ISSN (P): 2304-1455/ISSN (E):2224-4433
Volume 6(11), 210-220

Asian Journal of Agriculture and Rural Development

http://aessweb.com/journal-detail.php?id=5005
DOI: 10.18488/journal.1005/2016.6.11/1005.11.210.220

IN VIVO PROPAGATION OF POTATO (*SOLANUM TUBEROSUM* L.) CULTIVARS

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Article History:

Received: 15-Nov-2016
Revised received: 11-Dec-2016
Accepted: 20-Dec-2016
Online available: 5-Jan-2017

Keywords:
Solanum tuberosum,
CIP germplasm,
in vivo propagation

Abstract

In order to evaluate the morphological and qualitative characteristics of potato tubers total 35 genotypes were selected for propagation and trait screening. Consequential differences and diverse characteristics were found in all the genotypes after cultivation, wherein, among all the traits zina red, CIP 07, CIP 12, CIP 22, gave the highest results regarding yield and quality of potato tubers except CIP 03 which has low germination percentage and significant quality characters. The dendrogram was prepared to show the massive variation between potato genotypes. This screening is supportive to the permanent efforts to select the best genotype for the developing processing industry of Pakistan.

1. INTRODUCTION

Solanum tuberosum L. (Potato) from genus *solanum* belongs to the family Solanaceae, is an annual crop (Khurana *et al*., 2003). 2n=48 is the number of chromosome of potato. An auto-tetrapoloid potato is stuffy, perennials and heterozygous plant species (Roodbar *et al.*, 2008). Potato is originated from Peru in North America and feast to other parts of the world where in it is spread efficaciously plusdevelop essential crop of Europe (Bashir, 1981). Depending on cultivar during storage of potatoes start gathering reducing sugars, by which transport sweet flavour in their end vintages because of the objectionable brown shade of chips and fries as well as creating them unfit for chip treating (Schimmer, 1957).

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Potatoes which have rich reducing sugars concentrations are responsible for the browning of potato chips during frying and therefore lower applications of reducing sugars result in high quality product (Mazza, 1983). Potatoes are disbursed every wherein the biosphere with enormous amounts in which potatoes could be a right pedestrian vehicle for hectoring some fitness connected complications (Ezekiel *et al*., 2013). Because of their favourable effects on health, frequent of the compounds existing in potatoes are essential therefore they are highly required in the human diet (Katan & de Roos, 2004). During the year 2010 to 2011 the total cultivation of potatoes in all over Pakistan were recorded as 3491700 tones with total 159400 hectares, while in Khyber Pakhtunkhwa the total production area was 8900 hectares, in Punjab 148100 hectares, in Baluchistan 2000 hectares were recorded (Anonymous, 2005). In all over the world 315 million tons of potatoes were produced where in Pakistan total production was 3.49 million tons of potatoes with 14 kg/capita/year, while according to the year 2008 potatoes production was 2.5 million metric tons (FAO, 2008). Most vegetative crop for Pakistan is considered is potato in Pakistan which grown 101.5 thousand hectares on an area with a yearly invention of 666.1 thousand loads (Anonymous, 2005). Andigena is widely grown by native farmers since Mexico, from south America the North and Central American cultivars were most familiarized but from Colombia to Argentina the cultivars are likely active (Hawkes, 1990). In Europe Plant protection policies has been closely linked to potatoes (Ebbels, 2003). Due to the economic position of the crop and the wide range of pests that affect them, *Phytophthora infestans* causes Irish potato dearth in the 19th century, an effective example set for the distressing effects and far accomplishment implications a plant disorder (Bourke, 1964).The objective of the present study was to evaluate and study the effect of seed size (small, medium and large) on potato manufacture under field conditions plus also to select potato diverse genotypes for yield traits and processing aspects, for growers, food industrialists and the potato product consumers in Pakistan.

2. MATERIALS AND METHOD

Potato genotypes including exotic and local varieties obtained from different sources as collected from potato program were planted at National Agriculture Research Centre, Islamabad, Pakistan, during the month of October, 2014 for their evaluation and screening. The potato planting was done according to Randomized Complete Block Design with three replications. The fertilizer was applied @ 250-125-125 NPK (Nitrogen, Phosphorus and Potassium) kg per hectare at seed bed preparation. The other dose of N (250 kg/ha) was divided in to two equal parts, applied at first and second earthening up. Eight varieties per bed were sown in RCBD (R1 small tuber, R2 medium tuber, R3 large tuber) Propagating was done by guardianship tuber to tuber space 20 cm and line to line space 75 cm. Plant protection measures were applied as when they are compulsory. Depended on environmental conditions irrigation practices were done i.e. four to five times in a month. For all treatments uniform cultural practices were adopted. At crop maturity, devaluing [1]was done and tubers were harvested after 15 days of devaluing allowing tuber skin to firm up. In a specific temperature for additional cultivation these tubers were stored.

[1] **Note:** NPK stands for Nitrogen, Phosphorus and Potassium

Figure 1: (a) Soil bed preparation, (b) Size of tubers, (c) Tuber measuring tool

2.1. Collection of data/Yield parameters

The field measurement data of selected potato germplasm were recorded on the basis of phenotypic parameters germination percentage and height of plant (cm), No. of eyes per tuber, tuber shape, tuber skin type, No. tubers per plant, average tuber weight per plant, average tuber size per plant). Small size range was 10 to 20mm, medium size was 20 to 30mm and large size was 30 to 40mm (Table 1).

Table 1: Total computable parameters used

NO	Total Parameters	Methodology
1	Plant height/plant	By using meter rod plant height was measured from the bottom to the top maximum level of the plant in centimeter (Fig. 2.1).
2	Germination percentage (%)/plant	By subtracting the total number of tubers sown from the total number of tubers germinated multiplied by hundred Germination percentage was calculated and the values were expressed in percentage(%). Germination % age = No. of tubers sown / No. of tubers germinated × 100
3	Total tubers/plant	After harvesting the crop plant character was detected by calculating total number of tubers per plant manually.
4	Average tuber size/plant	With the helping of potato measuring tool plant size character was measured.
5	Average tuber weight/plant (gm)	By using electronic balance total number of tuber weight per plant was measured in weight measuring unit gram.
6	Quantity of eyes/tuber	By visual inspection after harvesting entire number of eyes per tuber were noted.
7	Tubers shape/plant	Tubers shapes were noted after harvest.
8	Skin type of Tubers/plant	By optical observation the tuber skin type were examined after harvesting.

2.2. Statistical analysis

To examine the *in vivo* data Statistix 8.1 software were used and for the construction of graph Microsoft excel were used. ANOVA (Analysis of variance) was applied for the comparison among diverse potato specie while for the grouping of recorded qualitative data UPGMA cluster was used.

3. RESULTS

After the cultivation of potato CIP germplasm the data were recorded according to the following parameters

3.1. Plant height and germination percentage

Variation record in plant height is from 37.200[a] to 1.300[h]. Among all the CIP germplasm Zina red gave the maximum height (37.200[a]) followed by Desiree (33.000[ab]) while, Minutes plant height was detected in CIP 03 cultivar (1.300[h]). 5% level of LSD at results about germination percentage were significant. Supreme sprouting percentage was obtained in CIP germplasms (06, 08, 10, 11, 12, 13, 16, 17, 20, 22, 30, 32, 33), desire, HZD2 1499 and Zina red (100.00[a]) monitored by CIP 02, CIP 05, CIP 19, CIP 28, CIP 29, CIP 31 and Astrix (93.33[ab]) while Lowest germination percentage was noted in CIP 03 (20.00[d]) (Figure 2, 3 and Table 2).

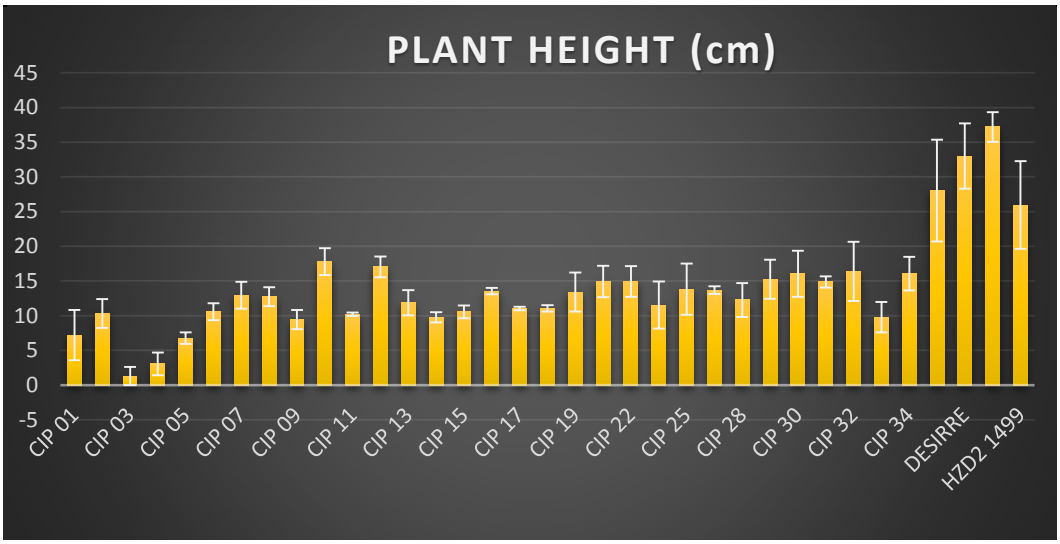

Figure 2: Plant height

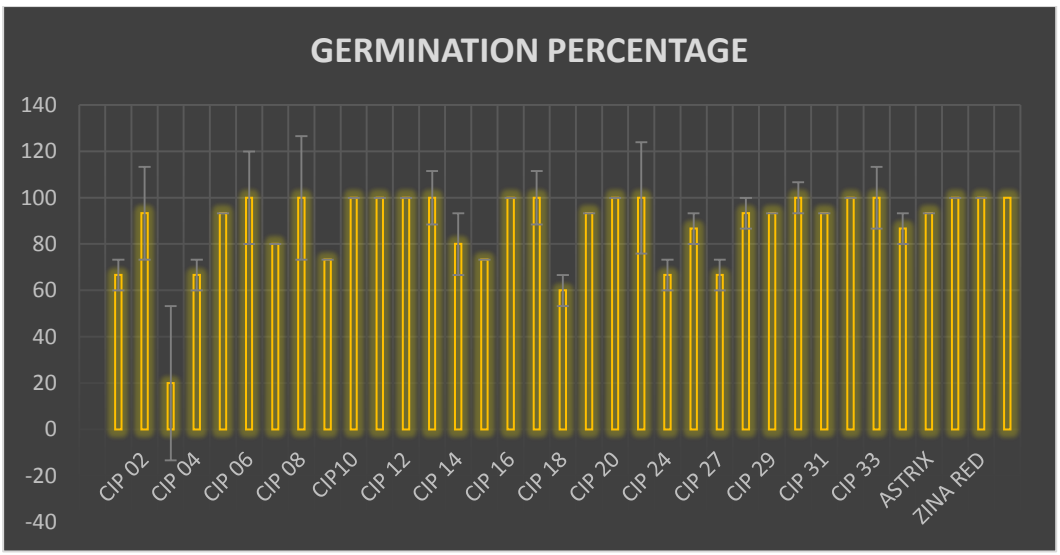

Figure 3: Germination percentage

3.2. Number of tubers per plant and Number of eyes per tuber

CIP 07 (10.133[a]) and CIP 12 (9.267[ab]) showed supreme tubers per plant while, CIP 03 (1.000[k]) showed lowest number of tubers per plant. By visual inspection CIP 01, 02, 04, 07, 09, 10, 12, 14, 16, 17, 20, 24, 25, 27, 28, 29 30, 31, 32, 33, Asterix, Desiree, Zina red, HZD2 1499 presented intermediate eyes per tuber although CIP 03, 05, 06, 08, 11, 13, 15, 18, 19, 22, 34 exhibited few eyes per tuber (Figure 4, 5 (a-i) and Table. 2).

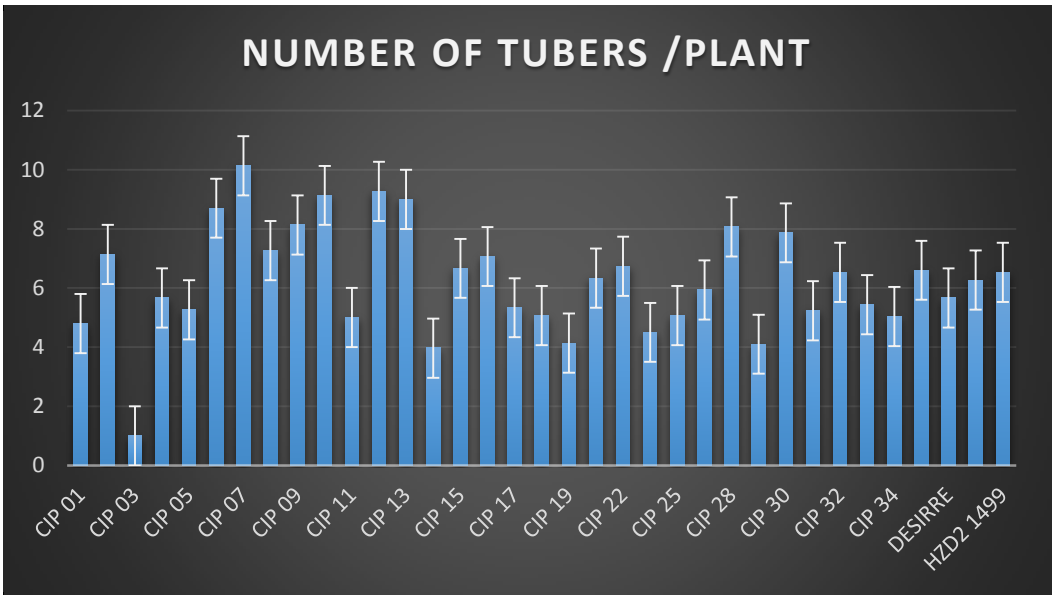

Figure 4: Number of tubers

3.3. Shape of the tuber and tuber skin type

For tuber shapes the composed gathered tubers were observed giving to the following Key.
Ovate: CIP05, CIP28, CIP31.
Oblong: CIP01, CIP03, CIP06, CIP07, CIP08, CIP09, CIP11, CIP15, CIP20, CIP25, CIP27, CIP29, CIP33, Asterix, Desiree, Zina red, HZD2 1499.
Round: CIP02, CIP04, CIP10, CIP13, CIP16, CIP18, CIP19, CIP24, CIP30, CIP32, CIP34.
Long oblong: CIP12, CIP14.
Obovate: CIP17, CIP22.
According to the following key the tubers skin type were noted
Rough: CIP07, CIP16, CIP017, CIP19, CIP28, CIP30, CIP34.
Smooth: CIP02, CIP03, CIP04, CIP05, CIP06, CIP08, CIP09, CIP11, CIP12, CIP13, CIP14, CIP15, CIP18, CIP20, CIP22, CIP24, CIP27, CIP29, CIP31, CIP32, CIP33, Asterix, Desiree, Zina red, HZD2 1499.
Partially netted: CIP01, CIP25.

Figure 5 a-i: Tuber skin type and shape of different CIP and local germplasms

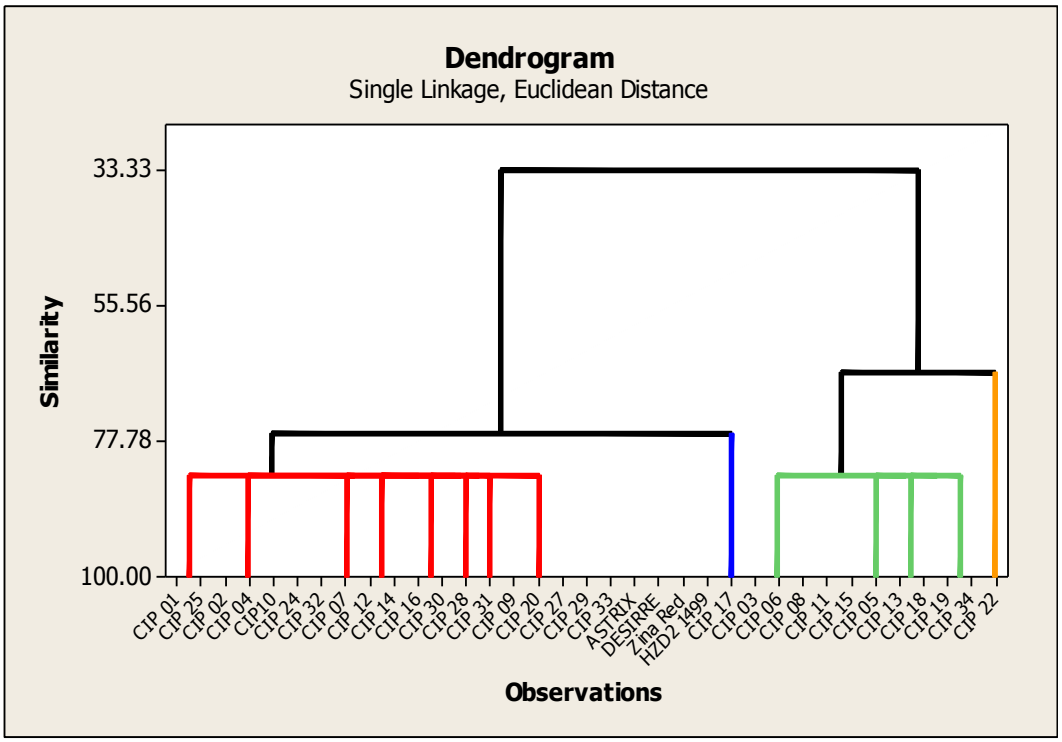

Figure 6: On the basis of qualitative characterization UPGMA cluster observed in 35 genotypes of potato

Analysis was measured by the UPGMA (Un weighted Pair Group Method with Arithmetic average) between CIP and local Potato cultivars for the qualitative correlation principal and cluster component. By UPGMA cluster analysis 35 diverse genotypes of potato paired into two main clusters, having extra sub-clusters, clusters I and II, (Fig. 3.5). Within I group showed that, genotypes were closely accompanying with each other, though slightly diverse inside the II group. In sub groups these subgroups further divided comprehended of genotypes. The ecotypes presented by dendrogram that were products of inherently analogous form, assembled unruffled. In the existent study, the cluster (band) analysis the altered genotypes were interposed with each other, which established no association between the qualitative development arrangements and their geographical source beneath examination.

4. DISCUSSION

Maximum plant height among all the genotypes were obtained in Zina Red (37.200^{a}) and lesser height was produced by CIP 03 (1.300^{h}). This modification in plant height (cm) may be due to the genetic transformation of verities. Our upshots are also in mark with Luthra *et al.* (2005) who also give description difference in between the unlike genotypes allocated to enough growth. Similar results in potato were also testified by other personnel (Schittenhelm *et al*., 2006; Shaterian *et al*., 2008). Present studies showing maximum number of germination percentage contained (100.00^{a}) at CIP germplasms (06, 08, 10, 11, 12, 13, 16, 17, 20, 22, 30, 32, 33), desiree, HZD2 1499 and Zina red in that order followed by CIP germplasms (02, 05, 19, 28, 29, 31) and Astrix (93.33^{ab}) however this difference among the genotypes might be due to genetically disparity and ecological conditions. Due to (Patel *et al*., 2008) large size tubers of high quantity might be due to inattentive plant beginning and with plant progression. Analogous effects were renowned by Khan *et al.* (2013) who described 80% to 95% disproportion in development percentage between tested cultivars.

Present studies showed the maximum number of tubers per plant in CIP 07, followed by CIP 12 (9.267^{ab}) (10.133^{a}). Variation between tubers per plant might be due to genetic growth in all the genotypes. Imperative protagonist in stolen and tuberilisation processes showed genetic makeup and environmental factor (Subarta & Upadhya, 1997). The results are within agreement with the conclusion of Singh and Ahmad (2008) who described variance due to vegetation and tuber origination. According to our fallouts average tubers weight per plant was in Zina Red (338.029^{a}), surveyed by HZD2 1499 (280.68^{ab}) while these alteration may be due to the aspects of genotypes, suitable progress plus disorder although these outcomes are adjusted to the deduction of Tuku (2000). The average tuber size per plant showing the existent work of the altered potato varieties were significant (5%) in which resolute number of minor size tubers were obtained in CIP 10(9.0000^{a}) tracked by CIP 12, CIP 13 and CIP 30 (8.3333^{ab}). Genotypes with medium size of tubers were observed in CIP 22 (3.0000^{e}) followed by CIP 28 (4.6667^{abcd}) although Medium tubers were found in CIP 03 (0.0000^{h})while, great number of large size tubers were found in Zina red (4.3333^{a}) followed by HZD2 1499 (3.6667^{ab})besides minimum number of huge size tubers were establish in CIP 03 (0.0000^{d}). Present work was buttressed by Masarirambi *et al*. (2012) which showed that by seed size the last size and number of tubers formed per plant was managed. Recent results about the qualitative characteristics showed that numbers of eyes per tuber in all the genotypes were intermediate in nature which were found in CIP 01, 02, 04, 07, 09, 10, 12, 14, 16, 17, 20, 24, 25, 27, 28, 29 30, 31, 32, 33, Asterix, Desiree, Zina red, HZD2 1499 and some of them like CIP 03, 05, 06, 08, 11, 13, 15, 18, 19, 22, 34 showed unsatisfactory eyes per tuber while, tubers shape also exhibited variation among all the potato germplasm tubers where in CIP05, CIP28, CIP31 presented ovate shape, CIP01, CIP03, CIP06, CIP07, CIP08, CIP09, CIP11, CIP15, CIP20, CIP25, CIP27, CIP29, CIP33, Asterix, Desiree, Zina red, HZD2 1499 indicated oblong shape, CIP02, CIP04, CIP10, CIP13, CIP16, CIP18, CIP19, CIP24, CIP30, CIP32, CIP34 revealed round shape, CIP12, CIP14 showed long oblong and CIP17, CIP22 showed obovate shape. Tuber skin types were noted in which rough types were CIP07, CIP16, CIP017, CIP19,

CIP28, CIP30, CIP34, however smooth types were designated by CIP02, CIP03, CIP04, CIP05, CIP06, CIP08, CIP09, CIP11, CIP12, CIP13, CIP14, CIP15, CIP18, CIP20, CIP22, CIP24, CIP27, CIP29, CIP31, CIP32, CIP33, Asterix, Desiree, Zina red, HZD2 1499 and partially netted were exhibited by CIP01, CIP25. Our results about qualitative characteristics was within contract with Khan *et al*. (2014) as they determined that all the characteristics of potatoes in which tuber shape, skin colour, flesh colour, eye depth and their general presence are the distinguishing qualities of potato for money making interest about performs and innumerable handling whereas, in former observations of Ganga *et al*. (2013). With a little bit similarity with our work most of their potato verities contours were unalike from our existing results and numbers of eyes were littler in utmost of the cultivars which showed

5. CONCLUSION

Existent studies concluded that such type of trainings is necessary to enhance yield of potato. Field experiment or *in vivo* propagation should be shepherded to cultivate parsimoniously or economically attainable diseases-free planting quantifiable. In the altered areas of Pakistan researchers need to improve these genotypes to check their production for future research study

Funding: This study received no specific financial support.
Competing Interests: The author declares that s/he has no conflict of interests.
Contributors/Acknowledgement: All authors participated equally in designing and estimation of current research.

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APPENDICES

Table 2: LSD All-pairwise comparisons test for all morphological traits

Genotypes	Plant height (cm)	Germination%	Average weight of tubers	Number of tuber/plant	Average tuber small size/plant	Average tuber medium size/plant	Average tuber large size/plant
CIP-01	7.200^{fgh}	66.67^{bc}	55.74^{jk}	4.800^{ghij}	4.6667^{cde}	1.6667^{fgh}	2.3333^{bc}
CIP-02	10.300^{def}	93.33^{ab}	102.40^{hijk}	7.133^{abcdefghi}	8.0000 ^{ab}	2.3333^{defgh}	1.6667^{cd}
CIP-03	1.300^{h}	20.00^{d}	3.24^{k}	1.000k	3.0000^{e}	0.0000^{h}	0.0000^{d}
CIP-04	3.067^{gh}	66.67^{bc}	153.25^{cdefghij}	5.667^{defghij}	3.0000e	3.3333^{cdefg}	2.6667^{abc}
CIP-05	6.767f^{gh}	93.33a^{b}	88.58^{ijk}	5.267^{efghij}	7.3333^{abc}	1.0000^{gh}	1.3333^{cd}
CIP-06	10.567^{def}	100.00^{a}	200.99^{bcdefg}	8.700^{abcd}	8.0000^{ab}	3.6667^{bcdef}	1.3333c^{d}
CIP-07	12.933^{cdef}	86.00^{abc}	168.68^{cdefghi}	10.133^{a}	6.0000^{abcde}	2.0000^{efgh}	1.3333^{cd}
CIP-08	12.733^{cdef}	100.00^{a}	131.34^{defghij}	7.267^{abcdefgh}	8.0000^{ab}	2.3333^{defgh}	1.3333^{cd}
CIP-09	9.433^{efg}	73.33^{abc}	101.39^{hijk}	8.133^{abcde}	7.3333^{abc}	3.0000^{defg}	1.3333^{cd}
CIP-10	17.800^{c}	100.00^{a}	245.85^{abc}	9.133^{ab}	9.0000^{a}	4.0000^{abcdef}	1.3333^{cd}
CIP-11	10.200^{def}	100.00^{a}	103.07^{hijk}	5.000^{fghij}	6.3333^{abcd}	3.0000^{defg}	1.3333^{cd}
CIP-12	17.033^{cd}	100.00^{a}	232.92^{abcd}	9.267^{ab}	8.3333^{ab}	4.3333^{abcde}	2.0000^{bc}
CIP-13	11.867^{cdef}	100.00^{a}	215.00^{bcde}fg	9.000^{abc}	8.3333^{ab}	4.0000^{abcdef}	2.0000^{bc}
CIP-14	9.767^{efg}	80.00^{abc}	110.53^{ghijk}	3.967^{jk}	5.3333^{bcde}	1.6667^{fgh}	2.6667^{abc}
CIP-15	10.533^{def}	73.33^{abc}	142.63^{cdefghij}	6.667^{bcdefghij}	6.6667^{abcd}	1.0000^{gh}	1.3333^{cd}
CIP-16	13.533^{cdef}	100.00^{a}	155.40^{cdefghij}	7.067^{abcdefghi}	7.0000^{abcd}	2.3333^{defgh}	1.3333^{cd}
CIP-17	11.033^{cdef}	100.00^{a}	94.62^{hijk}	5.333^{efghij}	7.0000^{abcd}	2.6667^{defg}	2.0000^{bc}
CIP-18	11.067^{cdef}	60.00^{c}	122.66^{efghij}	5.067^{efghij}	5.3333^{bcde}	3.3333c^{defg}	1.3333c^{d}
CIP-19	13.400^{cdef}	93.33^{ab}	154.84^{cdefghij}	4.133^{ij}	4.0000^{de}	3.0000^{defg}	1.6667^{cd}
CIP-20	14.933^{cde}	100.00^{a}	224.18^{bcde}	6.333^{bcdefghij}	5.3333^{bcde}	4.3333^{abcde}	2.3333^{bc}
CIP-22	14.933^{cde}	100.00^{a}	241.30^{abc}	6.733^{bcdefghij}	7.0000^{abcd}	6.3333^{a}	2.0000^{bc}
CIP-24	11.533^{cdef}	66.67^{bc}	104.76^{hijk}	4.500^{hij}	5.6667^{bcde}	2.6667^{defg}	2.0000^{bc}
CIP-25	13.833^{cdef}	86.67^{abc}	199.26^{bcdefgh}	5.067^{efghij}	4.0000^{de}	3.6667^{bcdef}	2.0000^{bc}
CIP-27	13.700^{cdef}	66.67^{bc}	132.00^{dcefghij}	5.933^{cdefghij}	4.6667^{cde}	2.6667^{defg}	1.3333^{cd}
CIP-28	12.267^{cdef}	93.33^{ab}	175.64^{bcdefgh}i	8.067^{abcdef}	8.0000^{ab}	4.6667^{abcd}	2.6667^{abc}
CIP-29	15.267^{cde}	93.33^{ab}	91.19^{ijk}	4.100^{ij}	5.6667^{bcde}	3.0000^{defg}	2.0000^{bc}
CIP-30	16.033^{sde}	100.00^{a}	220.56^{bcdef}	7.867^{abcdefg}	8.3333^{ab}	4.0000^{abcdef}	1.6667^{cd}
CIP-31	14.867^{cde}	93.33^{ab}	122.76^{efghij}	5.233^{efghij}	4.6667^{cde}	3.3333^{cdefg}	2.3333^{bc}

CIP-32	16.400^{cde}	100.00^{a}	233.55^{abcd}	6.533^{bcdefghij}	6.0000^{abcde}	3.6667^{bcdef}	3.0000^{abc}
CIP-33	9.800^{efg}	100.00^{a}	115.90^{fghij}	5.433^{efghij}	5.666^{7bcde}	2.6667^{defg}	2.0000^{bc}
CIP-34	16.067^{cde}	86.67^{abc}	141.70^{cdefghij}	5.033^{fghij}	4.0000^{de}	3.6667^{bcdef}	1.3333^{cd}
Asetrix	28.033^{b}	93.33^{ab}	237.97^{abcd}	6.600^{bcdefghij}	5.3333^{bcde}	4.0000^{abcdef}	2.0000^{bc}
Desirre	33.000^{ab}	100.00^{a}	233.11^{abcd}	5.667^{defghij}	7.0000^{abcd}	4.6667^{abcd}	2.6667^{abc}
HZD2 1499	25.933^{b}	100.00^{a}	280.68^{ab}	6.533^{bcdefghij}	5.3333^{bcde}	5.6667^{abc}	3.6667^{ab}
Zina red	37.200^{a}	100.00^{a}	338.02^{a}	6.267^{bcdefghij}	4.3333^{cde}	6.0000^{ab}	4.3333^{a}
LSD(0.05)	7.1194	33.304	107.97	3.0812	3.0417	2.5789	1.7112