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Evaluation of Potato (Solanum tuberosum L.) Varieties for Yield Attributes

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Abstract
Objectives: Five potato varieties (Gudenie, Degemegn, Belete, and two local varieties named Father & Susalluh) during the autumn and seven potato varieties (Jalene & Tolcha in addition to varieties used in autumn during the winter season during the winter season were evaluated for their tuber yield attributes under rain fed condition of the 2015/16 crop calendar with the objective of evaluating the yield potential of improved & local varieties of Irish potato in Chencha district Gamo-Gofa zone Ethiopia. **Methodology**: The experimental field was laid out in Randomized Complete Block Design with four blocks and three biological repeats. **Results**: statistical results revealed significant difference among the treatments (Varieties) in the entire yield traits during the winter season whereas; tuber number per plant & unmarketable yield were statistically significant among the varieties during the autumn cropping season. The highest number of tubers per plant was recorded in Local-1 variety whereas the lowest number of tubers per plant was recorded in Belete variety during the autumn cropping season. During the winter cropping season, the maximum number of tubers per plant was recorded in Local-1 variety. In the winter season varieties showed highly significant differences ($p < 0.01$) in marketable yield. Unlike autumn season, in the winter cropping season, the highest marketable yield (33.17 t ha^{-1}) was recorded in Local-2(Susallu) variety while the lowest marketable yield (12.10 t ha^{-1}) was record in Local-1 variety. The results in relation to very small tubers (mean unmarketable yield <20 g $tuber^{-1}$) noted to be highly significant ($p < 0.01$) among the varieties during both cropping seasons. The highest unmarketable yield was recorded in Local 1. The statistical analysis for total yields showed significant differences ($p < 0.05$) among varieties only during winter growing season. Total yield of tubers ranged from (21.98 t ha^{-1} in Local-1 to 13.56 t ha^{-1} in Degemegn) in autumn season & (36.64 t ha^{-1} in Local-1 to 20.63 t ha^{-1} in Tolcha) during the winter cropping season.**Conclusion**: Finally, we conclude that the study evidently demonstrated the effect of varietal difference on the yield attributes of potato. The growth performance of the Irish potato varieties brought from Holeta Research Center was promising though later on the yield attribute was found to be superior in the Susalllu (Local-2) variety in our research.
Kewords: Potato, Yield attributes, Chencha-Gircha, Jalenie, Gudenie, Degemegn, Tolcha

1. Background and Justification

The potato (*Solanum tuberosum* L.) originated in the highlands of the Andes in South America (Hawkes, 1978). Potato belongs to the *Solanaceae* family, genus *Solanum*. It`s life cycle is a perennial and spreads itself by vegetative propagation. Potato is grown as an annual species for commercial purposes (Graham et al., 2001). Potato is among the most important and promising horticultural crops of the future world. Potatoes are a source of both food and cash income in the densely populated highlands of sub-Saharan Africa and among the major tuber crops produced in Ethiopia (Scott et al. 2000). Several factors do affect the growth, morphological characters and yield attributes of potato of which selection of appropriate varieties and production techniques being the most important ones.

Moreover, in Ethiopia, there are limited number of released potato varieties for the farmer. Most of the released potato varieties demonstrated inconsistency with respect to yield attributes across locations and seasons. As can be noted from various agro-climatology documents, Ethiopia is endowed with diverse agro ecological and hence soil conditions. In the country, Holeta Research Center takes the leading role in breeding and releasing potato varieties followed by Haramaya. Most of the varieties bred and released by Holeta Research Center are confined and perform prominently under agro-ecological conditions similar to the research center. In Gamo Gofa Zone, 15,000 hectares of land is covered by potato production which is 9% of the total potato production in the country. Some of the varieties of potato released by Holeta Research Center have been introduced to Chencha area some few years back. However, the tuber yield and quality collected per hectare is quite substandard compared to the national recommendation.

2. Objectives

2.1. General objective:

- ✓ To evaluate the yield attributes of improved and local potato varieties.

2.2. Specific objectives:

- ✓ To identify the superior variety of potato for yield attributes.
- ✓ To establish a working document for further studies.

3. Research Methodology and Materials

3.1. Study Site Description

The project was established at Chencha Woreda; AMU-Gircha research Center which is located approximately 6km Northwest of Chencha Woreda. Chencha is located in the Gamo Gofa administrative zone of the SNNPR. The woreda encompasses 50 administrative 'kebeles' and with an altitude ranging between 1600-3200masl. It has two agro-eciological zones: 'dega' (2300-3200masl, 82%) and 'woinadega' (1500-2300masl, 18%); with total area coverage of 37,650ha. The mean annual temperature and rainfall of the study areas are 22.5^0c and 1400mm respectively. The altitude of Gircha is 3007m.a.s.l.The soil textural class is clay loam (WVE, 2012).

3.2. The Experimental Materials and Designs

Five improved varieties of potato cultivars (Gudenie, Degemegn, Belete, Jalene, Tolcha) were collected from Holeta Agricultural Research Center and two local varieties (Qay Dinich/Father (Local-1 in our research work) and Susallu (Local-2 in our research work) that are indigenous to the area were established and evaluated at Gircha Highland Fruits and Vegetables Research Center agro-ecological condition during the 2015-16 autumn 'Meher' and winter 'Belg' cropping calendar. The field was laid out in a randomized complete block design (RCBD) with four blocks and three biological repeats. The unit plot size was 3.0 m x 1.8 m that is 36 plants per plot and 5 rows per plot. Tubers were planted with a spacing of 60 cm x 25cm. Fertilization, weeding, irrigation, earthing up and disease and insect pest scouting were committed following the conventional recommendations.

3.3. Data collection and analysis

All data on the yield attributes and tuber quality were recorded. Data on yield attributes comprised of; tuber number per plot, tuber weight per plot (kg), tuber number per plant, tuber weight per plant (g) and yield (t/ha). Tubers were also graded as marketable (>20 g) and non-marketable (<20 g) on weight basis. The raw data was subjected to ANOVA and analyzed statistically by using SAS statistical software (SAS, 2002/3) Version 9.1. Means were separated by Least Significant Difference Test at 0.05 probability level.

4. Results and Discussions

Potato cultivation in Ethiopia would need intensification of the improved variety and year round supply of good quality produce. Adaptation trial to specific agro-ecology has been a key strategy for improving potato productivity. With this view point, this research was conducted to screen the superior potato variety in terms of yield attributes under Chencha condition.

Table .1 Mean marketable yield, unmarketable yield and total yield of potato cultivars at Chencha Woreda((August-December, 2015)

Varieties	Autumn Cropping Season			
	TNPP	MY t/ha^{-1}	UMY t/ha^{-1}	TY t/ha^{-1}
Belete	2.75c	13.71	0.85c	14.56
Degemegn	3.05c	12.85	0.71c	13.56
Local 2 /Susalluh	8.75b	18.17	3.81b	21.98
Local 1 /Red Potato/	12.25a	12.56	6.85a	19.41
Gudenie	4.65c	18.62	1.81c	20.42
LSD (0.05)	2.0	NS	1.50	NS
CV (%)	20.5	34.9	34.8	32.6

*TNPP- Tuber number per plant, *MY- Marketable yield *UMY- Unmarketable yield (t/ha), *TY-Total yield (t/ha), *NS-Non-Significant

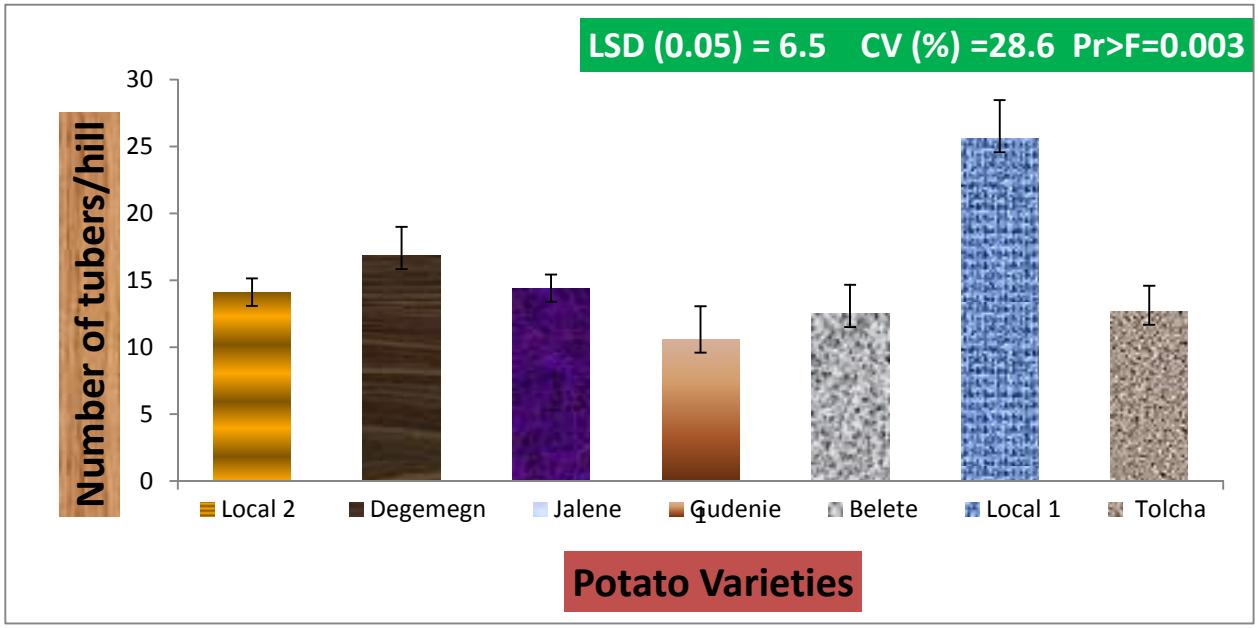

Fig.1. Differences in tuber number per hill among Irish potato varieties at Gircha Highland Fruits and Vegetables Research Center during the Winter Cropping season (February-June, 2016).

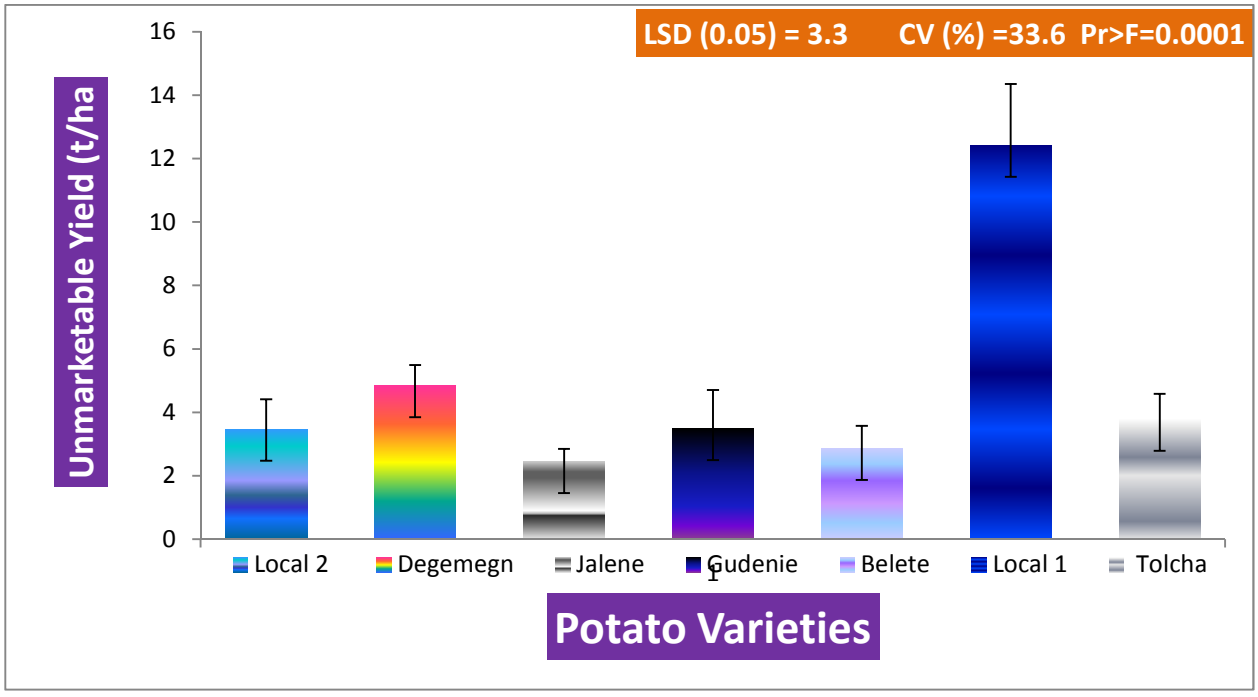

Fig.2. Differences in unmarketable tuber yield among Irish potato varieties at Gircha Highland Fruits and Vegetables Research Center during the Cropping season (February-June, 2016).

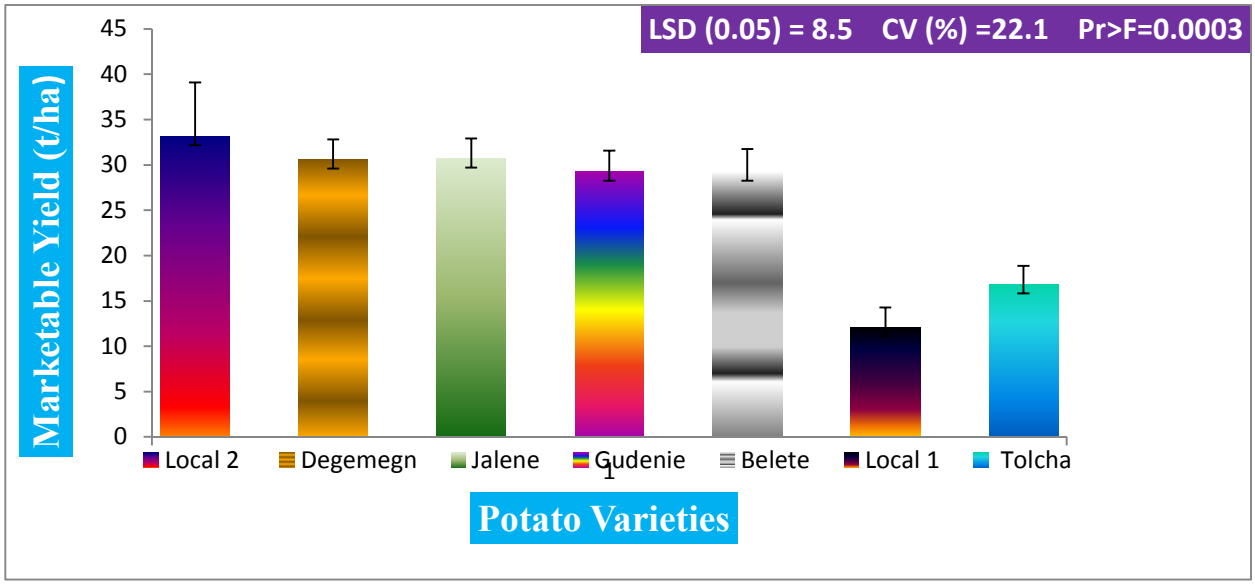

Fig.3. Differences in Marketable tuber yield among Irish potato varieties at Gircha Highland Fruits and Vegetables Research Center during Winter Cropping season (February-June, 2016).

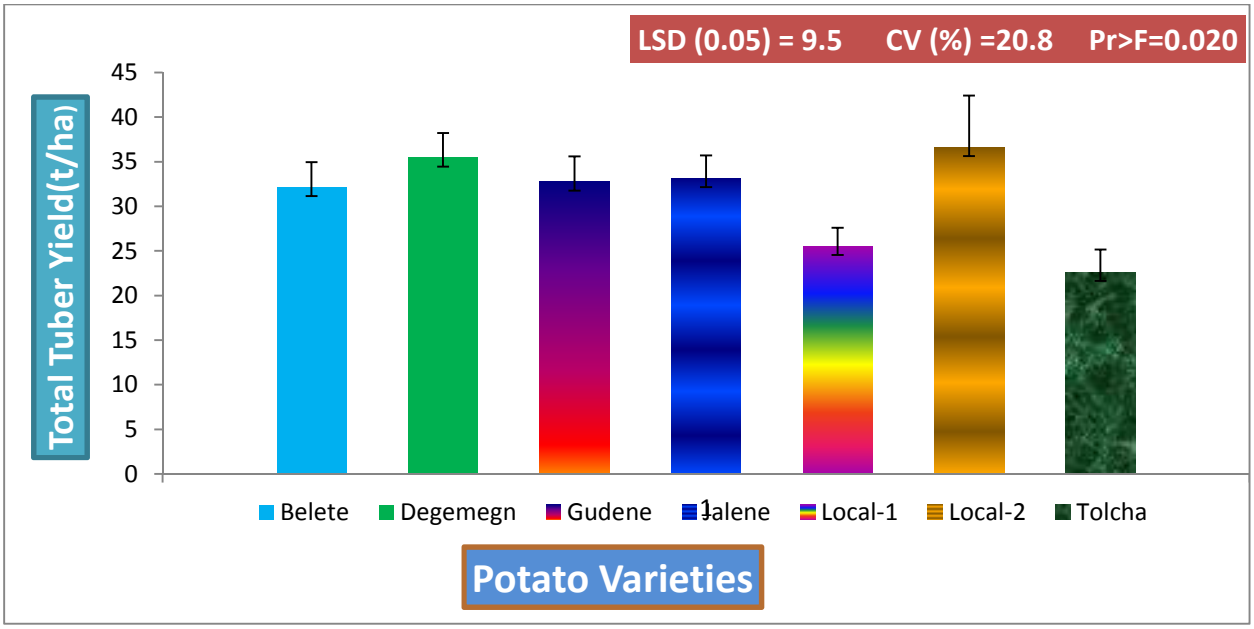

Fig.4. Differences in Total tuber yield among Irish potato varieties at Gircha Highland Fruits and Vegetables Research Center during the Winter Cropping season (February-June, 2016).

The data regarding tuber number per plant revealed that a very highly significant ($p < 0.01$) effect in both growing seasons. During autumn growing season the highest number of tubers per plant was recorded in Local 1 variety (12.25) followed by Local 2 (8.75) and both were at par with each other and significantly higher than others. Lower number of tubers (2.75) per plant was recorded in Belete variety (Table-1). The highest mean tuber number (25.58) also observed in Local-1 variety during the winter growing season which demonstrated a double rise compared to the autumn season mean tuber number. Significantly higher mean tuber per plant was recorded in the autumn season where the least was in Gudene variety (Fig. 1). These result aligns with the findings of Berhanu and Tewodros (2016) where they reported Jalenie variety (19.07) produced highest and significantly higher mean total tuber number per hill whereas; Ararsa variety recorded significantly less mean tuber number(8.6). Another research by Subarta and Upadhya(1997) further indicated that number of tubers per plot depends mainly on number of stems per plot, total number of stolons and stolons tuberized.

The analysis of variance regarding marketable yield (>20 g) presented in Table 1 showed statistically non-significant difference among the varieties in the autumn growth season. The highest marketable yield (18.62 t ha^{-1}) was recorded in Gudenie Variety followed by Susallu whereas; the rest varieties showed moribund trend in

marketable yield with the least marketable yield (12.56 t ha^{-1}) achieved in Local-1 (Father) potato variety.

However, in the winter cropping season, potato varieties showed highly significant ($p < 0.01$) difference with regards to marketable yield (Fig. 2). Unlike autumn season, in the winter season the highest marketable yield (33.17 t ha^{-1}) was recorded in Susallu (Local-2) variety whiles the least marketable yield (12.10 t ha^{-1}) record in Local-1(Father) variety. The growth performance and the yield attributes recorded in the Local-1 remained to similar during both cropping seasons. In the other varieties, the mean marketable tuber yield recorded in the winter cropping season was much better than the ones recorded in the autumn cropping season. Similarly, research works by Habtamu *et al*., (2016) found that marketable yield significantly varies by variety according to the experiment conducted at Eastern Ethiopia.

The results in association to very small tubers (mean unmarketable yield <20 g $tuber^{-1}$) turned out to be highly significant ($p < 0.01$) among the varieties in both of the cropping seasons. (Fig. 3). It ranged from 6.85 t ha^{-1} to 0.71 t ha^{-1} in Local-1 and Degemegn varieties respectively during the autumn cropping season whereas; it ranged from 12.43 t ha^{-1} to 2.45 t ha^{-1} in Local-1 and Jalene varieties which were at par with the rest varieties respectively during winter cropping season. The difference noted in unmarketable tuber yield could be attributed to variability in varieties. Moreover, unmarketable tuber yield might be controlled more importantly by intensively manipulating the growing environment associated to factors such as disease incidence, agronomic practices and harvesting practice (Berga *et al*., 1994).

The finding on mean total tuber yield ranged from 21.98 t ha^{-1} in Susallu (Local-2) to 13.56 t ha^{-1} in Degemegn in the autumn cropping season whereas; it ranged from 36.64 t ha^{-1} in Susallu (Local-2) to 20.63 t ha^{-1} in Tolcha in the winter cropping season. The statistical analysis for total tuber yields showed non-significant and significant difference ($p < 0.05$) among varieties during autumn and winter growing season respectively (Fig.4). The highest total tuber yield was recorded in Susallu variety in both seasons. The least total tuber yield 13.56 t ha^{-1} was recorded in Degmengn variety followed by Belete variety 14.56 t ha^{-1} in the autumn cropping season while 20.63 t ha^{-1} was recorded in Tolcha followed by Local-1 variety 24.53 t ha^{-1} in the winter cropping season. These results are also confirmed with the findings of other authors who reported that yield differences among genotypes were attributed both by the inherent yield potential of genotypes and growing environment (Elfinesh, 2008 & Asmamawu, 2007).

5. Conclusion and Recommendations

Seven potato varieties during the winter season and five potato varieties during the autumn cropping season were evaluated for their yield attributes at Chencha agro-ecology condition during the 2015/2016 crop calendar. The yield and yield components were higher during winter/'Belg' season as compared to autumn/'Meher' season. Winter season of production was found to be more suitable for potato production in Chencha-Gircha condition. Actually there was high temperature fluctuation during autumn season especially at the time of bulking phase (Oct-Nov, 2015) which might have happened to be the limiting factor for the low yields on top of the varietal performance. During both seasons Susallu/ Local-2 variety demonstrated the superior total and marketable tuber yield and yield components.

This result further revealed the existence of variations among nationally released potato varieties in yields and yield component in both season of production in Chencha-Gircha condition. From the mean analysis, Gudenie variety produced the highest total and marketable tuber yield than the rest improved varieties during the autumn cropping season. However, there was significantly higher total tuber yield observed in Degemegn variety during the winter cropping season. Variation in tuber yield ranks in the order: Jalene > Gudenie > Belete which also at par with each other. The Varieties were not significantly different in total and marketable tuber yield during the same cropping season.

The number of tubers per plant was consistently higher in Local-1 variety locally named 'Father' or 'Qay Dinich' in the study area but produce more number of under grade tubers which accounted for the higher unmarketable tuber yield in both of the cropping seasons. As a result, the percentage of total and marketable tuber yield was low in Local-1 variety. According to the farmers' choice, it is not a good character of any variety to produce small tubers, because it doesn't benefit farmers' as the market value of small tubers is very low and less likely to be used for soup and stew. Similarly, Tolcha variety resulted in low total and marketable tuber yield during the winter cropping season and even it did not entirely germinate during autumn cropping season. Eventually, from our cross-seasonal field experiment, we conclude that the study evidently demonstrated the effect of varietal difference on the yield attributes of potato. The yield attribute was found to be superior in the Susalllu (Local-2) variety in our research.

Moreover, all varieties performed much better in the winter cropping season compared to the autumn cropping season. Gudenie during autumn and more importantly Degemegn followed by all other improved varieties except Tolcha performed better during the winter cropping season. Local-1 variety is not suitable to be cultivated in the study area during both of the seasons. Apparently, we recommend the farmers in the study area to avoid use of this variety for production but, it can be used for further breeding works in research center.

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Annexes

Annex 1 ANOVA results for autumn 'Meher' season growth and yield data

Mean Tuber Number per plant

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Variety	4	269.1680000	67.2920000	40.41	<.0001
Block	3	3.2060000	1.0686667	0.64	0.6027
Error	12	19.98	1.665		

Mean Marketable Yield

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Variety	4	140.6059000	35.1514750	1.00	0.4432
Block	3	98.4538200	32.8179400	0.94	0.4530
Error	12	420.23	35.02		

Mean Unmarketable Yield

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Variety	4	105.8861200	26.4715300	27.90	<.0001
Block	3	1.0309200	0.3436400	0.36	0.7815
Error	12	11.38	0.95		

Mean Total Yield

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Variety	4	221.1131800	55.2782950	1.61	0.2346
Block	3	89.6400800	29.8800267	0.87	0.4828
Error	12	411.45	34.29		

Annex 2. Anova results for winter 'Belg' growing season growth and yield data

Mean Tuber Number per Plant

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Variety	6	587.7842857	97.9640476	5.16	0.0030
Block	3	12.5067857	4.1689286	0.22	0.8815
Error	18	354.14	16.86		

Mean Marketable Yield

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Variety	6	1572.867593	262.144599	7.96	0.0003
Block	3	189.747325	63.249108	1.92	0.1626
Error	18	593.05	32.95		

Mean Unmarketable Yield

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Variety	6	287.7830929	47.9638488	9.74	<.0001
Block	3	3.6646679	1.2215560	0.25	0.8616
Error	18	92.33	4.397		

Mean Total tuber Yield

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Variety	6	838.5170357	139.7528393	3.40	0.0203
Block	3	146.7536679	48.9178893	1.19	0.3421
Error	18	887.5	42.26		

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Notes

Note 1. This is an example.

Note 2. This is an example for note 2

Table 1. The capitals, assets and revenue in listed banks

	Total capital stock	Income of main business	Total assets
Pudong Development Bank	39.2	214.7	5730.7
Bank of China	459.4	3345.7	59876.9

Description for the above table.

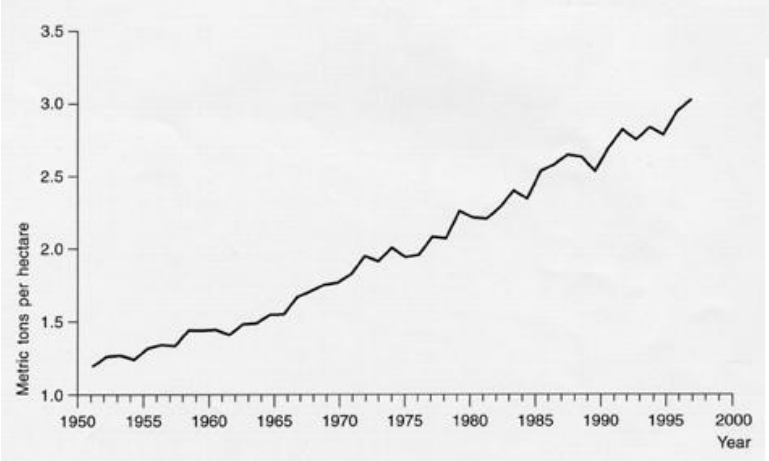

Figure 1. The Trend of Economic Development

Description for the above figure.