolcha (Stand. check)	117.55	111.80	6.45	0.31
CV (%)	25.79	27.89	20.26	18.29
LSD (0.05)	61.62**	62.69**	NS	0.12***

Key: TTY= total tuber yield; MTY= Marketable tuber yield; TN= Tuber number; TW= Tuber weight.

Table 12. Tuber yield of potato as affected by genotypes at Bako (2002 (Set-I)

Variety	TTY (q ha^{-1})	MTY ((q ha^{-1})	TN	TW (kg)
CIP389703.3	223.63	216.34	5.80	0.69
CIP385021.26	304.19	279.19	6.70	0.72
CIP385383.12	300.77	284.75	8.25	0.60
CIP387679.17	298.63	276.41	6.15	0.68
CIP389701.1	400.03	390.31	10.50	0.89
KP90138.1	330.58	319.47	6.55	0.89
CIP385021.44	287.52	269.47	7.45	0.72
Wechecha (Stand. Check)	142.37	127.79	7.35	0.65
CV (%)	20.35	20.92	16.48	13.29
LSD (0.05)	85.56***	83.188***	1.78***	0.14**

Key: TTY= total tuber yield; MTY= Marketable tuber yield; TN= Tuber number; TW= Tuber weight.

Table 13. Tuber yield of potato as affected by genotypes at Bako (2002 (Set-II)

Variety	TTY (q ha^{-1})	MTY (q ha^{-1})	TN	TW (kg)
CIP392640.513	391.70	330.58	9.85	0.66
CIP392640.534	104.87	95.84	7.23	0.32
CIP392622.511	309.75	290.99	10.10	0.80
CIP392640.501	95.84	76.39	6.35	0.24
CIP391058.545	533.38	468.79	9.05	0.84
CIP392618.511	363.92	330.58	8.60	0.77
CIP392640.511	383.37	336.14	8.25	0.92
Wechecha (Stand. Check)	234.05	202.10	9.45	0.78
CV (%)	20.96	16.22	17.29	24.30
LSD (0.05)	93.12****	63.55****	2.22*	0.24****

Key: TTY= total tuber yield; MTY= Marketable tuber yield; TN= Tuber number;
TW= Tuber weight.

Recommended Results

Variety Adaptation

Adaptation study was conducted at Shambu during 1997-1999 cropping seasons to verify tuber yield and adaptability potential of some nationally released potato varieties. The initial planting materials were received from Holetta Agricultural Research Center. Tubers were planted at appropriate planting time except in 1998, which was 15 days late to the local planting time. Hence the result was tremendous tuber yield decline suggesting optimum-planting time has vital importance for potato production with regard to disease development. The varieties were evaluated for their tuber yield, growth performance and disease/insect pest reaction. Significant variations were observed among potato varieties in marketable and total tuber yield in all the study years (Table 14).

When the over all performance of the varieties considered, *Menagesha, Tolcha and Wechecha* showed better vegetative growth performance and gave higher marketable and total tuber yield in that order as shown in table 8 below. This could be an indication that these varieties are more adaptable to the area. The superior varieties were also proved to be tolerant to late blight disease in the field condition. In contrary, Awash and AL-624 were found highly susceptible to late blight disease that was clearly reflected on the tuber yields recorded. The local variety was completely wiped out by late blight disease in its early growth stage before tuber formation. In nutshell, based on the present study these best bet varieties were recommended for wider area production in the western highlands of Oromiya, Ethiopia.

Table 14. Yield of potato variety adaptation study at Shambu, 1997-1999 cropping seasons

Genotypes	Marketable tuber yield (q ha^{-1})				Total tuber yield (q ha^{-1})			
	1997	1998	1999	Mean	1997	1998	1999	Mean
AL-624	58.05	20.37	155.60	78.00	66.39	27.40	166.60	86.80
Awash	95.33	41.18	122.20	86.22	103.73	45.37	133.30	94.13
Menagesha	288.88	59.18	325.90	224.65	303.23	75.55	322.40	233.73
Tolcha	154.74	50.74	155.50	120.33	163.730	59.26	162.90	128.63
Wechecha	142.96	32.59	111.10	95.55	155.63	50.74	122.20	109.23
Local	26.81	10.00	74.10	36.97	39.55	14.07	97.90	50.27
F	**	*			*	*	*	
CV (%)	17.06	39.45	*22.57		16.02	34.88	26.01	
LSD (5%)	39.67	25.17	60.51		40.40	28.81	6.31	

Plant Density

Plant density experiment was carried out with three potato varieties at Bako Agricultural Research Center for two years during the rainy seasons of 1985 and 1986. The purpose of the study was to determine optimum plant population based with in-row spacing that affect growth, yield and quality. The experiment was carried out in split plot design with three replications. The varieties AL-615, AL-253 and AL-624 were subjected to main plot, while with in-row spacing 10, 20, 30 and 50 cm were applied on sub-plots.

Seed tubers were planted on 9 m^2 plot on 75 cm spaced ridges. The field was cultivated, ridged and weeded as per the recommended practices for potato. Prior to planting, 300 $kgha^{-1}$ DAP was applied. Tubers were harvested at 112 days in 1985 and at 93 days in 1986 season. The longer maturity period in 1985 season was due to use of insufficient sprouted seed tubers. Tubers were graded as marketable and unmarketable based on tuber size and tuber condition.

Plant Growth and Main Stem

Actual plant stands harvested were 55 and 80% of the theoretically expected population for 10 and 20 cm while 89 and 95% for 40 and 50 cm spacing, respectively (Table 15) due to more late blight infestation and death of plant. The number of main stems per m^2 decreased as spacing increased due to less number of seed tubers planted per unit area in wider spacing. Plants of wider spacing had relatively thick stem. The incidence of late blight was serious on AL-624 and AL-615 especially in 1986 cropping season. The disease on set was at early stage and its effect was apparent on tuber yield (Table 16). AL-253 was also attacked by early and late blight in 1986, but the incidence was insignificant. The variation in disease incidence was also noted among spacing.

Table 15. Effect of within-row spacing of potato on plant growth and main stem at Bako in 1985-86 cropping seasons (mean of two years and three potato varieties)

Within-row spacing (cm)	Plant population ha^{-1}		Main stem ha^{-1}
	Expected	Actual harvested	
10	125,000	68,889	363,800A
20	66,666	53,215	226,000B
30	43,478	40,622	167,800C
40	33,333	29,637	121,900D
50	26,315	25,066	105,600D
Mean	58,958.4	43,485.8	197.020

Key: Means with the same letter are not significantly different at 5%.

Tuber Yield

The variations among within-row spacing were significant for both marketable and total tuber yield and weight of tubers per plant. The general trend of tuber in different within-row spacing showed decreasing of total and unmarketable yields with wider spacing between plants. On the other hand, the marketable yield and weight of tubers per plant increased with wider spacing (Table 16). This had tremendous practical implication in potato production. There were significant differences among varieties and variety x year interaction for tuber yield (Table 17). AL-624 and AL-615 gave very low tuber yield.

Table 16. Effect of within-row spacing on tuber yield and weight of tuber per plant at Bako (mean of two years)

Within-row spacing (cm)	Marketable tuber yield (q ha^{-1})	Total tuber yield (q ha^{-1})	Weight of tuber per plant (kg)
0	48.35B	197.67A	0.38E
20	53.36AB	175.51AB	0.41D
30	55.72AB	164.77AB	0.47C
40	54.32AB	148.39B	0.53B
50	69.49A	151.42B	0.62A
Mean	56.25	167.65	0.48
CV (%)	32.20	21.67	14.7

Key: Means followed by the same letter are not significantly different at 5%.

High percentage loss of plant stand and thin stems were produced in narrower spacing (higher population) due to competition for resource. The 10 and 20 cm spacing between plants gave high total and low marketable tuber yield, and smaller size tubers. In contrary, 40 cm and 50 cm spacing between plants gave high marketable tuber yield and large size tubers per plant (Tables 16 and 17). This agrees with Smith (1977) work, that closer spacing in potato production increases the total tuber yield but decreases marketable tuber yield.

One of the important factors to determine potato plant population is the purpose the tuber is used for. A higher population is needed for seed than for ware potato production (Wiersema, 1980). In this experiment 10 cm in-row spacing gave the highest total tuber yielder with many smaller tubers. Small tubers produce more sprouts per kilogram of seed and with small seed; a large per unit weight seed can be planted. When within-row spacing was reduced from 20 to 10 cm the amount of seed tubers required for planting a unit area was higher than the additional yield obtained. Therefore, for Bako area it was concluded that 20 cm and 50 cm within-row spacing were the best for seed and ware potato production, respectively.

Table 17. The effect of varieties and varieties x year interaction on total and marketable tuber yield in (q ha^{-1}) at Bako in 1985 and 1986 seasons

Variety	Marketable tuber yield (q ha^{-1})			Total tuber yield (q ha^{-1})		
	1985	1986	Mean	1985	1986	Mean
AL-624	73.04A	5.76B	54.09	262.64A	35.14B	177.70
AL-615	34.95A	11.76B	23.36	159.28C	66.41C	112.85
AL-253	60.66A	121.96A	91.31	202.21B	222.61A	212.41
Mean	56.22	56.29		208.04	127.26	
CV (%)	16.68	15.99		31.38	9.30	

Potato-Maize Intercropping

Potato-maize intercropping was carried out at Bako Agricultural Research Center during 1987-1990 cropping seasons by employing randomized complete block design with three replications. Due to different maize varieties used for the study the data were analyzed separately for each year. During 1987 cropping season, the maize variety used was Bako composite, while in 1988 and 1989 Gutto was used for the study, and the potato variety used was AL-624. The fertilizers, N/P_2O_5 75/75 kg ha^{-1} each were applied in the form of urea and DAP, respectively. The former was applied in split form at planting and at knee height, while the later applied at planting. Necessary cultural practices were done as required.

Treatment description

Arrangement	Population/ha	Ratio	Spacing (cm)
One potato plant followed by one maize plant	P= 44,444 M= 44,444	1:1	Between rows 75 Between plants 15
Potato planted between maize row	P= 44,444 M= 44,444	1:1	Between rows 37.5 Between plants 30
Sole potato	P= 44,444	1:0	Between rows 75 Between plants 30
Sole maize	M= 44,444	1:0	Between rows 75 Between plants 30

Key: P= Potato, and M= Maize

Potato performance

In 1987 cropping season, due to late planting as well as the shading effect of the maize variety, Bako composite, the potato intercropped was highly affected as a result the yield obtained was extremely low compared to sole potato (Table 18). Similarly in 1988 cropping season, potato in an intercropping has resulted in low yield, which is only 60% of the sole (Table 19). On the other hand, in 1990 cropping season potato tuber yield in an intercropped field was relatively high as sole potato (Table 19).

Analysis of variance showed that there was significant difference between intercropped and sole potato tuber yield in all the study years (Tables 18-20). However, it was observed that intercropping arrangement did not affect significantly potato tuber yield.

Table 18. The effect of intercropping on yield and value of maize and potato at Bako 1987 season

Treatments	Potato		Maize		IPMV (birr ha-1)
	Tuber yield (q ha-1)	Value (birr ha-1)	Grain yield (q ha-1)	Value (birr ha-1)	
One potato plant followed by one maize plant	9.56	191.20	36.10	902.50	1093.00B
Potato planted between maize row	11.91	238.20	37.96	948.00	1187.20B
Sole potato	105.47	2109.40	-	-	2109.40A
Sole maize	-	-	35.86	896.50	896.50B

Key: Means followed by the same letter are not statistically significant at 5% and IPMV-Intercropped potato/maize value.

Maize performance

Planting potato with maize did not affect maize plant. In an intercropped plot 3% and 10% more grain yield was obtained over sole maize in 1987 and 1988 cropping seasons respectively (Table 18 and 19). The reason for high yield in an intercropped plot might be due to better soil conservation as a result of more plant population per unit area. However, in 1990 cropping season intercropping had significant effect on maize yield. This might be because the experimental field used was inappropriate (infertile) which was continuously mono-cropped to maize. Cutworm and termite damage also contributed a lot for the reduction of maize yield in this cropping season.

Table 19. The effect of potato/maize intercropping on yield and agronomic traits of potato and maize at Bako 1988 cropping season

Treatments	No. of tubers/plant	Weight of tubers/plant (kg)	Tuber yield (q ha-1)	Grain yield (q ha-1)
One potato plant followed by one maize plant	4.90AB	0.15	31.85B	31.13A
Potato planted between maize row	4.47B	0.15	30.00B	36.89A
Sole potato	5.50A	0.19	51.85A	-
Sole maize	-	-	-	30.85A
Mean	4.96	0.16	37.90	32.96
CV (%)	1.01		8.69	4.87

Intercropping *vs* sole cropping

Economic analysis indicated that intercropping has advantage than sole cropping. From intercropped plots 243.19 birr more net return was obtained than sole potato and 160.94 Birr than sole maize (Table 21). Similarly, in 1990 cropping season, potato/maize intercropping gave 665.81 Birr over sole maize, while sole potato gave 181.19 Birr more net benefit over potato/maize intercropping (Table 22). Maize grower gets potato yield as bonus in addition to maize yield. This is probably due to weed suppression as a result of high plant population, so cost of weeding was reduced in an intercropping (Table 21 and 22). The land equivalent ratio (LER) of 1.7 was obtained under intercropping, which indicated good land use efficiency over sole cropping.

Table 20. The effect of potato/maize intercropping on yield and yield components of potato and maize at Bako, 1990 cropping season

Treatments	No. of tuber/plant	Weight of tuber/plant (Kg)	Tuber yield (q ha^{-1})	Grain yield (q ha^{-1})
One potato plant followed by one maize plant	4.77	0.22	58.71	40.30
Potato planted between maize row	4.60	0.15	59.12	31.19
Sole potato	7.10	0.23	77.83	-
Sole maize	-	-	-	67.14
CV (5%)				13.74
S.E.				1.73

Different maize varieties and soil fertility levels were used over the study years that have great contributions for the non-consistency of the results. In addition, damage due to cutworm and termite contributed for the low yield of maize in 1990. Considering these factors, economic evaluation was made for 1989 and 1990 seasons showing potato/maize intercropping is advantageous, regardless of the arrangements (Table 21 and 22).

Table 21. Economic assessment of potato/ maize intercropping at Bako, 1988

Treatments	Additional cost		Saved cost		Production cost (birr ha^{-1})	Net benefit (birr ha^{-1})
	Potato	Maize	Potato	Maize		
One potato plant followed by one maize plant	579.01	144.51	20.28	57.17	1107.69	183.04
Potato planted between maize row	519.19	84.68	30.07	66.96	1038.08	336.61
Sole potato	-	-	-	-	1020.36	16.64
Sole maize	-	-	-	-	548.96	98.89
Mean	549.10	114.60	25.18	124.13	928.77	158.80

Key: Cost reduced as a result of less weeding

Table 22. Cost-benefit analysis of potato/maize intercropping study at Bako, 1990

Treatments	Seed Cost		Production cost (birr ha^{-1})	Gross benefit (birr ha^{-1})	Net benefit (birr ha^{-1})
	Potato	Maize			
One potato plant followed by one maize plant	1950	30	2473.07	4042.72	1569.65
Potato planted between maize row	1950	30	2500.02	3812.42	1312.40
Sole potato	1950	-	2532.48	4154.69	1622.21
Sole maize	-	30	376.68	1151.90	775.22

Fertilizer Requirements

Soil fertility decline is noted as the principal cause for crop yield reduction in western Oromiya. This aspect may assume serious dimension in root and tuber crops production, particularly potato, as the crop is heavy feeder of nutrients, because it bulks high yield in a relatively short period.

To this effect, a study was conducted at Bako Agricultural Research Center, during 2000 and 2002 cropping seasons to evaluate the influences of different levels of N and P on growth, yield components, yield and some quality traits of two potato varieties. Three N levels (0, 69 and 138 kg ha^{-1}) and four P levels (0, 69, 138 and 207 kg ha^{-1}) were employed for the study. The two varieties were assigned to the main plot while factorial combined N x P levels to sub-plot. Twelve soil samples were collected at a depth of 0–30 cm from different places of the experimental s ite before planting to form one composite sample to appraise soil physico-chemical properties (Table 23).

Table 23. Physico-chemical characteristics of Nitisols of experimental site

pH	EC	Sand (%)	Silt (%)	Clay (%)	CEC	Bas.S	T.N (%).	O.C (%)	P (ppm)		Av.K (ppm)
									Av.P	T.P	
4.55	0.02	40	26	34	22.6	35	0.154	1.74	7.48	1740	105

Key: EC= electric conductivity, CEC= cation exchange capacity, Bas.S = base saturation, T.N = total nitrogen, O.C = organic carbon, Av.P = available phosphorous, T.P = total phosphorous, Av.K = available potassium and ppm= parts per million.

So far fertilizer studies emphasized only on tuber yield without considering tuber quality such a s specific gravity, tuber s ize categories (tuber grade) and dry matter. Hence, in this study we considered these issues because of quality dictates the demand for potato market. The main effects of N supply revealed significant differences with regard to vegetative growth and tuber development. Days to flowering and maturity, plant height, stem number, marketable tuber yield etc. were affected significantly (Table 24). Fresh and dry weights of above and under ground biomass and percent tuber dry matter yield showed significant difference among N levels and between varieties. Whereas, P supply only significantly influenced plant height, dry weight of above ground biomass and specific gravity.

Application of N delayed DM, which is considered as a factor for high tuber yield. Supply of N also significantly affected quality parameters via size categories and specific gravity. In the present study, production of number and weight of 25-75 g and >75 g tuber size categories (grade 2 and grade 1 tubers respectively) were highly influenced by N supply thereby affecting tuber quality and yield, in turn it affect potato market. *Menagesha* was superior both in number as well as weight of grade 1 and grade 2 tubers in this regard, which have high market demand and fetches high price. Marketable and total tuber number and average tuber weight showed increments by 63.1%, 38.9% and 54.1%, respectively as a result of N supply over control, suggesting that N improved tuber yields not only by influencing yield per se but also through affecting yield components (tuber number and average tuber weight).

With respect to yield components, biological and economical yield Menagesha was proved to be superior to Tolcha at all N levels supplied (Table 24). This suggested the possibility of selecting high yielding and efficient N utilizing genotypes for profitable and viable potato production. The study also suggested adjustment of N supply depending on the varieties as an approach to improve potato productivity and to minimize escalating costs of fertilizer and environmental pollution. It seems from the study that application of 69 N kg ha^{-1} to Menagesha and *Tolcha* could optimize tuber yields and quality for Bako area. On the other hand, it appeared that potato is non-responsive to P supply in Bako soils probably owing to the high phosphate fixation associated with soil acidity. Hence further study is suggested on use of organic amendments like farmyard manure and compost supply to facilitate P nutrient release for plant.

Table 24. Mean dry matter (kg ha^{-1}), fresh tuber yield (q ha^{-1}), and some other agronomic parameters of potato as influenced by the main effects of nitrogen, phosphorus and variety

Source of variation	PH (cm)	SN	FTY	DM	HDM	TDM
Variety						
Tolcha	30.71	4.30	376.70	104.11	703.06	3202.63
Menagesha	55.28	5.13	681.12	111.36	1265.47	5445.88
LSD (0.05)	5.11	NS	141.40	1.35	106.30	1079.00
Nitrogen (kg ha^{-1})						
0	37.28	4.17	384.31	106.83	716.50	2774.54
69	42.93	5.00	533.77	106.88	912.51	4744.62
138	48.79	4.98	704.64	109.50	1323.78	5453.61
LSD (0.05)	2.75	0.69	83.83	2.27	49.65	851.5
Phosphorous (kg ha^{-1})						
0	41.03	4.66	508.30	108.94	892.43	4312.52
69	40.97	4.27	508.54	107.11	980.78	4441.62
138	44.79	5.07	533.75	106.67	972.23	4331.44
207	45.20	4.87	563.06	108.22	1091.60	4229.46
LSD (0.05)	3.17	NS	NS	NS	57.33	Ns

Key: PH=plant height in cm; SN=stem number per plant; DM= days to maturity; HDM=Haulm dry matter and TDM=tuber dry matter.

Inter- and Intra-row Spacing

The influences of inter and intra row spacing on yield, yield components, and root quality of potato. Menagesha was studied at Shambu and Arjo for three cropping seasons (2001-2003). This study was initiated by farmers request to improve the nationally recommended 70 x 30 cm spacing since they thought difficulty for agronomic management between rows and plants for vigorously growing varieties like Menagesha. The experiment was laid out in randomized complete block design with three replications. The treatments used were four inter row spacing (70, 80, 90 and 100 cm) and three-intra row spacing (30, 40 and 50 cm) in a factorial arrangement. The over years combined analysis of variance for intra row spacing showed highly significant ($P<0.01$) differences on tuber weight at Arjo and on total and marketable tuber yield at Shambu. Maximum marketable tuber yield 278.4 and 188.5 q ha^{-1} were recorded for 30 cm intra row spacing at Shambu and Arjo, respectively (Table 25). Yield differences the locations were assumed to be due to the differences in the inherent soil macro and micronutrients and prevailing climatic conditions, besides variations in appropriate agronomic management practices adhered on time.

In contrast to intra row spacing, inter row spacing did not show significant difference on all parameters measured except for total tuber yield at Shambu. The interaction effects of inter and intra row spacing resulted in non-significant variation for all parameters at both locations. Based on the partitioning and interaction effects of inter and intra row spacing, 70-90 cm inter row spacing by 30-40 cm intra row spacing could be recommended for potato production in the western highlands of Oromiya. This spacing includes the nationally recommended spacing for potato production, which is 75 x 30 cm. Therefore, this wider spacing is recommended to accommodate varieties with different growth morphology and for efficient application of packages of technologies between rows and plants.

Response of Potato to N and P Fertilizer

This study was conducted at two locations Arjo and Shambu for three cropping seasons (2001-2003) to evaluate the influences of different rates of N and P fertilizer supply on tuber yield, yield components and quality of potato variety, Menagesha. The experiment was laid out in randomized complete block design with three replications. The treatments used were consisted of five N levels (0, 41, 82, 123 and 164 kg ha^{-1}) and four P levels (0, 46, 92 and 138 kg ha^{-1}) in factorial arrangement. Potato tuber N, P and K concentration was estimated in laboratory on dry matter base. Potato crude protein production was then calculated as the product of N content and tuber dry weight as influenced by N supply, variety and environmental factors.

Table 25. Influence of intra and inter row spacing on tuber yield (q ha^{-1}) and yield components of potato (2001- 2003 cropping seasons)

Intra row spacing (cm)	Arjo				Shambu			
	MTY	TTY	TN	TW	MTY	TTY	TN	TW
30	188.51	209.91	11.71	0.86	278.36	330.21	9.99	1.18
40	187.08	203.61	13.16	1.05	251.07	301.26	10.42	1.25
50	176.03	188.76	13.01	1.15	217.61	261.11	11.05	1.33
CV (%)	23.52	19.97	23.96	26.66	32.26	25.97	19.73	29.09
LSD	NS	NS	NS	0.123**	27.52**	25.29**	NS	NS
Inter row spacing (cm)								
70	184.79	203.82	11.54	0.92	273.09	332.42	10.65	1.18
80	191.18	206.12	12.42	1.02	237.71	278.94	9.73	1.22
90	181.82	203.49	13.36	1.07	255.89	299.87	10.99	1.37
100	177.75	189.62	12.77	1.07	228.61	238.88	10.58	1.24
CV (%)	23.52	19.97	23.96	26.66	32.26	25.97	19.73	29.09
LSD	NS	NS	NS	NS	NS	25.29*	NS	NS

*Key: MTY=Marketable tuber yield, TTY=Total tuber yield, TN=Tuber number per plant, TW=Tuber weight per plant, NS=Non-significant (P>0.05, *=significant at 5% probability level (P<0.05) **=significant at 1% probability level (P< 0.01).*

The over-years combined analysis of variance of N supply showed significant differences for total and marketable tuber yield and tuber weight per plant at Arjo and Shambu. P supply also resulted in significant difference for total and marketable tuber yield, and number and weight of tuber per plant at Shambu (Table 26). Differences (P<0.01) were observed between the two locations, Arjo and Shambu in potato fresh tuber yield, tuber dry matter yield, tuber N, P and K concentration and tuber crude protein averaged across all levels of N and P, probably resulted from the inherent differences in soil fertility and climates (Table 27). It is essential to understand that, at Shambu potato attained 77.9% of the maximum fresh tuber yield at 0 kg ha^{-1} N supply, while at Arjo it attained only 61.8% of its maximum fresh tuber yield. Hence, potato tuber yield response to N supply was superior at Arjo than that of Shambu.

The study depicted that probably in relatively fertile soils like Shambu and in plots that received in-organic nitrogen fertilizer, tuber N concentration was higher and concurrently tuber crude protein production was also higher than at poor fertile soils of Arjo and in plots that where not received N fertilizer indicating the influential effect of N on crude protein production, besides tuber yield. On average, N supply resulted in 31.2% increase of both tuber dry matter and crude protein as compared to non-N supply indicating that there are possibilities to improve potato tuber crude protein production through sustainable N supply and management (Table 26).

The interaction of N and P resulted in non-significant differences for all parameters at both locations, and in contrary, location x N showed significant differences with regard to most of the parameters. Hence, it is possible to recommend nitrogen separately for both locations. The most salient finding of the study indicates the practically possibility of developing appropriate soil fertility management at which optimum fresh tuber yield, organic matter and concomitantly protein production taking place, like the supply of 41 to 82 kg ha^{-1} N depending on the soil and agro-ecological conditions of the areas. In contrary to N, the effect of P supply was found non-significant with respect to tuber N, P and K concentration, production of tuber crude protein and tuber yield. However, it is imperative to supply P for potato production, as it is deficient in most soils and especially in acids soils of western Ethiopia.

Table 26. Influence of nitrogen and phosphorous fertilizer rate on total and marketable tuber yield and yield components of potato (2001-2003 cropping seasons)

N (kg ha^{-1})	Arjo				Shambu			
	TTY (q ha^{-1})	MTY (q ha^{-1})	TN	TW (kg)	TTY (q ha^{-1})	MTY (q ha^{-1})	TN	TW (kg)
0	288.45	217.84	9.43	0.84	290.51	247.35	8.73	0.79
41	381.29	283.88	10.63	1.08	352.45	293.82	9.35	0.92
82	423.47	298.41	10.16	1.13	373.01	303.58	9.47	0.98
123	467.10	358.10	11.07	1.23	357.60	299.95	9.44	1.01
164	431.30	324.04	10.56	1.21	368.82	281.29	9.62	1.00
CV (%)	25.47	35.05	25.29	24.34	19.12	25.47	19.87	25.07
LSD	47.36**	48.51**	NS	0.13**	31.11**	33.92**	NS	0.11**
P (kg ha^{-1})								
0	361.56	270.70	9.97	1.02	288.09	233.81	8.52	0.76
46	394.46	288.69	9.92	1.08	328.23	268.22	8.90	0.90
92	410.98	314.17	10.74	1.15	367.83	303.37	9.69	1.00
138	426.27	312.31	10.84	1.15	409.75	335.40	10.12	1.11
CV (%)	25.47	35.05	25.29	24.34	19.12	25.47	19.87	25.07
LSD	42.36*	NS	NS	NS	27.83**	30.34**	0.77**	0.10**

*Key: MTY=Marketable tuber yield, TTY=Total tuber yield, TN=Tuber number per plant, TW=Tuber weight per plant, NS=Non-significant (P>0.05, *=significant at 5% probability level (P<0.05) **=significant at 1% probability level (P< 0.01).*

Table 27. The influence of environment (location) on potato tuber N, P, K, N/P, K/P concentration (%), and tuber dry weight (t ha^{-1}), tuber organic matter (%) and crude protein (%)

Location	N	P	K	CP	TDW	TOM	N/P	K/P
Arjo	1.41	0.34	1.56	8.83	8.30	96.07	4.21	4.69
Shambu	1.61	0.26	2.32	9.98	6.84	94.63	5.99	8.68
F-test.	***	***	***	***	**	***	***	***

Crop Protection

Monitoring Potato Tuber Moth

A pheromone funnel trap was used to determine the population dynamics of potato tuber moth at Bako in 1989. The highest population levels were recorded in October and November when more than one moth/week was recorded. This season coincides with low rainfall and temperature. The lowest population level was recorded in months when one or less moth/week was recorded and no potato tuber moths were recorded in the months of July, August and April (Table 28). Based on this result, the population level of potato tuber moth was low during the main cropping season for potato production (June to October) when it did not exceed one moth per week. On the other hand, the highest population levels were recorded in months of November and December when the potato was already harvested. Though the pest occurrence was so sporadic, over decades it has been observed that potato tuber moth led 100% damage when no control treatment applied.

Table 28. The effect of temperature, relative humidity and rainfall on the population dynamics of potato tuber moth at Bako in 1989 cropping season

Months	NMT/W	ANMT/W	MMT ^0C	Relative humidity (%)	Rainfall (mm)
January	3	0.75	19.70	44.70	1.50
February	1	0.25	21.55	42.70	8.90
March	1	0.25	22.65	53.90	102.90
April	0	0	21.45	59.70	60.40
May	1	0.25	21.85	59.30	10.90
June	1	0.25	20.45	69.35	145.30
July	0	0	19.40	81.20	341.30
August	0	0	19.40	78.60	194.50
September	4	1	19.75	67.90	230.40
October	3	0.75	20.25	52.20	87.20
November	7	1.75	19.10	46.30	6.40
December	8	2	19.20	50.00	0.20

NMT/W= Number of moth trapped/week, ANMT/W = Average number of moth trapped/week, MMT = Mean monthly temperature

Controlling Late Blight

Late blight is one of the major diseases of potato in the major potato production areas of the country. The study was carried out during 1993 cropping season at Bako by employing four planting dates (June 4, June 18, July 2 and July 16), three varieties

(Sisay, AL-624 and UK-803) and chemical Ridomil Mz 63.5 WP. The study was arranged in split plot design in that chemical spray and non-spray assigned on main plot and varieties to sub-plot, while planting date to sub-sub-plot with three replications. Of the three varieties the highest mean Sisay recorded disease incidence score on variety AL-624 followed. Variety Uk-803 was found to be resistant with low level of the disease even at the time when pathogen progress is aggressive to devastate the variety AL-624. The result was reflected by higher tuber yield of Uk-803 without any chemical spray as compared to other varieties. In contrary, AL-24 was susceptible to late blight and as result its tuber yield was increased in response to Ridolmil Mz 63.5 WP chemical spray, while Sisay was intermediate (Table 29 and 30).

Table 29. Effect of variety, chemical spray and planting date on the incidence (%) of late blight at Bako, 1993

Planting date	AL-624		Sisay		Uk-803	
	Unsprayed	Sprayed	Unsprayed	Sprayed	Unsprayed	Sprayed
June 4	34.8	6.2	18.5	4.0	11.6	3.4
June 18	38.8	10.6	23.5	7.5	19.8	6.5
July 2	39.5	14.6	31.9	11.4	24.8	8.0
July 16	61.0	4.5	36.6	6.0	17.7	7.0
Mean	43.5	9.0	27.6	7.2	18.5	6.2

The disease was highly affected by chemical application. There was significant variation between chemical treated and untreated treatments (Table 29 and 30). However the chemical effect on resistant variety was not much expressed implying that chemical spray not significantly affected disease development and tuber yield in resistant variety. The disease development was also similarly affected by planting date. In the early planting date, the disease incidence was relatively lower than to the subsequent late planting date. Further more, the early planting date was not affected by late blight disease till 45 days of crop age, and even on susceptible variety, AL-624 disease reached maximum at 77 days age of the crop. This gave the chance to the crop to cover 75% of its growth period. But in the late planting date, the crop was full in field inoculums load and prevalence of conducive weather, which resulted in complete failure as early as 42 days after planting. The disease incidence and tuber yield was inversely related as can be observed from tables 29 and 30.

Table 30. Effect of variety, planting date and fungicide on the yield of potato at Bako, 1993

Planting date	AL-624		Sisay		Uk-803	
	Unsprayed	Sprayed	Unsprayed	Prayed	Unsprayed	Sprayed
June 4	5.87A	27.73A	14.03A	28.18A	16.97A	15.57A
June 18	4.03A	15.17B	12.20AB	27.77A	12.93AB	15.90AB
July 2	2.23A	14.80BC	9.10ABC	15.53BC	12.60AB	12.20BC
July 16	2.23A	9.60D	8.50BC	17.78BC	9.63BC	14.43ABC

Key: Means followed by the same letters in the column are not statistically significant from each other at 5%.

Demonstration and Popularization

On-farm Demonstration

The best performing potato varieties such as AL-253, AL-567, AL-624, AL-575 and AL-563, which have been tested and proved under research condition, were demonstrated on farmers' field around Bako in 1983 cropping season. The demonstration of AL-567 and AL-624 were conducted on producers' cooperative field, while AL-253, AL-563 and AL-575 were undertaken on individual farmers' field. Farmers managed the field as per research recommendations with frequent close supervision. Producers cooperatives were applied 300kg ha^{-1} DAP, the blanket recommendation rate for potato production, while the individual farmers applied farmyard manure.

As compared to the on station, on-farm tuber yield of the potato varieties demonstrated was higher probably because of the high soil fertility condition of farmers' field and t less infestation by late blight disease. On the other hand, AL-624 and AL-253 gave poor tuber yield due to poor management practices applied in the field (Table 31). Stimulated by the demonstration result farmers of the area were very much enthusiastic and requested seeds of improved potato varieties for production.

Table 31. Tuber yield of potato genotypes on farmers' field around Bako in 1983 cropping season

Host farmers	Variety	Marketable tuber yield (q ha^{-1})	Unmarketable tuber yield (q ha^{-1})	Total tuber yield (q ha^{-1})
Producers cooperatives	AL-567	537	32.39	569.39
Producers cooperatives	AL-624	159	13.12	172.49
Individual farmers	AL-253	152.94	1.43	154.37
Individual farmers	AL-563	449.43	11.00	460.43
Individual farmers	AL-575	387.05	54.87	392.92

Rapid On-farm Demonstration

Through this rapid adaptation study, seeds of improved potato varieties were supplied to selected farmers of Gimbhi, Nedjo, Hawwa Walali and Sayyo districts in West Wollega Zone in close consultation with district agricultural expertise. Potato production recommended packages were also supplied with seeds. Farmers were advised to plant seeds according to local planting time and manage all potato plots uniformly as per recommendation.

The field performance of improved potato varieties presented in table 32 and figure1. The improved potato varieties were found tremendously exceeding the local check and liked very much by farmers due to their tuber yield and good disease reaction. In particular, Menagesha variety was found superior over wider agro-ecologies of western Ethiopia followed by Wechecha and Tolcha, respectively. Thus based on this rapid technology verification, these improved potato varieties are recommended for wider area production through out the zone.

Table 32. Improved potato varieties adaptation and demonstration study in West Wollega Zone

District	2001				2003		
	Menagesha	Tolcha	Wechecha	Local	Menagesha	Tolcha	Wechecha
Gimbhi	340	143	138	0	-	-	-
Nedjo	316	188	183	64	375	230	252
Hawwa	-	-	-	-	200	150	150
Walali Sayyo	523	222	306	0	-	-	-
Mean	393	184	209	64	288	190	201

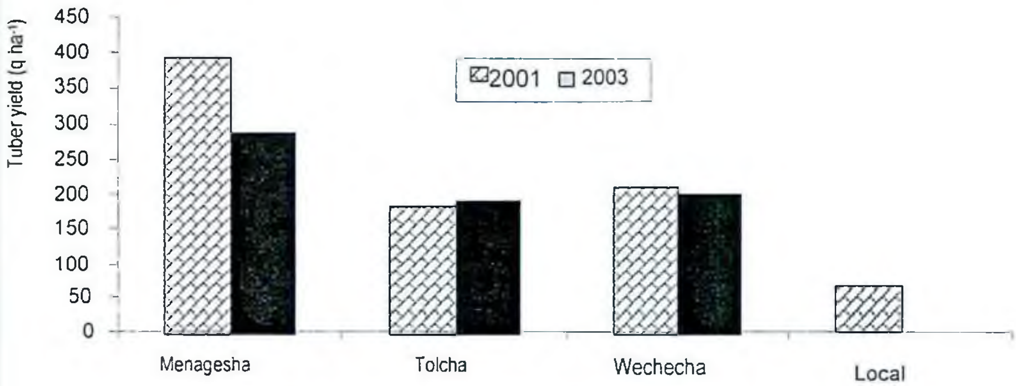

Figure 1. Tuber yield potential of some improved potato varieties in selected districts of West Wollega Zone

Seed Production

On-farm

Improved seeds of *Menagesha* were distributed to host farmers along with its full production package, being facilitated by village level extension workers. The project provided well sprout improved quality seeds; fertilizer, technical advice and training during different project implementation phases (Table 33).

Table 33. The amount of seed and fertilizer supplied to host farmers directly by the project during 1999-2001 cropping seasons

Particulars	District		
	Jimma Arjo	Jimma Horro	Jimma Rare
Number of host farmers selected	51	51	51
Number of seeds supplied	20400	20400	20400
Amount of fertilizer (kg)	1530	1530	1530
Number of host farmers offered training	51	51	51

On-farm multiplication and demonstration of improved seeds were undertaken with active participation of host farmers. Host farmers provided land, labor and undertook every seed production practices and post harvest handling. Farmers constructed diffused light stores (DLS) using local materials. They were also the nucleus and active members of participatory Potato Seed Technology Transfer evaluating group. During the project period, a total of 153 households in three districts directly benefited from the project (Table 33). Yield increase from the adoption of improved potato seed variety has been very large; 3-5 times yield advantage over local varieties. It is interesting to note that the multiplicative effect is over 11 folds in that the final evaluation of the project showed a total of 1684 farm households have been reached indirectly through farmer-to-farmer seed dissemination within and outside the target districts. This show how effective is the informal seed system to reach smallholders for seeds that public governmental organization do not produce and distribute as mandate crop, such as potato. This perhaps because of farmers distributed the on-farm multiplied improved seeds using indigenous seed transfer channels such as barter, free gift and sales. This system has a number of advantages for farmers over formal seed exchange because it uses indigenous means for information flow and exchange of goods, and its informal nature makes it less rigid than the formal seed sector. So farmers have easy access to seed and often know from whom they obtain the seed.

From the significant interest observed in rapid adoption of potato technologies by farmers it was realized that potato is the potential food security crop in the areas. It was based on farmers' felt need and preference for the crop that efforts were made to increase and disseminate the selected variety through their active participation. The achievements recorded in this project also revealed that improved potato production could significantly contribute to the national food security goal, if dealt with at macro level. In general, it is significant to note that sustainable community-based seed multiplication and dissemination system is developed for the project areas that could serve as a model for enhancing informal seed system to reach the resource poor farmers. In fact, scaling up of the project to reach more and more potato growers surrounding the project areas need due considerations.

True Potato Seed

CIP potato genotypes were evaluated for open pollinated TPS and subsequent tuber yield production at Bako Agricultural Research Center in 1995 under rain fed and irrigated condition. All the test genotypes flowered, but only few gave berries in the main season while all except CIP382173.12 flowered and gave barriers in the off-season.

Matured berries harvested and put in store for one or more weeks depending on their maturity. Seeds were extracted from mature and soft berries washed with clean cold water and died under shade or in storage house and stored for about two months to initiate germination. The seeds were sown on seedbeds and germinated after two weeks. Seedlings were transplanted to field of experiment five weeks after emergence at a spacing of 75 cm between ridges and 20 cm between plants. The field experiment was laid down in single observation plot of 15 m^2. The blanket fertilizer rate, 300 kg ha^{-1} diammonium phosphate (DAP) for potato production was applied and incorporated into the soil. Recommended potato production agronomic packages like ridging, hilling and watering were adhered.

Vegetative growth performance and development of TPS seedlings were found fantastic and comparable with tuber seed growth performance of potato. However, there was a significant variation in establishment of TPS seedlings among genotypes. Tubers were ready for harvesting and dug after three and half months after transplanting. The genotype, CIP387894.2 gave higher seedling tuber yield but was not uniform in shape and size of tubers, followed by CIP383032.15, which gave uniform color shape seedling tuber (Table 34). In contrary, CIP38137.15 gave seedling tubers, which were uniform in size, shape and color and highly acceptable qualities s of not less than potatoes produced from seed tuber. But CIP384079.6 gave small sized tuber, which were unmarketable for ware but could be used for seed.

From the present study, a few open-pollinated TPS tuber yielding potential was identified as source of disease free health potato production for Bako and similar areas. TPS gave higher tuber yield, which are comparable with potatoes produced from seed tuber. In light of the potato production constraints mentioned above the study showed the potential of TPS as an alternative technology for potato production in the Bako and similar agro-ecologies. This can be evidently observed from the tuber yield 28.8t ha^{-1} recorded and fairly uniform tubers obtained from TPS progenies (Table 34). TPS production is however viable in the off-season under irrigation to overcome fruit drop by heavy rain of the main season (Girma Abera, 1997).

Table 34. Potato genotypes open-pollinated TPS tuber yield potential and some agronomic parameters

Genotypes	FM	FR	NM	HT	ST	SP	ED	CT	TY	FO	FRO
CIP38302.15	Yes	Yes	8	54	Nu	U	Sh	W	24	Yes	Yes
CIP378501.3	Yes	No	-	-	-	-	-	-	-	Yes	Yes
CIP38121.5	Yes	No	-	-	-	-	-	-	-	Yes	Yes
CIP382173.12	Yes	No	-	-	-	-	-	-	-	Yes	No
CIP381376.15	Yes	Yes	7	52	U	U	Sh	W	21	Yes	Yes
CIP380479.6	Yes	Yes	8	38	U	U	Sh	W	21	Yes	Yes
CIP377315.2	Yes	No	-	-	-	-	-	-	-	Yes	Yes
CIP387894.2	Yes	Yes	6	45	Nu	U	Sh	W, P	26	Yes	Yes

Key: FM=flowering at main season, FR=fruiting at main season, NM=number of main stem, HT= height in (cm), at 60 days after transplanting, ST=size of tuber, SP=shape of tuber, ED=eye depth, CT=color of tuber, TY=tuber yield (t ha^{-1}), Sh=shallow eye depth, W=white, P=pink, FO=flowering at off-season, FRO= fruiting at off season and NU=not uniform and U=uniform

Seed Storage

At Bako Agricultural Research Center also the Diffused Light Store (DLS) has proved to be efficient in tuber seed storage and vindicated to be increasing potato production and productivity of the areas. DLS has been demonstrated to host farmers of the project area such as Jimma Arjo, Jimma Horro and Jimma Rare districts, west Oromiya. As a result some potato farmers have been successfully adopted the DLS structure technology for potato storage. It is possible to store seed tubers for about 8 months in the DLS, depending on the variety. The structure can be constructed from locally available materials such as trees or mesh wire for wall, and grasses and/or iron sheets for roof. The size of the store to be constructed is, however, determined by the amount of tubers intended to be stored.

On the other hand, agricultural experts from East and West Wollega Zones of non-project districts came to the center to visit the structure, while others requested training visit arrangement to demonstrate the structure to render them practical skills in constructing the structure in their districts. We also provided the design and photos of DLS structure for the interested experts of some district.

Conclusion and Recommendations

Potato Improvement Program, over years of experimentation has identified and developed a number of high yielding, and disease and/pest resistant/tolerant potato varieties. Among them, AL-624, AL-100, Awash, Sisay, Tolcha, Wechecha and Menagesha are the prominent ones. However, availability of seed of improved genetic material is often a primary reason for lack of adoption, even if well-adapted and acceptable varieties are available and released.

In the region except a few demonstration work on farmers field and non-continuous supply of small amount of potato seed to localized areas, no single improved potato seed were reached the farmers of western part of Ethiopia either formally or informally before the "Potato Technology Transfer Project" assisted by ASARECA/CIP in 1998, which introduced packages of potato technologies along with improved potato seed, Diffused Light Store Menagesha. This is mainly attributed to the lack of seed source. There is no governmental or non-governmental organization that is responsible for the multiplication and dissemination of improved potato seed in the country. Even though formal seed organization was found, it is ineffective to meet the seed needs of resource poor small-scale house holds. Here, policy measure which facilitates the transfer of new technologies to users should be designed and implemented to improve the general productivity of farm. Such measure include establishment of agricultural cooperatives which benefit their members through collective bargaining for input supply and fair price for their produce; creating favorable conditions for vertical integration of entities engaged in seed generation, production/multiplication, packaging, transporting and marketing for efficient and timely delivery of seed to users (Beyene and Aberra, 1998).

Therefore, we devised the solutions and recommend participatory potato seed multiplication and also encourage private entrepreneurs' involvement in such activity to restructure and help improve potato production expansion of small scale house hold farm in the western parts of Ethiopia. It is also interesting to note that through participatory on-farm potato seed production we proved that potato seed production as commercial activity found so lucrative for any interested private investors to join the business as a kilo of potato tuber seed was sold on average by 4 birr at Arjo, by 2.0 birr at Shambu and by 2.5 birr at Wayu, project areas, and also by about 2.5 birr on average in most potato production areas of the country. In addition, if technically backstopped on sustainable base it is viable for farmers to be seed producers either as individual or in groups. This system includes seed production/multiplication by private entrepreneurs and farmers themselves and farmer-to-farmer seed dissemination through local market seed channels. Along with the establishment of informal and formal seed production systems, it is also imperative to organize cooperatives to facilitate ease arrangement of markets for the sales of seed produce. This essential recommendation can be realized when different responsible organizations and private entrepreneurs work hand in hand; these organizations could be research institute, ministry of agriculture, non-governmental organizations, developmental organizations, private investors and farmers.

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Annexes

Annex 1. Recommended and released potato varieties for different agro-ecologies of Ethiopia

Variety	Yield (t ha^{-1})	Altitude (m)	Rainfall (mm)
AL-1	8-10	1500-2500	700-900
AL-100	30-40	1500-2500	700-900
AL-148	25-30	1500-2500	700-900
AL-560	30-40	1500-2500	700-900
AL-624	30-40	1500-2500	700-900
Bedasa	40.59	1700-2000	700-800
Chiro	32-40	1600-2000	700-800
Digemegn	46.70	1600-2800	nd
Gorebela	30.10	2700-3200	nd
Guwassa	24.40	2240-2630	nd
Jallene	44.80	1600-2800	nd
Menagesha	27.00	nd	nd
Tolcha	33.10	nd	nd
Wechecha	21.80	nd	nd
Zemen	37.18	1700-2000	700-800
Zengena	30.35	2000-2800	1000-1500

Key: nd=no data. Source: (Girma Abera et al., 2004)

Annex 2. Recommended agronomic practices for potato production under different agro-ecologies of Ethiopia

Agronomic practices	For the highland and mid altitude areas of western Ethiopia	Merits
Spacing for ware potato production	75 x 30 cm for ware potato production but can be extended based on plant growth morphology For example for Menagesha 70-90 spacing between rows and 30-40 between plants were recommended for the highlands	▪ High quality produce ▪ High tuber yield ▪ Less disease pressure ▪ Ease for hilling and plot management
Spacing for seed tuber production	75 x 20 cm for small to medium see d tuber production but can be reduced based on plant growth morphology t and soil fertility condition	▪ High quality produce ▪ High tuber yield
Spacing for TPS seedling tuber production	70 x 20 cm for TPS seedling transplanting and further small to medium seed tuber production but can be reduced based on plant growth morphology and soil fertility condition	Large amount of seedling tuber produced
Fertilizer for Bako area	69 kg N ha^{-1} and 20 kg P ha^{-1} for Bako Research Center and probably poor soils in the Bako areas	▪ High quality produce ▪ High tuber yield ▪ High protein production
Fertilizer for Arjo and Shambu highlands	41 kg N ha^{-1} for Shambu highlands and 82 kg N ha^{-1} for Arjo highlands along with 10 to 20 kg P ha^{-1}	▪ High quality produce ▪ High tuber yield ▪ High protein production
Integrated Fertilizer	▪ Half of the recommended rate plus 5 t ha^{-1} farmyard manure , or ▪ Apply 10 t ha^{-1} farmyard manure alone	▪ Good soil fertility replenishment ▪ Improve physical and chemical properties of soil ▪ Improve tuber yield and quality
Weeding/Hilling	▪ First weeding two weeks to a month depending on field condition ▪ Requires 2-3 hilling depending on crop growth and field condition ▪ Do not weed/hill after complete flower	▪ Highly determinant as potato is poor competitor at early growth stage ▪ Improves 10-15% tuber yield
Late blight control	▪ Application of Ridomil WP, Bresthan 10 (Chlothalonil), Dithane M-45 (Mancozeb), polyrm M (Maneb) ▪ Use of resistant or tolerant varieties	▪ High quality tuber yield ▪ Economically and environmentally sound production
Potato tuber moth control	▪ Cover seed tubers with soil after planting, clean seed stores, avoid remnants of last season, ▪ Use Diaznon 60 EC 20 ml in 10 litters of water, Fenitrithion 50% EC (Sumathion), Malathion and Cypermethrin 50% EC (Symbush).	▪ High quality tuber yield ▪ Economically and environmentally sound production
Planting date	▪ Early to mid April for the highlands ▪ Early to mid June for Bako area	▪ Disease free ▪ High yield ▪ Good quality

Appendix 3. Marketable and total tuber yield of the top performing potato genotypes under screening evaluation at Bako in 1985 and 1986 cropping seasons

Genotypes	1985		1986	
	Marketable tuber yield (q ha^{-1})	Total tuber yield (q ha^{-1})	Marketable tuber yield (q ha^{-1})	Total tuber yield (q ha^{-1})
AL-404	53.33	163.32	63.33	97.77
AL-556	35.55	244.43	227.77	306.65
UK-80-3	66.66	161.10	215.55	304.43
CIP3378329.8	32.22	161.10	230.00	280.00
CIP378371-5	84.44	184.44	175.55	215.55
CIP378501-16	26.66	101.99	137.77	217.77
MS-IS-2	54.44	158.21	86.66	108.88
CIP378501-3	44.44	189.99	140.00	256.66
AL-531	111.11	282.22	29.77	49.77
AL-257	66.66	216.66	133.33	175.55
AL-252	60.66	147.77	148.88	252.21
CIP378367-4	66.66	147.77	208.88	336.65
AL-517	66.66	234.43	154.44	221.10
CIP378366-2	77.77	164.43	76.66	87.77
AL-574	91.33	150.66	160.44	175.55
AL-610	80.00	274.44	64.00	107.55
AL-563	81.33	173.33	164.88	243.54
AL-264	72.22	151.10	172.22	204.44
AL-560	56.66	148.88	184.44	344.44
AL-516	61.11	335.33	95.11	138.66
AL-119	31.11	175.33	97.77	181.10
AL-575	53.33	194.44	207.77	265.54
AL-578	34.44	225.21	180.00	303.33
AL-115	88.88	247.54	105.55	135.55
U-59 A(26)	68.81	159.99	360.00	400.00
AL-624	48.88	259.99	38.88	111.10
Mean	62.13	194.39	148.45	212.38

Appendix 4. Potato tuber yield as influenced by genotypes at Bako in 1981 and 1982 cropping seasons

Genotypes	Marketable tuber yield (q ha^{-1})			Total tuber yield (q ha^{-1})		
	1981	1982	Mean	1981	1982	Mean
AL-624	281.47	211.55	246.51	318.25	391.54	354.39
AL-253	229.62	81.33	155.47	257.32	147.69	202.51
AL-568	300.75	112.22	206.49	334.39	207.77	271.08
AL-634	357.70	155.55	256.63	388.06	240.14	314.10
AL-257	235.70	80.74	158.22	245.02	121.77	183.39
AL-563	245.84	95.55	170.69	182.54	101.51	142.03
AL-108	291.55	98.51	195.03	312.10	159.10	235.60
AL-615	243.85	249.63	242.24	264.40	333.62	299.01
AL-601	252.44	263.40	257.92	271.44	419.84	245.64
AL-578	291.90	195.55	243.73	313.82	281.92	297.87
AL-646	369.90	191.11	280.51	375.00	282.96	328.98
AL-580	233.03	67.85	150.44	258.95	128.98	193.97
AL-517	332.44	113.99	233.22	339.10	201.99	270.55
AL-556	296.14	55.99	176.06	321.84	122.28	222.06
AL-570	277.03	92.14	184.59	304.40	136.58	220.49
AL-575	98.51	53.33	75.92	114.58	105.18	109.88
AL-148	350.81	68.14	209.48	367.77	98.51	233.14
AL-204	255.60	82.96	169.28	352.11	148.29	250.20
AL-567	159.25	54.22	106.74	169.32	144.07	141.69
AL-569	168.11	232.22	200.17	182.03	311.48	246.76
Local	128.88	65.55	97.22	141.84	95.17	118.51
F	*	NS		*	NS	
CV (%)	23.48	16.94		27.84	30.16	
LSD (5%)	135.63	70.09		129.12	93.04	

*Key: F= probability value, * = significant (p<0.05), NS= non- significant (p<0.05).*

Appendix 5. Potato tuber yield and yield components of potato as influenced by genotypes at Bako in 1985 cropping season

Potato genotypes	Marketable tuber yield (q ha^{-1})	Total tuber yield (q ha^{-1})	No. of tuber Per plant	Weight of tuber per plant (kg)
AL-100	52.95	148.58	8.40	0.59
AL-108	51.10	129.62	6.76	0.40
AL-119	58.88	150.36	7.13	0.56
AL-212	48.51	174.44	8.13	0.65
AL-219	48.88	118.21	7.26	0.55
AL-250	27.40	107.77	7.10	0.61
AL-253	52.59	134.06	9.73	0.60
AL-264	56.66	134.07	7.90	0.60
AL-305	37.40	147.69	6.70	0.57
AL-335	27.03	117.55	6.20	0.61
L-350	-	81.77	6.94	0.59
AL-404	32.22	142.42	6.26	0.57
AL-517	81.63	255.69	12.90	0.82
AL-528	54.44	203.77	10.13	0.65
AL-531	105.55	253.7	11.16	0.57
AL-556	55.18	216.66	11.06	0.48
AL-578	64.44	167.64	10.20	0.82
AL-601	75.92	205.18	10.76	0.65
AL-615	25.92	148.88	10.03	0.67
AL-624	82.59	251.76	8.30	0.83
CIP378329.7	57.03	154.43	9.26	0.51
CIP378367.4	53.33	178.88	10.63	0.45
CIP378501.3	54.81	167.03	8.00	0.93
HS.IC-2	56.29	170.73	8.43	0.75
UK-80-3	65.55	169.62	9.00	0.57
Local	16.66	49.25	6.90	0.92
F	**	**	**	**
CV (%)	38.98	19.20	18.64	21.47
LSD (5%)	33.83	40.16	2.62	0.22

*Key: F= probability value, * = significant (p<0.05), NS= non- significant (p<0.05).*

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