NEPALESE HORTICULTURE

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The society has following objectives:

- ☞ Enhance public awareness towards the importance of horticulture.
- ☞ Develop linkages with related national and international institutions.
- ☞ Support government/ non-government organizations in planning and implementing horticulture development program.
- ☞ Encourage horticulturists and recognize their contributions in developing horticultural sector in the country.
- ☞ Create conducive-environment for horticulture development in the country.
- ☞ Develop a strong work ethic in horticulture.
- ☞ Promote horticulture as an integral part of environmental conservation activity.

The President's Message

In Nepal, horticulture has been a major thrust to lift up the national economy lately. The Government of Nepal, through its Ministry of Agriculture and Cooperatives, has given due priority on the development of this sector. The recent 3-year plan of Nepal Government targets at food and nutrition security through modernization of production techniques and commercialization of agricultural/horticultural products locally and globally. Without appropriate, yet sufficient, research and development efforts, it would be difficult to improve upon the present state of concerns in agriculture, especially in horticulture.

Many enterprenuers, private institutions and NGOs and INGOs have come up with thier activities today for expansion of horticultural business on various sub-sectors such as fruits, vegetables, flowers, plantation crops, spices and medicinal herbs indicating that horticulture needs to be promoted at much higher level in commercial scale.

For the promotion of horticulture sector, the traditional technology of production, management and post-harvest activities might not be enough for overall growth of this sector in the competitive business and enterprenuership develpment today. The multi-facet roles of this sector in the enhancement of national economy indicate that emphasis on research activities must be carried out adequately and timely so as to develop a specific package of practices/activities for horticultural crops. All professional horticulturists affiliated with education, research and development orgainization may give sufficient interests and time to solve crop-specific-field problems through basic and applied research.

The outcomes that generated from research activities must be scientifically documented so as to make aware of recent findings, to replicate the methodology and to share the evidences among horticulturists, irrespective of development workers, researchers, and policy analysts. For this, the present editorial board of Nepal Horticulture Society has done a commendable task to get research findings published in this issue. I hope the findings presented (through 13 papers) in this issues bear a meaningful and productive impact on promotional activities of horticultural development in Nepal as a whole.

Nepal Horticultural Society is greatful to all those who have contributed directly, indirectly or both to make this issue in this form. Special thanks are due to Dr. Deepak Mani Pokhrel, Editor-in-Chief and his associates for timely and quality editorial works.

Prof. Dr. Gyan K. Shrestha

Editor's Note

Nepal Horticulture Society (NHS) is a professional organization that holds together all horticulturists in the country working in government and non-government organization as well as private businesses. Since its establishment in 1990, the society has been regularly publishing journal and workshop proceedings thus contributing to horticultural research and development in the country. *Nepalese Horticulture,* an official publication of the society as journal, is one of our endeavors towards wider dissemination and sharing of horticulture related outcomes of researches, reviews, studies and investigations in the country. Such is very important to achieving developments such as livelihood, food security, poverty reduction, public health and environmental sustenance foreseen by state policies and plans as well as millennium goals.

With ever-increasing number, scope and activities of various organizations such as universities, colleges, research institutes, GOs, NGOs and business organizations, we expect an increasing number of horticultural research projects and activities in the country. On such ground, state researchers, development workers and private entrepreneurs should have multitude of horticulture related findings, observations and experiences in hands to be shared by wider community. Therefore, cooperation by state horticulturists, specifically the society members, is important from the journal's sustenance and development point of view. Nonetheless, *Nepalese Horticulture* is facing a deficit of publishable manuscripts as well as problems in fetching reviewers' quality remarks timely. The society's members are frequently observed reluctant in submitting manuscripts for publication, in organizing the submitted materials properly even after availing them with reviewers' sincere remarks and in reviewing the manuscripts submitted by other colleagues as and when requested. We expect fellow horticulturists, as an author, to submit valuable findings, observations and experiences in a publishable form. In addition, their timely and constructive remarks on the materials requested for evaluation and development, as a reviewer, are also valued much to improve the journal's performance. The executive body in the society should also be considerate on acknowledging the scientists, researchers and writers' contributions and improving the journal's scopes and quality.

We gratefully acknowledge the regular supports extended to the society by various institutions such as CEAPRED, MEDEP, IDE, FORWARD and individuals that made publication of this issue possible. We also express our sincere gratitude to the authors for their interest on publishing manuscripts in *Nepalese Horticulture,* the reviewers for their timely remarks and valuable efforts on improving the manuscripts, members in the executive committee for their moral supports and members in the editorial board for their hard works in bringing out this issue. We are also thankful to all subscribers, readers and well-wishers of *Nepalese Horticulture*. We look forward to your continued supports and thank you all again.

Editor-in-Chief

Guide to Author(s)

Nepalese Horticulture has special interest on publishing research and development articles related to horticultural issues in the country and likely environment outside. It also provides space for such reviews, experiences, success stories, news and other communications. Followings are the guidelines to authors willing to submit their manuscript for publication in *Nepalese Horticulture*.

1. The manuscript must be an original work written in English and not published elsewhere.
2. The title should be short and specific reflecting major contents in the manuscript. It should be formated as Heading 1.
3. Aurthor(s)' name should follow the title in new paragraph formatted as Heading 2. Supplimentary information such as educational attainment, organization, title/designation and contact addresses including telephone, fax. and e-mail regarding the author(s) should come as footnotes on the first page.
4. The abstract not exceeding 200 words should concisely state major objective, methodology, findings and conclusions. It should not include diagram, footnote, equation or any parenthetical reference.
5. Key-words in alphabetical order should not exceed ten standard words.
6. Main text of the technical manuscripts should include introduction, objective, theoretical framework, methodology, result and discussion and conclusion. Review-based manuscripts can be confined to introduction, objective, discussion and conclusion.
7. The manuscript should not exceed 5000 words in total, and it should be in MS-word with page set up on A4 size and text format on Times New Roman font of 12-point size. The top and left margins should be set at 3cm and the right and bottom margins at 2.5cm.
8. The title of the manuscript set as HEADING 1 (paragraph style) should be in title case for major words only and bold 14-point font size. The first level headings should be all capitalized in bold 12-point font size. The second level headings should be in bold 12-point font size sentence case. The third level headings should be italicized in sentence case and normal 12-point font size.
9. Number of footnotes should be minimized, and it should not come for citation.
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    For a magazine article: Pandey, R. R. and P. M. Pradhanang, 1995. Potato wilt and its control measures (Nepali). **In:** Prabidhi Sangalo, vol. 9(3), pp.99-102. Nepal: Lumle Agriculture Research Center, Pokhara.

    For a year book/ report/ periodical: National Pay Commission, 1992. A report on the pay structure for civil servants. Nepal: Aradhana Press, Kathmandu.
    UNESCO, 1986. Statistical yearbook. Paris : UNESCO Press.

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    For edited works: Danziger, S. and P. Robert, 1982. The war on income poverty: achievements and failures. **In:** P. M. Sommers (ed.), Welfare Reform in America, Boston : Martinus Nijhoff, pp.31-52.

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Field Test of Citrus Greening: the Scratch Method

Janardan Khadka*[1], Yasuo Kawamura[2] and Mitsuru Okuda[3]

ABSTRACT

Huanglongbing (HLB) commonly known as citrus greening caused by Candidatus Liberibacter is a major destructive disease of citrus. As farmers are encouraged to use grafted saplings due to root-rot and foot-rot problems, infected scion used for grafted sapling production can be initial source of HLB infection. Established citrus orchards show various symptoms similar to HLB infection, and thus identifying HLB is difficult merely based on physiological disorder and nutrient deficiencies. Therefore, it is necessary to develop efficient, quick and simple diagnostic method for HLB. A scratch method, which is efficient, quick and simple diagnostic, was tested with newly developed LAMP method, which is more sensitive to HLB than conventional PCR. The study revealed that about 74% results from scratch method agreed with the results from LAMP. Moreover, the scratch method that required small effort and simple equipments proved to be reliable and its possibility to use for HLB diagnosis in field condition.

Key words: Citrus-greening, huanglongbing, iodine-test, LAMP, scratch-method

INTRODUCTION

Huanglongbing, previously known as citrus-greening, is a major destructive problem of citrus growing areas in the tropics and subtropics. It has been most serious threat to citrus industry in Asian countries like China, Thailand, Indonesia, India, Nepal, Pakistan and Bhutan. Graça (1991) presents an overview of citrus-greening worldwide. Roistacher (1996) and Ohtsu *et al.* (1998) reported that citrus-greening is one of the most destructive diseases of citrus in Nepal and a great threat to the future of citrus industry there. Unless the disease is understood and controlled, citrus will slowly but surely decline. Traditionally seedlings were used as planting materials. Recently, because of root-rot and foot-rot problems, trifoliate is being used as rootstock in mandarin and sweet orange. Free of HLB scion selection from mother plant is very important for quality saplings production. Therefore, establishment of HLB free mother-plant block and, for that, identification of HLB infected plant in established orchard is much crucial.

As of now, there are three types of HLB diseases known: the Asian (*Candidatus Liberibacter asiaticus*), the African (*Candidatus Liberibacter africanus*) and the American (*Candidatus Liberibacter americanus*) types. The disease is vector transmitted; commonly known as psylla. Of which two types namely Asian citrus psyllid (*Diaphorina citri* Kuwayama) and African citrus psyllid (*Trioza erytreae* del Guercio) are identified.

Rapid, sensitive and accurate diagnosis of HLB is an important step to control the disease. Ohtsu *et al.* (1998) classified 7 types of the HLB symptoms as important tools for its rapid diagnosis. HLB can be diagnosed by visual plant symptoms, HLB-specific fluorescent substance, Enzyme-linked immunosorbent assay (ELISA) with monoclonal antibodies, Polymerase chain reaction (PCR), quantitative PCR (qPCR) and Loop-mediated isothermal amplification (LAMP). PCR, qPCR and LAMP are used to detect low-level *Candidatus Liberibacter asiaticus* infection in citrus trees (Okuda *et al.*, 2009), but these methods are

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time-consuming, expensive and not suitable for large number of samples in field condition. Because distinguishing HLB-infected trees from those of physiological disorder due to zinc and manganese deficiency is very difficult, PCR is commonly used method of HLB diagnosis. However, PCR assay is expensive, not suitable for a large number of samples and time-consuming. Such delays timely removal of infected-trees and allows the trees' longer stay in field to complicate the problem. Therefore, a rapid and accurate diagnostic test of HLB is important to control the disease, and, for the test, it is necessary to develop an efficient, quick and simple method. Previous study reveled that HLB infected citrus leaf accumulates starch granules (Schneider, 1968), and histological method using iodostarch reaction can be used for distinguishing HLB from other factors (Onuki *et al.*, 2002). In this study, a simple scratch method for investigating HLB was considered, and the reliability of this method was analyzed.

MATERIALS AND METHODS

Collection of samples

Samples were collected from trees with and without typical symptoms, and used as mother plant for sapling production at Central Horticulture Centre, Kirtipur, Kathmandu, Nepal. Nine different citrus lines containing 22 varieties used as mother plants were selected. Among the sample trees, 100 were grafted (18 varieties) and 15 were seedling (4 varieties). Fully grown leaf samples were taken from half of the tree height. Samples were immediately stored in ice box and used for both scratch and LAMP method.

Fig. 1: Iodine-starch reaction in the scratch method; yellow color HLB negative (a) and black color HLB positive (b)

Scratch method

This method is based on iodine-starch reaction. HLB-positive leaf accumulates more starch than HLB-negative leaf. Whole leaf sample was taken for the test. The leaf surface was ruptured by rubbing on it a small piece of abrasive paper (that should not produce any color in water) gently for 15-20 times. The piece of abrasive paper thus rubbed on the leaf surface that contained the leaf tissues was put into a small plastic bag with sealer. Roughly a milliliter of pure or distilled water was put into the bag followed by 2-3 drops (25 µl) of 0.05 M iodine solution. The plastic bag was then sealed and the iodine solution and the piece of abrasive paper with small pieces of leaf tissues were mixed gently by pressing and rubbing from outside. After mixing, the color of the water changes to black or dark brown if the sample is HLB infected or to yellow or pale yellow if the leaf sample is HLB-negative (fig.1).

LAMP

LAMP is known as sensitive detection method for confirmation of HLB symptoms (Manjunath *et al.*, 2008) and in this study it is used as reference method. LAMP kit is recently developed method which has alkali solution (NaOH) for extraction, Acetic acid solution for neutralization, Premix HLB, Fluorescent color, Enzyme and miliQ. In addition to these chemicals Iso-propanol and 80% ethanol need to be prepared. In this method, the midrib of a leaf sample (about 5 mm square) was excised with a razor blade. Two to three pieces of leaf samples were put in 1.5ml plastic tube. Alkali solution (250 mM NaOH) was used for DNA extraction. Samples were incubated at 95ºC for five minutes. Acetic acid

solution (concentration 2.5 M) was used for neutralization. Grinding sample is not necessary like conventional PCR. After removing the homogenate, propanol was added, and then centrifuged at 15000 rpm for 15 minutes. Upper phase of the liquid was discarded and DNA pellet remaining at the bottom of the tube was cleaned with 80% ethanol. After cleaning miliQ was added to dissolve the pellet (DNA sample) and stored at -20ºC. Premix HLB, Fluorescent color and Enzyme were mixed to prepare reaction mixture. Two µl of extracted DNA sample was mixed with 23 µl of prepared reaction mixture. Mineral oil was put little bit in each reaction tube and mixed properly. After mixing, it was incubated at 65ºC for an hour. After an hour the reaction tube was immediately removed and the color of liquid was observed. Green fluorescent color indicated HLB-positive sample and colorless negative (fig.2).

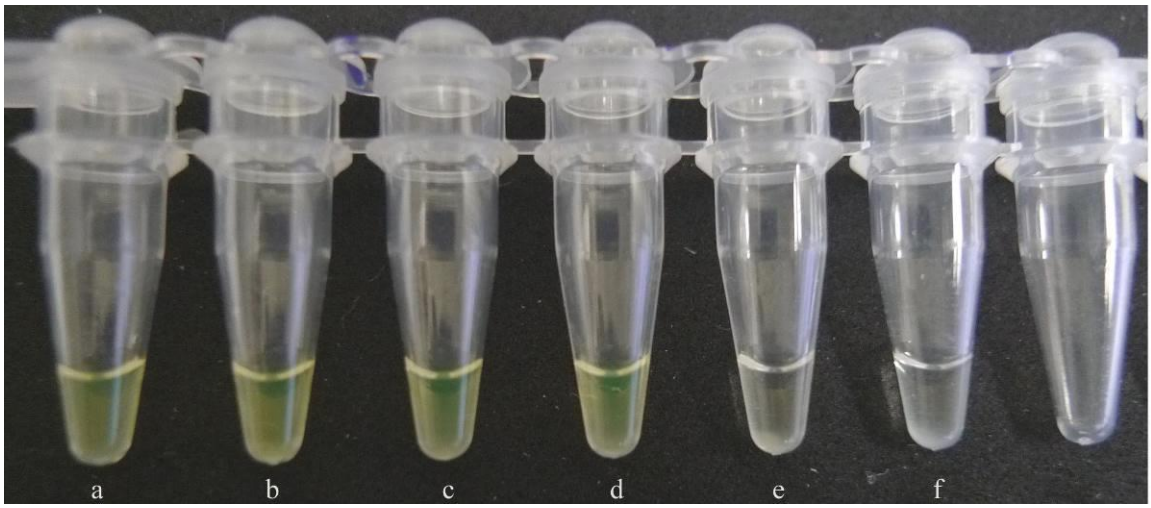

Fig.2: HLB detection by LAMP method; a, b, c and d - HLB positive and e and f - HLB negative

Based on LAMP result of the 115 samples, Yoshida Ponkan from Mandarin line, Miyagawa Wase from Satsuma Mandarin line, Taracco Nucellar, Blood Malta and Local selection from Orange line and Marsh Seedless from Grape Fruit showed HLB positive (Table 1). 13 samples from the six varieties showed positive result. Interestingly, all positive samples were grafted trees. Based on results of scratch method 22 samples from eight varieties showed HLB positive (Table 1). Three samples of Okitsu Wase and a sample of Thai selection gave positive result in this method but they were negative in LAMP. In this method the results of 16 samples were unclear. These unclear samples from scratch method had both positive and negative results in LAMP method.

Table 1: HLB diagnosis in citrus leaves by scratch and LAMP methods

Citrus Line	Name of Varieties	Tree Type	No. of Samples	Positive (+)		Negative (-)		Unclear (±)	
				LAMP	Scratch	LAMP	Scratch	LAMP	Scratch
Mandarin	Yoshida Ponkan	G	23	4	4	19	17	0	2
	Ohta Ponkan	S	4	0	0	4	4	0	0
	Thai Tangerin	G	3	0	0	3	3	0	0
	Hayaka	S	1	0	0	1	1	0	0
	Dekopong	S	1	0	0	1	1	0	0
	Commun	G	1	0	0	1	1	0	0

	Local	G	15	0	0	15	11	0	4
King Mandarin	Kinnow	G	1	0	0	1	1	0	0
Satsuma Mandarin	Miyagawa Wase	G	4	1	1	3	0	0	3
	Okitsu Wase	G	11	0	3	11	7	0	1
Tangors	Murkott	S	9	0	0	9	6	0	3
Orange	Taracco Nucellar	G	5	1	3	4	2	0	0
	Yoshida Navel	G	1	0	0	1	1	0	0
	Blood Malta	G	3	1	1	2	2	0	0
	Oroval	G	1	0	0	1	1	0	0
	Local selection	G	25	5	8	20	15	0	2
Tangelos	Orlando	G	2	0	0	2	2	0	0
Grape Fruit	Marsh Seedless	G	2	1	1	1	1	0	0
Pummelo	Thai Selection	G	1	0	1	1	0	0	0
	Local selection	G	1	0	0	1	0	0	1
Kumquat	Round Fruit	G	1	0	0	1	1	0	0

Table 2: Comparing diagnosis result of scratch method with LAMP

Citrus Line	No. of samples	Agreement	Disagreement	Result not clear
Mandarin	48	39	3	6
King Mandarin	1	1		
Satsuma Mandarin	15	7	4	4
Tangors	9	6	0	3
Orange	35	27	6	2
Tangelos	2	2		
Grape Fruit	2	2		
Pummelo	2		1	1
Kumquat	1	1		
Total	115	85 (73.9%)	14 (12.2%)	16 (13.9%)

RESULTS AN DISCUSSIONS

Table 2 indicated comparison of diagnostic result of scratch method and LAMP. Result indicated that 85 samples out of 115 (73.9%) gave same results in both diagnostic methods. However, scratch method results of 14 samples (12.2%) were opposite from the LAMP results. In addition, scratch method was unable to give clear results for 16 samples (13.9%). Since LAMP is more sensitive than scratch method, LAMP detected HLB from samples without any visual symptom. 73.9% results of scratch method agreed with the results of LAMP. Taba *et al.* (2006) found 75% agreement for citrus leaf samples between PCR results and iodo-starch assay. This finding supports our study and indicates the consistency of the result regardless of detection process modification and plant samples. In this study, some disagreement might be due to low infection to accumulate starch in leaves that did not produce any clear HLB symptom. From this evidence, scratch method can be used as simple, easy, quick and economical for large samples in field condition.

CONCLUSION

Scratch method, which is efficient, quick and simple diagnostic method for HLB, indicated 73.9% results agreed with LAMP. Thus it indicated that scratch method can be used to diagnose HLB infection. Furthermore, this method is useful to diagnose large number of samples in field condition. So, it might be important for quality sapling production in nursery and citrus orchard management.

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Varietal Performance of Broccoli for Summer Season Production

Sharmila Piya[1], A. R. Bajracharya[2], J. L. Mandal[3] and B. P. Choudhary3

ABSTRACT

Broccoli is considered as a very high value vegetable, due to its high content of vitamins and minerals. An experiment was conducted to test varieties of broccoli for summer season (March-May) production during 2002 and 2003 at Agriculture Research Station, Pakhribas (1740 masl) in Randomize Complete Block Design (RCBD) with three replications. The tested varieties were Premium Crop, Universal, Centauro, Sakura and Beejo Sheetal. The highest marketable head yield was from variety Premium Crop (12.01 t/ha) followed by Centauro (11.42 t/ha), while Beejo Sheetal and Universal produced 8.92 t/ha and 8.56 t/ha, respectively. Similarly, in case of plant height, Premium Crop (53.02cm) was the tallest plant and the Universal (36.39cm) was the shortest. Higher plant spreading was recorded from Centauro (71.53cm) and Premium Crop (69.98cm). Terminal head weight was recorded highest for Centauro, followed by Bejo Sheetal and Premium Crop with 0.348 kg, 0.345 kg and 0.325 kg respectively. Considering all of these parameters, varieties Premium Crop and Centauro were found superior over rest of the varieties for summer season production.

Key words: Broccoli, off-season, variety

INTRODUCTION

Broccoli is highly nutritious vegetable among cole crop group. The word broccoli means 'little sprouts' in Italian. It is believed to be the first of the cole crops to evolve from wild cabbage (Delahaut and Newenhouse, 1997). It is rich in vitamin A, C and minerals. The green buds and thick fleshy stalk are used as vegetable. This vegetable is also tastier than cauliflower and cabbage. Its market price is always two times higher than cauliflower and cabbage even in normal (winter) season. There are two types of broccoli available in market- green heads (also called Calabrese in European Country) and purple types. Purple types are grown in limited scale in England. Despite, its high nutrition and monitory value very few formal studies have been carried out in Nepal.

Table 1: Vitamin contents of cole crops (mg/100g of edible portion).

Vegetables	Vit A	Vit B_1	Vit C
Cabbage	400	27	100
Cauliflower	70	56	75
Broccoli	9000	33	137

Source: Brown and Hutchison (1949) as cited by Chatterjee (1986).

Variety plays an important role in production ultimately on farm income. It is very necessary to test the varieties incoming to our country especially when huge numbers of hybrid vegetable seeds are being imported (Subedi and KC, 2004). Hybrids are generally heat tolerant and they do well in summer season. Therefore, with the purpose of varietal testing of broccoli for summer season, this study has been carried out at Pakhribas.

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MATERIALS AND METHODS

The experiment was carried out in two consecutive years 2002/03 and 2003/04 at Pakhribas. There were six varieties namely; Green Sprouting, Premium Crop, Universal, Centauro, Sakura and Beejo Sheetal. Experiment was laid out in RCBD and each treatment was replicated three times. In the year 2002/03 the local check variety Green Sprouting did not germinate and in the year 2003/04 seed of this variety was not found in the market. Seed sowing was done in February under polythene tunnel and planting was done at the seedling age of 51 days. DDVP (76% EC) and Metacid were sprayed to control aphid, flea beetle and cabbage butterfly. The cultural practices like gap filling, irrigation, weeding was done as per the requirement in crop growing period. Fertilizer NPK @ 100: 60:50 kg/ha and FYM @ 10 t/ha were applied. Seedlings were transplanted at the spacing of 60cm x 45cm. Finally data analysis was done by using GENSTAT computer package.

RESULT AND DISCUSSION

Marketable yield (t/ha)

The marketable yield (t/ha) was found significantly different among different varieties (P>.001). The highest yield was obtained from Premium Crop variety (12.01 t/ha) (Table 2). This variety produced significantly highest yield compared to all other varieties except variety Centauro (11.42 t/ha), which produced the second highest yield. The lowest yield of 8.56 t/ha was produced from variety Universal. All of these varieties are F1 hybrids. Local check (OP) variety Green Sprouting did not germinate, due to which this variety could not be included in the comparison.

Table 2: Marketable yield of broccoli varieties.

Varieties	Marketable yield (t/ha)
Beejo Sheetal	8.92c
Centauro	11.42ab
Premium Crop	12.01a
Sakura	10.16bc
Universal	8.56c
F value	>.001
LSD	1.652
CV%	13.2

Figures within column indicated by same letters are not significantly different at 5% level.

The yield of broccoli averaged from 5-10 t/ha. According to Strange *et al.* (1996) average yield of broccoli in California is 16.8 t/ha^{-1}, while Peet (1995) reported 7.4 to 10 t/ha in South America and Stirling (2006) reported 5.4 to 10.9 t/ha yield in Australia. Similarly, Kahn (2002) reported 10.04 t/ha yields for Variety Premium Crop in Oklahoma. Our result also falls within the yield range reported by different scientists.

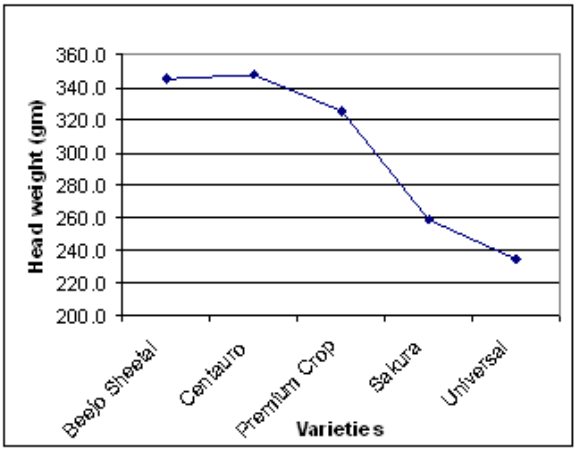

Fig.1: Performance of broccoli varieties on average head weight

Terminal head weight

Head weight was significantly different at 5% level among varieties. This showed that Centauro variety produced highest head weight (348 gm), which was followed by Beejo Sheetal (345 gm). This result indicated that Centauro produced bulky head at first harvest. Premium Crop, Sakura and Universal produced smaller sized heads with 325 gm, 259 gm and 234.gm respectively (fig.1). Stirling (2006) reported that average marketable head weight of broccoli ranged from 207.5 gm to 310.8 gm. Similarly, according to Chatterjee (1986) the average head may be 25 gm to 600 gm. Kahn (2002) found 272 gm of average head weight for variety Premium Crop, the head weight was found exceeded by the result of our experiment.

Table 3: Height of broccoli plants

Varieties	Plant height (cm)
Beejo Sheetal	47.31b
Centauro	48.07b
Premium Crop	53.02a
Sakura	44.79b
Universal	36.39c
F value	>. 001
LSD	4.205
CV%	7.5

Figures within column indicated by same letters are not significantly different at 5% level.

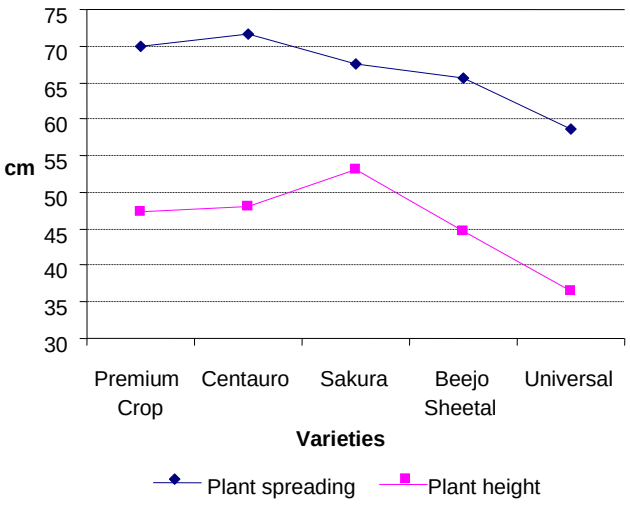

Fig.2: Spreading and height of broccoli plants

Plant height

Plant height was obtained statistically highly significant among the varieties (Table 3). The tallest plant height was recorded from variety Premium crop (53.02cm). This variety was found significantly tallest than rest of the varieties (Fig.2). Varieites Centauro, Beejo Sheetal and Sakura were recorded at par with respect to plant height with 48.07cm, 47.31cm and 44.79cm respectively (Table 3). Shortest plant height was recorded for Universal variety (36.39cm).

Plant spreading

The response of plant spreading due to varieties was found highly significant (P>.001). Centauro variety was observed as the highest spreading plant (71.53cm). Centauro was significantly different from all other varieties except Premium Crop (69.98cm). Premium Crop also differed from Beejo Sheetal and Universal varieties.

Head depth

Different hybrid varieties were found statistically significant (P>0.005) with regards to head depth. Highest head depth was recorded from Premium Crop (13.14cm), which was followed by Centauro (12.84cm). Sakura and Beejo Sheetal were having 11.27cm and 10.94cm head depth respectively.

Head diameter

Centauro variety was recorded to have the highest head diameter (14.59cm). While varieties Premium Crop, Beejo Sheetal and Sakura were observed as statistically at par

with 13.64cm, 13.32cm and 3.04cm diameter respectively. Variety Universal produced smallest head diameter (11.94cm). According to Chatterjee (1986) the terminal head may be 15 – 25 gm in diameter.

First harvesting days

Maturity days due to varieties were recorded significantly different. The observation was taken from the planting to first harvesting. Premium Crop was found earliest in harvesting (55 days). Sakura, Centauro and Beejo Sheetal varieties were harvested in 57 days, 61 days and 64 days respectively. According to Peet (1995) broccoli generally matures in 45 to 60 days after transplanting, which varied depending on the time of year and the variety planted (fig.3).

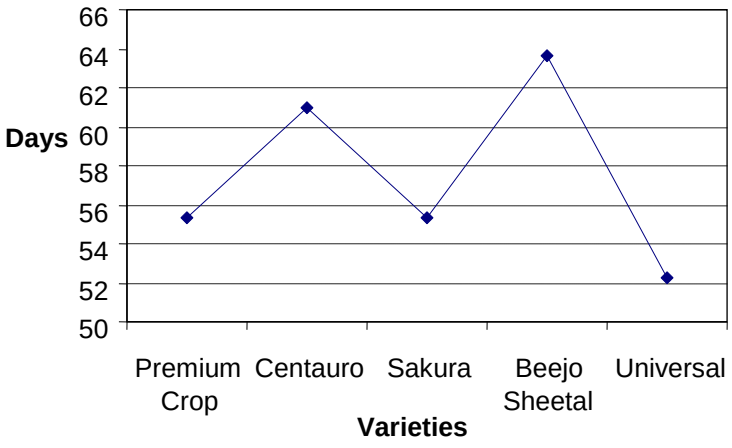

Fig.3: Days of first harvesting

Total number of harvesting per plant

The observation was also made on total number of harvesting. Broccoli also produce small heads from axillary shoots after main one is removed, which are also called as spears. Side shoots found ready to harvest in 9-10 days after previous harvesting. This was found highly significant due to varieties and significant to interaction of variety and year. Premium Crop variety was recorded to have the highest number of harvesting (3.75) during its growing period in the second year of experimentation. This variety was also found to have the highest number of harvesting in first year (2.44). This result demonstrates that Premium Crop variety gives maximum number of harvesting. Side shoots averaged between 45 to 136 gm. Garrison (1985) reported an average of 13 side shoots per plant in variety Premium Crop. A paper also reported that 2-3 more commercial harvests are possible, if the field is properly maintained. These reports are in agreement with our result.

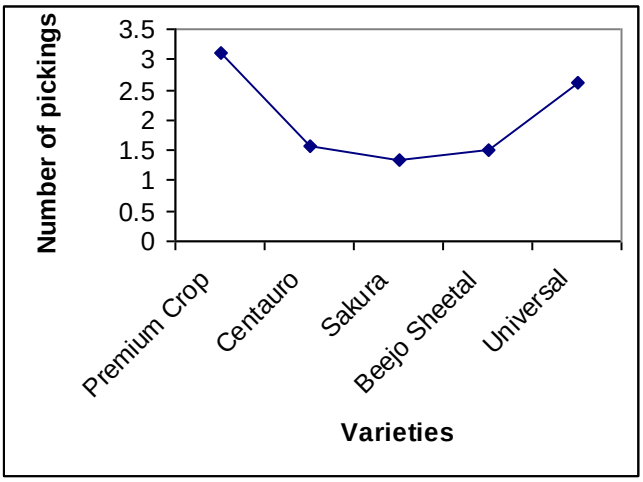

Fig. 4: Total number of harvesting

Problems of summer season broccoli production

Aphids (*Brevicoryne brassicae*) and cabbage butterfly (*Pieris brassicae*) were found as the most problematic insects for broccoli production in summer season. Next important problem of summer broccoli production was yellowing of heads in storage. Over maturity at harvesting, higher storage temperature and/or exposure to ethylene are the major reasons of broccoli cluster yellowing (Cantwell and Sustow, 2000). As broccoli is sensitive to

ethylene, it should not be stored with other products which produce ethylene (tomato, apple etc.). To reduce the yellowing, heads must be cooled with water, ice whatever is available immediately after harvesting (Strange *et al.*, 1996).

CONCLUSION

Based on the two years experimental result, it can be concluded that broccoli can be produced in summer season by using the hybrid varieties. Varieties Premium Crop and Centauro were found superior over other varieties in terms of yield (12.01 t/ha and 11.4 t/ha respectively). While considering bulky head, varieties Centauro, Premium Crop and Beejo Sheetal (347.8 gm, 325 gm and 345.3 gm respectively) were found better as compared to others. In conclusion, varieties Premium Crop and Centauro can be recommended for off-season production.

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Incidence of Clubroot Disease in Crucifer Vegetables at Madhyapur Thimi, Bhaktapur

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ABSTRACT

Crucifers are important winter vegetables in Nepal. Many of the crops suffer from clubroot disease affecting yield drastically. In Madhyapur area of Bhaktapur, observations were made for four years continuously with farmer participation. Depending upon the vegetable species, on an average, the intensity of clubroot disease ranged from 15% to as high as 98%. On an average, the incidence was 34% in 2002, 45% in 2003, 57% in 2004 and 57% in 2005. The disease has been increasing in all crucifer crops. Cabbage was affected the most followed by cauliflower, knolkhol, mustard and turnip in order. Broccoli had least incidence of the disease in the study area. However, some farmers reported the disease to affect the crop as much by over 90% in 2010.

Key words: Cole crops, disease incidence, *Plasmodiophora brassicae*

INTRODUCTION

Vegetable growing is the major provocation of the farmers of Madhyapur (Thimi) area, Bhaktapur. This is a famous area for vegetable production in Nepal reflecting its name as Kitchen garden of Kathmandu Valley. It also used to supply different vegetables to other city areas of the country. In 1999, during the visits of vegetable farms, an unusual pattern of root bulging (i.e. swollen roots forming galls) in several cole crops was observed; this disease in cole crops is called clubroot. In fact, in Kathmandu Valley, the disease was noticed in cauliflower in Kalimati-Sitapaila area in 1993 with a loss of 9% to 55% of the crop depending upon the fields of cauliflower. In 1994, the loss was increased to 62%.(Shrestha *et al.,* 1998). The disease was also observed in Shankhamul and Balkot area (PPD, 2002). In several farmers' fields in Madhyapur Thimi, disease was observed the closely in 2000. In mild cases, plants wilt and get stunted during day time and become normal at night when transpiration rate goes down. In severe cases, the plant dies. In 2001, we made lively group interaction and discussion regarding clubroot disease with 20 farmers of Madhyapur Thimi who grow cole crops. These farmers reported that it was becoming a serious problem in their cauliflower and cabbage fields.

Not only the farmers of Madhyapur area but also the farmers of other places of Bhaktapur district have faced tremendous economic loss threatening sustainability of crucifer vegetable production in the district. Lately, severity of this problem has also been reported from other districts, such as Makawanpur, Kavre, Nuwakot, etc. Clubroot disease, the most devastating disease of Brassica crops worldwide, is caused by the pathogen *Plasmodiophora brassicae* affecting cabbage, cauliflower, turnip, mustard, and Chinese cabbage. The disease invades plant's root system affecting water and nutrient absorption and transport (Narisawa *et al.*, 1998).This study aimed to know severity of the disease in several of crucifer vegetable species and quantify the percentage loss of different cruciferous vegetables grown at Madhyapur area of Bhaktapur district from 2002 to 2005.

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METHODOLOGY

Among the many vegetable species grown in the Madhyapur area, crucifiers are major crops in winter and spring seasons. So, selected crops for this study were broadleaf mustard/mustard, broccoli, cabbage, cauliflower, knolknol and turnip.

Twenty farmers who grew one or more of these vegetables were included in the study program. The selected site was the river basin area situated at the south of the highway between Thimi Chowk and Hanumante Bridge to the north of the Hanumante River. Although planting dates of the said crops were somewhat different, however, the selected farmers have had similar dates of planting. The growing techniques adopted by all these farmers were essentially the same. Participant farmers' plots for mustard were 20, broccoli 5, cabbage 12, cauliflower 10, knolkhol 7, and turnip 15. Two of the 5 broccoli growers were contacted in January 2011 to review the disease incidence in their fields.

In all the years of study period, the farmer fields of these cruciferous crops were visited two times; first at one month after planting and the second at one month after the first visit. Three participant farmers and the researcher made critical observations of the clubroot disease occurrence inspecting all fields included in the study. Where necessary, some plants were uprooted carefully to confirm the disease incidence. The selected plant populations of each crop in each farmer were 100; so, included plant populations for this study totaled 6900 in every year.

RESULTS AND DISCUSSION

The study indicated that all the crops under the critical observation were affected by the disease and the average incidence was ranged from 15.35% to 98.1% (Table 1) showing the seriousness of the clubroot problem for the production of crucifer vegetables at Madhyapur Thimi in coming years. The attack was highest in cabbage in all four years of study, giving the mean value of 83.69%. In 2003, the disease incidence recorded in one farmer's cabbage field was as high as 100% infection. The cabbage growers were very disappointed with the incidence and they asked for an immediate control measures for appropriate solutions.

Table 1. Four-year observations on the average incidence of clubroot in various crucifer vegetables at Madhyapur Thimi (Percent of plant population)

Crops	Plants	2002	2003	2004	2005	Mean
Broccoli	500	18.2	34.35	25.8	30.6	27.24
Cabbage	1200	80.25	98.1	75.65	80.75	83.69
Cauliflower	1000	40.1	66.6	67.6	80	63.58
Knolkhol	700	25.08	48.5	95.1	75.5	61.05
Mustard	2000	25	40.5	34.35	35.8	33.91
Turnip	1500	15.35	25.2	45.5	40.35	31.6
Mean	1150	34	48.88	57.33	57.12	

The mean values of 4 years study indicated that cauliflower received the second highest infection recording a figure of 63.58%. In 2002, the incidence was 40.1%, which increased in subsequent years also leading to 80.0% incidence in 2005 (Table 1). The difference in the disease occurrence between 2003 and 2004 was although insignificant but the figures are still very high to show significant loss in cauliflower production.

The mean value was lowest (27.24%) in broccoli, because the incidence in every year of study was comparatively low which ranged from 18.20% in 2002 (lowest) to 34.35% in 2003 (highest). Discussions with two broccoli growers in January of 2011, these farmers

were quite unhappy as they observed the disease over 90% in their fields. Mr Raj Krishna Shrestha planted broccoli in one-twentieth hectare of land and he was disappointed seeing all his plants infected with the disease. This indicates that clubroot in broccoli is getting more severe than some years before. The broccoli is a new and an emerging vegetable crop in Madhyapur area; its incidence must be minimized so as to reduce high economic loss from this disease.

Broadleaf mustard is very popular winter cruciferous vegetable in this area. Every participant farmers has grown this crop in his vegetable block due to very remunerative and continuous pay offs for long duration for almost two months. The Table 1 shows that this crop has also substantial incidence of the disease giving the mean value of 33.91%. The incidence in 2002 was 25.0%, which increased to 40.5% in 2003, but remained near to 35% in later years.

The situation was quite different in knolkhol which had variable year to year differences in clubroot incidence. In 2002, the clubroot-affected plants were 25.08% of the population, which increased greatly in later years, giving as high as 95.1% in 2004. In this year, the turnip had also highest incidence (45.5%) among the four years and the least incidence was in 2002. Considering the mean values of 4-year period in all important crucifer vegetables, the crop susceptibility to the pathogen infection was quite variable at the study sites of Madhyapur area. Based on the incidence percentage, these vegetables can be placed in order of cabbage > cauliflower > knolkhol > mustard > turnip broccoli (Table 1).

Careful observations to the yearly mean values of incidence, irrespective of vegetable species, in general, it appears that the intensity of clubroot disease is increasing every year. It was 34.0% in 2002, which increased over 57% by 2005. This is a very high percentage of loss in vegetable crop production in winter and spring seasons.

It appears that the clubroot has been a devastating disease in cruciferous vegetable crops reducing the production of vegetables and hampering the income of growers in every year. The disease is difficult to eliminate from the fields but can be managed effectively using different tactics. Farmers need to be alerted with this disease and they need to adopt available control measures timely such as cultural (PH correction with the use of lime) and chemical (use of Nebijin) in integrated manner. Nebijin can be used in transplanting hole during transplanting for cost effectiveness.

Concerning the management of this disease, no host resistance is available. Fungicides have been recommended for the chemical control (Singh, 1985) but the effects were variable and depended on several production factors. Biological control has been indicated using *Heteroconium chaetospira*, which was effective to suppress the disease in field (Narisawa *et al.*, 1998). Significant reduction in clubroot index was also observed in plots treated with *Trichoderma harzianum* (Timila and Shrestha, 2000).

A management trial consisting of different treatments revealed that there are significant differences among the treatments in the incidence of club-affected plants (PPD, 2001). Lowest incidence was found in benlate treatment followed by *Trichoderma harzianum* application. Lime applications also reduced the disease over the control treatment. Seedling age could also affect the incidence as the 7-week old seedling when transplanted had low clubroot as compared to 3 or 4 weeks old seedlings (PPD, 2002). Pandey (2009) reported that planting of clubroot-free seedlings would be better alternative approach over the fungicidal treatments in grown up plants in the field. He has given some techniques to produce such disease-free seedlings in the nursery.

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Gerbera Cultivation and Postharvest Management Practices in Kathmandu Valley

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ABSTRACT

A field survey was carried out to find out production and postharvest handling practices of gerbera adopted by the growers of Kathmandu, Bhaktapur, Lalitpur and Kavre districts during September to December, 2009. About 68 varieties of gerbera were found to be grown by the entrepreneurs. It was noticed that the production and handling practices differ with the growers and localities. Better quality gerbera flowers were produced with the abundant use of compost and organic matter rather than chemical fertilizer. It was necessary to raise the bed height above 2 feet in low lands whereas about 1 foot was enough in the uplands. Besides, timely adequate sanitation measures were needed for better quality and quantity production of the flower. Red and pink flowers were highly preferred in the market, while the purple color had the lowest preference. Total production of gerbera in Kathmandu valley was found to be 6,21,200 sticks per year. Out of total production, summer, autumn, spring and winter shared 32.03%, 29.38%, 24.50% and 14.09% respectively. Price of the cut flower highly varied with respect to the seasons. During winter, price of the flower was the highest. The postharvest loss was found higher (3.3%) in winter than in summer (2.9%). The major causes of postharvest losses were due to inappropriate handling of the cut flower and varietal characteristics of gerbera.

Key words: Cut flower, gerbera, postharvest, seasons, varieties, vase-life

INTRODUCTION

Nepal has predominantly an agriculture-based economy where floriculture sub-sector holds a great export potential. In Nepal, commercial flower production has been expanded to 34 districts throughout the country. Also, the production area under floriculture is gradually increasing throughout the country. This sector provides employment opportunities to about 2,500 people among which 60% of them are women (FAN, 2007). Floriculture in Nepal has been converted into an established business over a period of one and half decade. It was observed that the total turn over of this sector in 2006 was about 230 million rupees (FAN, 2007). In a recent estimation this value has increased to 560 million rupees in 2010 (FAN, 2010). Nepalese cut flowers stands at one of the most prioritized position in international market as compared to other agricultural products in terms of export market potential (UNCTAD/WTO, 2007).

Gerbera (*Gerbera jamesonii*) also known as Transvaal daisy or Barberton daisy, is a member of the Composite family. Flowers of gerbera are available in a wide range of colors, including yellow, orange, pink, crimson, red, purple and white. Gerbera is most commonly used worldwide as a cut flower (Emongor, 2004). Gerbera is one of the ten most popular commercial cut flowers in the world and according to the global trends in floriculture; it occupies the fourth place among cut flowers (Choudhary and Prasad, 2000).

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The blooms are attractive, suitable for any type of floral arrangements and are available in different shades and hues. Besides floral arrangements, gerbera is widely used in bouquets and in dry flower crafts (Nair *et al.*, 2003).

Gerbera is one of the most important cut-flower species in Nepal which shows considerable demand in domestic and export markets. The daily demand of gerbera in Kathmandu is 1500-3000 sticks and cost of per stick gerbera is Rs.15.50. The area of gerbera cultivation in Nepal is 0.25 ha (5 Ropanies) (MOAC, 2009). Since the past 2-3 years, the domestic supply could not fulfill the total demand of gerbera and about 65% of the total demand was supplied by importing from India.

Generally gerbera is grown in Falgun-Chaitra or Shrawan-Bhadra in Kathmandu valley and production starts after 3 months of planting. In winter, especially, from October–February (Kartik-Falgun), there is high demand and low supply of cut flowers. Flower growers bring most of their domestic products (gerbera, carnation, gladiolus, Dutch rose) in the market after March-April (Chaitra-Baisakh) and do not get high price due to large supply. Besides, the problem with gerbera cut flowers is the short postharvest life (Wernett *et al.*, 1996). Low production due to fungal disease and high postharvest losses due to lack of postharvest treatment are the burning problems of the gerbera production and marketing in Nepal. Keeping quality is an important parameter for evaluation of cut flower quality, for both domestic and export markets (Nair *et al.*, 2003). The survey was carried out to know the existing situation of gerbera production and postharvest handling practices in Kathmandu valley.

MATERIALS AND METHODS

A field survey was carried out to analyze the existing situation of production and postharvest technology of gerbera in Kathmandu valley. Field survey was based on preliminary information regarding gerbera cultivation sites, type of promising varieties, cultural practices, types of soil, marketing system, and postharvest management aspects. The survey was conducted during September to December, 2009 in the existing 12 growers of different locations of Kathmandu valley. The surveyed locations were Dhulikhel, Bhaisepati, Kamalbinayak, Sipadole, Bajrabarahi, Godawari, Tokha, Sankhu, Bishalnagar, Kirtipur, and Dadhikot.

Besides the survey of growers' field, the questionnaires were filled and discussions were made with the retailers and wholesalers. Information was also gathered about sapling distribution, marketing, and postharvest aspects of the flower. The collected data from different sources like discussion, cultivation guide, questionnaires were entered in Microsoft Excel software. The data were analyzed by using SPSS 16.0 software package for descriptive and correlation analysis.

RESULTS AND DISCUSSION

During field observation, discussions with growers, retailers, wholesalers and from the questionnaires, following facts were found.

Shed house and field preparation

There was wide variation on shed house preparation, bed size, and planting system of gerbera. Sixty seven percent growers were using full closed shed house where as 33% growers had half closed shed house. It was observed that higher quality and production of gerbera could be obtained from full closed shed house system. Biradur and Khan (1996)

reported that it is very difficult to get good quality cut bloom of gerbera under open field condition. Similarly Emongor (2004) pointed out that cultivation of gerbera and other high valued horticultural crops (floriculture) under controlled environment (greenhouses) should be promoted.

There was a quite variation on plant spacing in the gerbera field. Plant spacing with 1x1 feet, 1.5x1 feet, 0.83x0.5 feet and 1x0.5 feet were observed at 33%, 25%, 25% and 17% in growers' field. It was recommended that space the plants 12 to 18 inches apart, being careful to plant the crown at or slightly above soil level (Tjia *et al.*, 2008).

Due to soil borne fungal problem in gerbera field, beds were raised in most of the plot but there was variation ranging from 0.3 to 2.5 feet. From the discussion, it was found that in low lands (Khet), due to high level of water level, there must be above 2 feet height of bed. If the field is in up lands (Bari), bed height might be 1 feet. This is for the precaution of root rot due to water level in the field. Growing gerberas in raised beds, mounds or containers is suggested during rainy season as excessive moisture would increase root rot incidence where drainage is a problem (Tjia *et al.*, 2008). The optimum bed height is shown in fig.1.

Fig.1: Optimum bed height in gerbera field

Variety and planting material used by gerbera growers

It was found that different varieties from different companies of gerbera were grown in Kathmandu valley. In Kathmandu, there were three agents supplying planting materials of gerbera. These agents were Flora Incorporated Trade, Tripureshwor; Crop Pro-Technepal, The Standard Nursery, Bansbari; and Flora Nepal Pvt. Limited, Kupandole and were selling the plants of different companies Florist, Florist De Kwakel B.V., Holland; Schreurs, The Netherlands and Preesman India Breeding Pvt. Ltd., Mumbai, India respectively. Out of 12 respondents, 6 growers were using varieties of only Florist, 4 growers were using varieties of only Schreurs, and 1 grower was using varieties of both Florist and Schreurs, whereas another one grower was using varieties of both Florist and Preesman. Gauchan *et al.* (2009) reported that generally two types of gerbera i.e., single and double were found in Nepali market and its demand was around 1,500-2,500 sticks per day. They also reported that around 3,000 plants could be grown per ropani.

There was big variation in growing number of varieties, ranging from 4 to 20. The mean and standard deviation of adopting varieties for cultivation were 10 and 5.12 respectively.

Likewise, there was big variation in cultivating number and type of plants. In Kathmandu valley, 43235 plants were cultivated in different locations. Out of them, there were 61.6% tissue cultured and 38.4% desuckered (division) plants. Aswath and Choudhary (2004) reported that most of the commercial varieties of gerbera are multiplied through tissue culture. Also they stated that this method enables a million fold expansions per year of a desired plant. Likewise Shailaja *et al.* (2004) reported that due to a great deal of variation, seed propagation of gerbera is not always satisfactory and multiplication through division of clumps or rhizomes is common. The lists of growers, variety and number of plants are given in Table 1 and 2.

Table 1: No. of plants, production and price variation in different seasons

Respondent/Gerbera grower	No. of plants

	Tissue culture	Sucker	Total
Bishwo Mani Pokharel, Kamalbinayak, Bhaktapur	10285		10285
lora Nepal Pvt.Ltd, Bajrabarahi, Lalitpur		2500	2500
Achyut Dhungana, Bakhundole, Kavre	500		500
Govinda Dhungana, Bakhundole, Kavre	1000	1500	2500
Rajan Thapa, Bans tole, Bhaisepati, Kavre	2000	3000	5000
Mandir Shrestha, Kitani, Godawari, Lalitpur	4500		4500
Prabindra Maharjan, Tokha, Kathmandu	2000	4000	6000
Shreedhar Karki, Indrayani, Kathmandu	3500	1500	5000
Gyanendra Thapa, Sipadole, Bhaktapur		600	600
Khem Raj Sharma, Chundevi, Kathmandu	2000		2000
Mandhoj Thapa Magar, Chanlakhel, Kritipur, Kathmandu		350	350
Sushil Khadka, Gamcha, Dadhikot, Bhaktapur	850	3150	4000
Total	26635	16600	43235
Percentage	61.6	38.39	100

Table 2: Lists of grown varieties and their vase life

S.N.	Varieties	Vase life (days)	S.N.	Varieties	Vase life (days)	S.N.	Varieties	Vase life (days)
1	Aisha (mini)	17	24	Excellence	17	47	Quote	11
2	Ambiance	11	25	Explosive (mini)	15	48	Rosalin	11
3	Amulet	13	26	Fiction	17	49	Salvadore	17
4	AvantGarde	11	27	Fiorella	15	50	Samada	15
5	AveMaria	13	28	Flyer	15	51	Samson	13
6	Aventura	15	29	Foske		52	Sarinah	13
7	Bellezza	11	30	Fusion	15	53	Savannah	13
8	Bismarck	13	31	Golianth	15	54	Scope	14
9	Bison (mini)	15	32	Guarda	13	55	Shayna (mini)	15
10	Blessing		33	Illusion (mini)	15	56	Sunglow	13
11	Bonbons	13	34	Junkfrau	13	57	Sunway	13
12	Cacharelle	14	35	Kayak		58	Suri (mini)	17
13	Candella	15	36	Luxuria	15	59	Tambre	15
14	Carambol	15	37	Malibu	11	60	Tresor	13
15	Carmen	17	38	Marquis	15	61	Valletta	13
16	Crystal Kimsey (mini)	17	39	Mexx	17	62	Viper (mini)	15
17	Dalma	11	40	Paco	0	63	Viviane	13
18	DanaEllen	15	41	PalmBeach	11	64	Vulcan (mini)	15
19	Doni	13	42	Paradox	13	65	WinterQueen	13
20	DoubleDutch	11	43	Picobello	12	66	Wintergold	13
21	Ebony	15	44	Popov	15	67	Woman	15
22	Ecco	13	45	Primrose	11	68	Yanara	13
23	Essence	13	46	PurplePrince	13			

Age of plants and color preference of gerbera growers

Gerbera growers were cultivating plants of different age ranging from 4 to 96 months and on an average 24.5 months. Standard deviation 26.82 showed that there was big variation of age in the cultivated plants.

White, yellow, pink, orange, red and purple flowers of gerbera were mostly found in growers' field. It was found that there was variation of varieties and color of flowers grown by farmers. About 8.3% growers were cultivating 20 varieties with all 6 types of colors whereas 25% growers had only 3 types of colors (white, pink and red). Similarly, 50% and 16.7% growers were cultivating 5 and 4 types of colors respectively. Out of 6 colors, red had dominance over others having 34 scores, followed by pink, white, yellow, orange and purple having 30, 22, 21, 12 and 2 scores respectively. Thus, red and pink color varieties

were highly preferred by growers, whereas purple had the lowest preference. The flower colors variation observed in growers' field are shown in Table 3. FAN (2009) also reported that in Chitwan and Pokhara, red color was mostly accepted by the buyers in all types of flower including gladiolus, rose, gerbera and carnation. In addition, orange mixed with white which is very common variety of gladiolus was also liked by many consumers.

Table 3: Flower color variation in growers' field.

Color	Frequency in different respondents											
	1	2	3	4	5	6	7	8	9	10	11	12
White	4	1		1	2	2	2	4	2	2	1	1
Yellow	5	1	2	2	1	3	1	3				3
Pink	4	1	5	1	3	2	4	6	1	1	1	1
Orange	2	1	1		2	3		2				1
Red	4	2	2	3	1	2	2	5	3	5	2	3
Purple	1		1									
Total variety	20	6	11	7	9	12	9	20	6	8	4	9

Soil treatment, fertilizer and irrigation application

Soil treatment: During the field observation, three growers (25%) were not aware about the soil treatment practice and did not disinfect the soil. One grower (8.3%) had used *Trichoderma* while eight growers (66.7%) had used formalin for disinfection of soil. The dose of formalin application was varied in their field. It showed that growers were not sincere about the dose of formalin for disinfection of the soil.

For successful cultivation of gerbera, disinfection of soil is prerequisite (Kumar Florists, 2007). In particular, the fungus is a menace to gerbera. The various methods of sterilization are sun, steam, and chemical. In chemical, use of formalin @7.5-10 lit./100 square meter is recommended. The pure chemical should be diluted 10 times in water and then sprayed or drenched on beds and then covered with plastic for 7 days, after that, flushed the soil approximately with 100 liter of water per square meter to drain the traces.

Fertilizer and irrigation application: There was wide variation in the use of fertilizer in gerbera field. It was found that fertilizer calculation was very difficult for most of the growers and they were using fertilizers in their own practical way. DAP, urea, potash for the fulfillment of NPK; bone meal; oil cake; $CaNO_3$; ash; and micronutrients having Ca, Zn, B were extensively used in the field of gerbera, but doses and time of application varied among growers. According to the growers, 0.56 kg/plant (on an average) compost was applied in the gerbera field although ranges were 0.2 to 1 kg per plant. After planting, regular foliar spray of 20:20:20: NPK were applied at fortnight or a monthly interval in the gerbera's field. From the grower's view and observation, good quality flower could be produced with the abundant use of compost and organic matter rather than chemical fertilizer. According to cultivation guide, during vegetative growth, N:P:K::20:20:20@0.4 gm/plant every alternate day for first three months and once flowering commences, N:P:K::15:8:35@0.4 gm/plant every alternate day were recommended (Kumar Florists, 2007). Gurav *et al.* (2004) suggested that the application of 20:20:15 g N, P and K /m2/month was found effective in producing good quality and high number of flowers in gerbera while Sekar *et al.* (2003) reported that application of 300 and 200 mg N and K each per week resulted in production of superior and higher flowers in gerbera.

Six growers had their well for irrigation; others had water collection pond and canal. It was found that watering to foliage part had negative effect on quality production, so irrigation on furrow with the help of pipe was preferred. Kumar Florists (2007) recommended excessive watering is not good for gerbera production.

Cultivated variety and their vase life

There were 68 varieties cultivated in Kathmandu valley. Out of these, 9 varieties were mini type and 59 varieties were standard type (Table 2). The average vase life of the 68 varieties were 14 (13.8594) and minimum-maximum vase life ranges from 11 to 17 days according to variety catalogue of different companies (Preesman, 2007; Florist, 2007; Schreurs, 2007).

Insects pests, diseases and disorders

White fly, mites and aphids were major insects in gerbera where as Fusarium, root rot, crown rot, botrytis diseases were observed as major disease in the growers' field. Physiological disorders observed in the field were leaf folding, pseudo flower, twins flower, scape pitting or cracking and stem bending. Tjia *et al.* (2008) reported that gerberas are often attacked by insects like leaf miner, caterpillars, cutworms, spider mites and thrips. They also reported that a number of fungal diseases like gray mold (*Botrytis cinerea*) and powdery mildew (*Erysiphe cichoracearum*) occurs during periods of prolonged cloudy weather and high humidity in gerberas. The visual symptoms observed in gerbera field are shown in Fig.2.

Fig.2: Insect pests, diseases and disorders; a. *Fusarium,* b. Pseudo flower, c. Leaf folding, d. White fly, e. Mites, f. Twins flower

Chemicals and pesticides use in gerbera farming

Fungicides like Carbendazim, Mancozeb, Cupper oxychloride, Captan, Hexaconazol, Polyram, Calixin, Acrovat were being used by the growers in their field. Similarly, insecticides like Prime (Acetaprimide); Endosulphan; Larvine(Teodicarp) for cotton caterpillar; Interprit; Vertimex; Omite; Rogor; Nuvan; Kalmyte for mites, thrips and white fly; Flebendioxide; Admire; Chloropyriphos; Cypremethrin; Malathion; Victor; Fersa were being used. Besides this, some growers were also using antibiotics like Korsing Ag (Streptomycin sulphate+Tetracycline hydrochloride), Antibak, Biomycin (Kasugamycin 3%). There was no any scientific application of pesticides for plant protection measures. It was found that growers were applying different chemical pesticides without knowing their benefit and hazards. The common practices of pesticide application were found to be based on farmers' experiences and consultation with agrovets and pesticides sales agents. FAN (2007) reported that neither grower nor the pesticide dealers are aware of specific pesticides requirement of flower crops and for specific conditions

Crop stage and time of harvesting

Growers were well acquainted that the gerbera flowers should be harvested when the outer two rows of disc florets were opened which is important for the longevity of the cut flower. But practically, farmers do not practice it due to varying in demand which determined the amount to be harvested and package of transportation. Salunkhe *et al.* (1990) reported that the optimum time for harvesting gerbera cut flower is when the outer two rows of disc florets were opened where as Reid (2004) recommended that most gerbera varieties should be harvested when the 2 outer rows of disk florets have begun to open.

Table 4: Variation in harvesting days after planting

Growers (Res.)	Post-harvest loss		Total loss	Harvesting days after planting	Age of plant (month)	Harvesting practice	Harvesting Time
	Winter	summer					
1	5	3	8		11	Twisting	Morning and evening
2				90	96	Twisting	Morning

3	4	2	6	75	4	Twisting	Morning and evening
4	5	2	7	80	4	Twisting	Evening
5	7	5	12	75	4	Twisting	Evening
6	5	2	7	60	24	Twisting	Evening
7						Twisting	Evening
8	5	2	7	75	17	Twisting	Evening
9	7	5	12		10	Twisting	Morning
10	5	1	6		40	Twisting	Morning
11	3	2	5	75	24	Twisting	Morning
12	7	5	12	70	36	Twisting	Morning and evening
Average	5.3	2.9	8.2	75	24.55		

The common planting materials of gerbera used by growers were either imported tissue cultured plantlets or desuckered 2-3 years' old plant. So, there was high variation on harvesting days after planting, it ranges from 60 to 90 days after planting (Table 4). About 42% growers harvested flowers in the evening, 33% farmers harvested in the morning whereas 25% farmers harvested flowers both in the morning and evening as per their time availability to send to wholesale market. All growers were found to be practicing twisting method for harvesting of the flower, not by cutting the stalk. Reid (2004) reported that gerbera flowers are harvested by twisting the stems off near the point of attachment to the rhizome; this is thought to encourage subsequent flower production.

Total annual production of gerbera in terms of money was calculated about 6.5millions excluding post-harvest loss. The average postharvest loss was about 8.2% (Table 4).

Table 5: Seasonal variation on production of gerbera per plant

Description	Maximum	Mean	Std. Deviation
Production per plant in winter	3.75	1.5729	1.42898
Production per plant in summer	11.25	5.4091	2.95408
Production per plant in autumn	11.25	5.2972	3.14246
Production per plant in spring	7.50	2.9207	2.83660

Table 6: Gerbera cut flower production in Kathmandu

Respondents	Sticks production					
	Winter	Spring	Summer	Autumn	Total	Annual/plant
1	35000	45000	60000	60000	200000	19.45
2	6000	10000	15000	15000	46000	18.4
3			4000	4000	8000	16
4	5000	10000	17000	17000	49000	19.6
5	8000	10000	16000	16000	50000	10
6	10000	33000	20000	20000	83000	18.44
7	2500	4200	10000	6500	23200	4.64
8	0	0	2500	2500	5000	8.33
9	6000	10000	22500	22500	61000	30.5
10	0	0	2000	3000	5000	14.29
11	15000	30000	30000	16000	91000	22.75
Total	87500	152200	199000	182500	621200	
%	14.09	24.50	32.03	29.38		
Average						16.58

Cut flower transportation and selling

Gerbera flowers were harvested and each flower was fitted with plastic cap in order to protect flower from floret

Table 7: Means of cut flower transportation

Means	Frequency	Percent
Motorcycle	7	58.34
Own vehicle	3	25
Public bus	1	8.33
Motorcycle/Tata mobile	1	8.33
Total	12	100.0

destruction during handling. Then, flowers were bunched keeping 10 sticks per bunch with rubber band and wrapped with newspaper for transportation. It was found that 58.34% growers used motorcycle, 25% used own vehicle, 8.33% used public bus, and 8.33% growers (Table 7) used both motorcycle and Tata Mobile for transportation.

Four wholesalers were involved in supply of gerbera flower in Kathmandu. They were Flora Incorporated Trade, Tripureshwor; United Flora Pvt. Limited, Teku; Flora Nepal Pvt. Limited, Kupandole; and Bagmati Flora Pvt. Limited. 41.67%, 33.33%, 16.67% and 8.33% growers were found to be selling gerbera cut flowers in Bagmati Flora, United Flora, Flora Incorporated, and Flora Nepal respectively. From the market observation and discussion, it was found that there was variation in gerbera cut flower's price among the wholesalers. Each wholesaler has its own grading and pricing system for the cut flowers.

Seasonal variation in the cut flower prices

Price of the cut flower was highly varied with respect to the seasons (Table 8). During winter, price of the flower was found the highest. It was also reported by FAN (2007). It was due to the lower production and higher domestic demand in winter.

Post-harvest loss

Table 8: Price (per stick) of gerbera cut flower in different seasons

Seasons	Minimum	Maximum	Mean	Std. Deviation
Winter	11.00	15.00	12.91	1.37510
Spring	6.00	10.00	7.82	0.98165
Summer	8.00	13.00	10.67	1.66969
Autumn	8.00	13.00	10.67	1.66969
Average	9.00	12.75	10.46	1.26056

The postharvest loss (Table 4) was found higher (3.3%) in winter than in summer (2.9%). The problem of stem breakage and bending was found higher during winter. The stem was more compact during winter. It might be due to the effect of low temperature (physical injury). Physiological loss was higher during summer possibly due to higher rate of respiration and transpiration. Salunkhe *et al.* (1990) explained that the flowers having higher specific weight at the time of cutting normally have better keeping quality which is reflected in press of petal tissues. They also stated that the summer crop produces flowers with long lasting qualities and performs better in the market than those produced in the winter. They found that summer flowers also had better keeping qualities than the autumn flowers.

It was observed that the major causes of postharvest losses were during handling and transportation of flowers. Unplanned production often causes selling problem in the market.

CONCLUSIONS

Based on the conducted survey, it can be concluded as

- Due to severity of soil borne disease in the gerbera field, soil treatment should be done for better production.
- Good quality flower could be produced with the abundant use of compost and organic matter rather than chemical fertilizer.
- It was necessary to raise the bed above 2 feet height in low lands (Khet) to avoid water lodging condition whereas in the up lands (Bari), bed height might be 1 feet.

- Regular picking of dry and diseased leaf, weeding, removal of crowed foliage were crucial sanitation and cultural practices for better quality production.
- Red and pink colors were highly preferred varieties of gerbera while the purple color had the lowest preference.
- The postharvest loss was found higher in winter than in summer. The problem of stem breakage and bending was found higher during winter. The major causes of postharvest losses were due to inappropriate handling and transportation of the cut flower. The varietal characteristics were also the cause of durability of the flower.

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Residual Effect of Partial Girdling after Three Years on Quality of Satsuma Mandarin Fruit

Arjun K. Shrestha[1] and W. Kibet

ABSTRACT

An experiment was carried out to see the residual effect of partial girdling on fruit quality and bark recovery of Satsuma mandarin three years after the date of girdling operation. In 2003, fruit trees located in the university farm of Ehime University received the girdling treatment of 10cm and 20cm width along with ungirdled branch as control. After three years, the bark recovery was found to be significantly higher in the branches that received girdling of 10cm width than 20cm girdling treatment. The fruit size, total soluble solid content and the titratable acidity were not significantly different among the three treatments. However, the largest fruit (98.4±3.52 g) was obtained from the ungirdled branch while the highest brix (10.5 ± 0.25 %) was recorded in the fruits harvested from the 10cm girdled branches.

Key Words: Acidity, brix, girdling, Satsuma mandarin

INTRODUCTION

Satsuma mandarin (*Citrus unshiu* Marc.) is the leading seedless citrus species in Japan owing to its excellent fruit quality and easiness to remove the peel. However, citrus production in Japan has been declining since 1970 due to competition both by citrus exported from other countries and other fruits like apples, bananas, melons and strawberries. In addition, citrus fruits face competition from industrial/processed products like candy, soft drinks and ice creams, which are more preferred by younger people (Iwagaki, 1995). Therefore, Japanese citrus growers are expected to produce high quality Satsuma mandarin in order to achieve handsome profits (Morinaga *et al.*, 2005). In general, consumers prefer fruits of medium to large size (Wright, 2000; Harty and Anderson, 1997) containing 10-14% sugars and about 1-0.8% titratable acid (Morinaga *et al.*, 2005; Harty and Anderson, 1997). The qualities including TSS content and size of fruits at harvesting are of considerable importance in commercial cultivation since these aspects influence the marketability of fruit.

Improvement in quality of fruit like increase in sugar content in a fruit can be achieved either by decreasing water or increasing carbohydrate availability to fruit along with increase in fruit sink strength. It has been observed that water stress during ripening concentrates fruit sugar resulting in fruits with higher soluble solids content (Iwagaki, 1997). Candido *et al.* (2000) in their experiment on effect of irrigation regime on yield and quality of processing tomato, found that soluble solids were the highest in un-irrigated fruits with 9.2 % Brix followed by fruits where supplementary irrigation was carried out when soil water potential dropped below –1.5 MPa with 7.20 Brix while fields where restoration of 50% and 100% maximum crop evapo-transpiration had 6.4 and 4.60 Brix respectively. Kriedemann and Ian (2003) reported that Brix in over watered 'Okitsu' Satsuma mandarins were the lowest (7.7 %) while water stressed trees produced fruits with the highest Brix (13.2 %), the fruit size was however reduced with water stress.

Carbohydrate partitioning to the fruit is considered as one of the principal factors influencing the fruit growth (Wright, 2000). It is commonly accepted that the availability

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of carbohydrates to any particular fruit is dependent upon the presence of carbohydrate source, i.e. leaves and the number of competitive sinks such as other fruit, rapidly growing shoots and roots. Elimination of competition for the carbohydrate to other parts than the growing fruits is one of the primary methods for improving the fruit quality. Girdling has been tried in several fruit species to improve fruit quality with the assumption that with the removal of a ring of a bark from a trunk or major limbs of a fruit tree, the downward transport of photosynthates and metabolites through the phloem to the roots is blocked resulting in more carbohydrates being available for the fruits and young leaves /shoots (Wright, 2000; Li and Goldschmidt, 2003; Onguso *et al.*, 2005). The size of the girdled portion vary from a single cut without removing a bark to larger sizes that involves removal of a strip of bark of up to 20cm or more. The technique involves temporary disruption of the conductive vessels, the phloem that carry carbohydrates to the roots. It has also been stated that this practice intensifies the moisture stress in the plant (Goell and Cohen, 1981).

In their experiments, Onguso *et al.* (2004), Poerwanto and Irdiastuti (2005), Mataa *et al.* (1997) and Wallerstein *et al.* (1974) using peach, rambutan, 'Ponkan' mandarin and sour orange respectively, observed that girdling increased carbohydrates above the girdled portion and reduced it below the girdle (Poerwanto and Irdiastuti, 2005; Onguso *et al.*, 2005). As a consequence, this will benefit the sinks above the girdle, i.e. the fruits and the shoots.

In 'on' trees, Li and Goldschmidt (2003) observed that there was no increase in total non structural carbohydrates in leaves of girdled trees and slight increase in barks above the girdle while in 'off' trees the concentration of starch in leaves was 3 times than in control and bark twice that of control. This indicates that in 'on' year the fruits use the photosynthates that increase above the girdle. Williams and Ayars (2005) observed that girdling Thompson seedless grapevines decreased water use approximately 15% until the girdle healed. This indicates that girdling may also affect water availability to the fruit.

Wright (2000), in his experiment on 'Fairchild' mandarin observed a reduction in titratable acidity due to girdling in the first year but no effect was observed in year 2 and 3. He also observed that November girdling led to increased fruit set and retention hence greater number of smaller fruits the first year while in the second year the fruits were few and larger. In the third year the yield was lower than control. In 'Aki'queen grapevines, girdling in the first year increased TSS and anthocynin content but this effect diminished on the second year. Onguso *et al.* (2005) in their experiment with peach found that brix was significantly higher in girdled trees for the first and second year but no difference was noted on the third year. He also observed that acidity was significantly reduced only in the first year and no effect was observed during the second and third year although the ring had not healed completely. Peng and Rabe (1996) in their experiment using 'Mihowase' Satsuma observed that girdling 2-5 weeks after the 'physiological fruit drop' (APFD) period significantly improved fruit color and TSS and showed no effect on yield and fruit size the first year but there was no effect on TSS and color the following year. Five weeks APFD girdled trees however significantly reduced fruit size compared to ungirdled the second year.

Notwithstanding, girdling has the potential to injure the trees to some extent and these girdles take considerable duration of time to heal the wound completely. The residual effect of this girdling on quality of Satsuma mandarin has not been studied. Since the literature cited show varied response between different fruits and also between cultivars of

the same fruit, this experiment was carried out to study the residual effects of partial girdling on fruit quality, three years after girdling in Satsuma mandarin.

MATERIALS AND METHOD

The present experiment was conducted in Satsuma fruit trees growing in the fruit orchard at the Ehime University Experimental Farm, Hojo located in southern Japan, 33°57' N, 132° 47' E at an elevation of about 20 m above sea level. The region has a mild temperate climate characterized by hot humid summers and cold dry winters. The soil at the experimental site is sandy loam (eutric fluvisol) with a pH (H20) of 5.7, a bulk density of a 1.08 gcm^{-3} and horizon A thickness of 0.15 m. The mandarin fruits trees used for this study had received 10cm girdling and 20cm girdling three years ago (2003) and the girdled wound had not been fully recovered by the third year. Five Satsuma mandarin fruit trees were used for the experiment. Each tree had 3 treatment units, 10cm partially girdled branch, 20cm partially girdled branch and ungirdled branch as control. The treatment was replicated in five trees. Thus, the experiment was laid out in the Randomized Complete Block Design (RCBD) with three treatments that were replicated three times.

For the evaluation of fruit quality, 20 fruits from each treatment branch were picked from all the replication, i.e. five trees. The fruits were weighed using physical balance. After that juice extraction was done by fruit destruction method, the soluble solids content in the juice was estimated using Automatic Temperature Correction Refractometer (Atago PR-1). The titratable acidity of juice was determined by acid-base titration method using 0.1 N NaOH using phenolphthalein as an indicator.

The data related to fruit quality were collected, tabulated and were analyzed using ANOVA test and separated by multiple range tests. For determining the effect on bark recovery, the bark that had regenerated was measured in all girdled branches of trees as a percentage of the total branch circumference. Thereafter, the values obtained for 10cm girdled fruit trees were compared with those of 20cm girdles using student t- test.

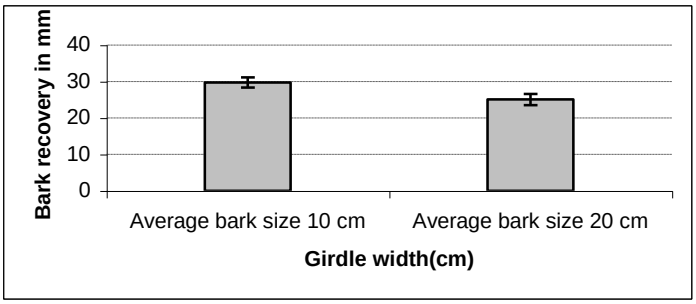

Fig.1: Girdle width influence on bark recovery in Satsuma mandarin

RESULTS

Bark recovery in the girdled portion

There was continuous and gradual recovery of the bark on the girdled portion of the branches of Satsuma mandarin tree. From the perusal of fig.1, it is apparent that the healing is in the faster rate in branches that received the treatment of 10cm girdling than in the branches receiving 20cm girdling. After three years of girdling operation, 10cm girdled branches had recovered 31% of the bark while 20cm-girdled branches had recovered 23% of the bark. Further, recovery of bark on the wounded portion of the stem is significantly higher in the branches receiving 10cm girdling than in the branches receiving 20cm girdling. Onguso *et al.* (2004) while working on peach also reported recovery of bark width on the stems those were subjected to the girdling. The bars are mean of recovered barks± standard errors. The means followed by same letter do not differ significantly by paired student t-test (n=4, p=0.01).

Fruit Quality

After three years of girdling operation, it was observed that the size of fruit did not vary in control than in the both of the girdled branches. The highest weight of fruit was recorded as 98.4 g as obtained in ungirdled branch while the lowest fruit weight of 93.0 g was recorded in branches that received the girdling treatment of 20cm width three years ago.

There was no difference in acidity of fruits obtained from girdled and non-girdled trees. Yamane and Shibayama (2006) working on 'Aki Queen' grapevine, Peng and Rabe (1996) on 'Mihowase' satsuma and Onguso *et al.* (2005) on peach made similar observation.

Table 1: Residual effect of 10cm and 20cm partial girdling on quality of Satsuma mandarin fruit

Treatment	Fruit weight (g)	Acidity (%)	TSS (%)
Control	98.4±3.52	1.1±0.05	10.0 ± 0.12
10cm girdle	97.4±2.33	1.1±0.04	10.5 ± 0.25
20cm girdle	93.0±4.18	1.1±0.10	10.4 ± 0.25

Values are means ± standard error. Means do not differ significantly from one another (p=0.05) by use of ANOVA test and multiple range test (n=4).

Brix levels of fruits harvested from the partially girdled trees were higher than control although the difference was not statistically significant. Yamane and Shibayama (2006) working with grapes found similar results in the second season while Onguso *et al.* (2005) working on peach found that Brix was significantly higher in girdled trees the first two years but the difference was not significant in the third year although the ring had not completely healed. Furthermore, there was no difference in total soluble content of fruit between 10cm and 20cm girdling treatment indicating that wider girdles do not enhance the effect of girdling over the longer duration after the imposition of treatment. It may be due to the fact that the influence of girdling on quality improvement diminishes gradually over time as the bark healing process occurs.

DISCUSSION

Although 10cm and 20cm girdling treatments resulted in significant increase in soluble solid concentration along with the decrease in acidity of fruit in the girdling year, its effect seems to reduce as the bark healing process takes place and speed up over time. The effect was not significant in the third year even though the bark was not fully regenerated. Brix and acidity of 10cm girdling were not different from those of 20cm girdle indicating that there is no advantage conferred by larger girdle to fruit trees. Since large girdle will take a longer time to heal and causes more injury to the tree, if girdling is to be used for fruit improvement, a smaller girdle that heals within the same year is preferable to enable the tree to regain its vigor within shorter duration of time.

From this experiment, it has been observed that the girdles reduced fruit size slightly, with 20cm girdle reducing the size more than 10cm girdle. This may be due to increased fruit set in the ungirdled and 10cm girdled branches than in the 20cm girdled branches although we did not count the fruits to determine yield per treatment branch. In addition it may also be due to the reduced vigor of the branch resulting from wider girdling / wounding in those branches. The fruits, however, were all of medium size and hence of good market value. Yamane and Shibayama (2006), Wright (2000) and Peng and Rabe (1996) have also made similar observations in their experiment related to girdling.

CONCLUSION

The size of a girdle determines how long it takes for the girdle to heal. In this study, 10cm and 20cm girdled branches of Satsuma mandarin had recovered 31% and 23% of its bark

respectively after 3 years of girdling. Fruit qualities were assessed to determine whether the delay in recovery had any effect on fruit quality. Wider girdles while being more injurious to the fruit tree than smaller girdles did not improve the fruit quality significantly in Satsuma mandarin in the third year. Therefore, the girdles that heal within one season might be more preferable to improve the quality of Satsuma mandarin fruit.

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IPY-8 and Khumal Laxmi: Newly Released Potato Varieties

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ABSTRACT

Several on-station and on-farm results demonstrated that CIP clones 388572.4k and 388572.1k are high yielder and moderately resistant to late blight and suitable for commercial cultivation in different agro-ecological domains of Nepal. Both of these cultivars are economically profitable in comparison to previously released potato varieties. In the trials, both of the clones were observed medium maturing type taking 100 to 120 days to harvest, which makes the clones fit in existing cropping systems. Main stems were counted average of 3 to 5 per plant and had medium height. Average tuber yield from CIP 388572.4k was 25 to 27 t/ha and that from CIP 388572.1was 24 to 28 t/ha i.e.3 to 6 tons higher than previously released varieties. Tubers had medium dormancy with low dry matter content (average of 17.1%) and medium (1.07) specific gravity. Farmers' preferences demonstrated the potentiality of good fresh market. Based on all of these superior characteristics, clone 388572.4k was released for commercial cultivation as variety "IPY-8" suitable for terai and clone 388572.1k as "Khumal Laxmi" from terai to high-hills on the year 2008.

Keywords: Clones, IPY-8, Khumal Laxmi, on-farm, on-station, varieties

INTRODUCTION

Demands of high yielding potato (*Solanum tuberosum* L.) varieties for disease and pest resistance have been increasing day by day in Nepal. Fulfillment of this demand is only possible through the development of new varieties for cultivation and recommendation of improved package of practices for commercial cultivation in the country (Khatri and Shrestha, 1999). Variety development at present in Nepal is done through own conventional breeding programme or through the introduction of exotic clones mainly from International Potato Center (CIP) Lima Peru. Own national breeding programme is still in its initial stage; therefore, National Potato Research Programme (NPRP) evaluates and compares the performance and potentiality of introduced clones with established varieties under glasshouse and on-station conditions first. High yielding and disease resistant clones are later assessed under on-farm conditions throughout the country. After the evaluation for couple of years, only highly preferred clones are proposed to release as the varieties for respective agro-ecological zones.

To systematize the varietal research, NPRP has developed a varietal evaluation scheme since long time and follows the steps through preliminary observation nurseries (PONs), initial evaluation trials (IETs), co-coordinated varietal trials (CVTs) and coordinated farmers field Trials (CFFTs) and farmer's acceptance test (FAT). Each of these steps takes at least 2 years for each clone. After 10 to 12 years' on-station and on-farm efforts of selection and testing in different agro-ecological domains, highly suitable clones are recommended for releasing. In all of these steps, development of high yielding potato varieties with resistance to major diseases, like late blight (*Phytophthora infestans*) and wart (Synchytrium endobitoticum) are the priority areas of NPRP Variety Research Unit (NPRP, 2007). Hattiban Research Farm Khumaltar (1350 masl) along with all of the research stations under NARC representing different domains are the major collaborators of NPRP for on-station experiments. Potato growers from out-reach research (OR) sites are

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considered as collaborator farmers participating in variety development scheme (Khatri *et al.*, 1999). This has resulted to release Kufri Sindhuri, Kufri Jyoti, Desiree, Khumal Rato-2, Khumal Seto-1 and Janak Dev so far for different agro-ecological domains of the country (NPRP, 2007). But naturally, after the use for some years, these varieties start loosing their resistance against diseases and reduction in tuber yield starts, hence; needs to be replaced by superior clones regularly.

A series of on-station and on-farm studies carried out during the years 1990/91 to 2005/06 throughout the country demonstrated both of the CIP clones 388572.4k and 3888572.1k superior to the check varieties (Khatri *et al.*, 2005) hence released as the varieties for commercial cultivation for terai and hills respectively. The materials and methods used in experiments are presented in material and methods and morphological and yield data gathered in the studies are presented in the results.

MATERIALS AND METHODS

For both of the clones, PONs, IETs, CVTs, CFFTs and farmers' acceptance tests (FATs) were the evaluation steps followed as per the variety evaluation scheme. Each clone was evaluated for at least two years in each experimental site. All the cultural practices were followed as per the recommendations of NPRP (Dhital and Khatri, 2008). The vegetative and yield parameters were recorded as per the requirement of experiment throughout the study period following protocol developed by Khatri *et al.*, (1999).

IPY-8 (Clone CIP 388572.4k)

On-station studies

During 1990/91 to 1996/97 along with several other new clones the performance of this clone was evaluated and compared with check varieties Kufri Jyoti, Kufri Sindhuri, Desiree, Khumal Seto-1 and farmers' local at NPRP Khumaltar, Horticulture Farm Daman, Regional Agriculture Research Station (RARS) Parwanipur Bara, RARS Tarahara, RARS Nepalgunj and Hill Crop Research Programme (HCRP) Kabre, Dolakha. Promising clones were selected and promoted to on-farm studies.

On-farm studies

Based on the performance observed from series of on-station trials further verification of this clone was done at farmers' fields as CFFT and FAT in the command areas of RARS Tarahara and Nepalgunj, representative sites from wet-terai and dry-terai, respectively during the years 1999/2000 to 2004/2005. Late blight disease response was observed all the years in trials and additionally at RARS Parwanipur during the year of 2005/06. Plant type, LB resistance, tuber yield, tuber appearance and taste results were the major parameters of variety selection along with the preference ranking of farmers recorded right at harvest of the trial as good (G), fair (F) and very good (VG).

Khumal Laxmi (Clone CIP 388572.1k)

On-station studies

Preliminary observations on performance for this clone were taken at NPRP Khumaltar, Nucleus Seed Potato Centre Nigaley and RARS Parwanipur during the years 1991/92 to 1994/95. IETs were carried out at RARS Parwanipur and NPRP Khumaltar, as the representative sites of terai and hill, respectively. CVTs were carried out at RARS Nepalgunj, RARS Tarahara, HCRP Kavre Dolkha, RARS Lumle and ARS Pakhribas in different years. Based on the results obtained from on-station experiments, this clone was promoted to on-farm studies.

On-farm studies

The performance of this clone under farmers' field conditions, number of trials were conducted at OR site Mainapokhar of RARS Nepalgunj, Mahuli site of RARS Tarahara, Bhakkimle and Hemja site of RARS Lumle, Sanagaun and Mulpani sites of NPRP Khumaltar and Basantapur site of ARS Pakhribas during the years 1989/99- 2006/07. In addition, this clone was further evaluated against late blight disease at NPRP Khumaltar and at RARS Parwanipur during the year 1993/94 and 1994/95. The tuber yield and farmers' preferences on evaluation clone were rated as in clone CIP 388572.4k.

RESULTS AND DISCUSSIONS

The major morphological features, varietal characteristics and reasons for recommendations of these two varieties are compiled and presented as the text below and yield results and farmers' rating on different parameters are in respective tables.

IPY-8 (CIP 388572.4k)

Plant characteristics

Growth habit: Medium height, vigorous, spreading and open type
Stems: Few, medium thick and green color, slightly hairy, straight and well developed wings
Leaves: Stiff deposition, green rachis color, ovate lanceolate, close type, smooth surface and grey green foliage, glossiness, wavy leaf margin, few folioles and pointed tips in leaves
Flowers: Few flowering in short day conditions, open-pollinated and fruiting occurs in the field, dropping flowers type with yellow anther
Response to diseases: Field resistant to late blight and susceptible to wart disease
Response to the pests: Not studied
Response to climate: Not studied
Stem density: 3-4 stems/plant
Maturity: Medium (100 to 120 days after planting) type
Tubers: Medium sized with smooth skin surface, slightly developed eye-brows, red eye and creamy flesh
Number of tuber/plant: 10-12 tubers
Sprouts: Bulbous sprout type, moderate violet color with many root tips
Tuber shape: Round
Tuber color: White
Eye depth: Medium
Dormancy period: Medium (6 to 8 weeks from harvest days)
Average yield: 25-27 t/ha

Special features

- Can be grown successfully in inner terai and terai domains
- Field resistant to late blight disease
- Yielding higher than previously released varieties (Kufri Jyoti, Kufri Sindhuri and Desiree)

Reason for recommendation

In the main winter season, this clone/variety has been superior in plant and yield parameters to Kufri Sindhuri, Desiree and Khumal Seto-1 and farmers' local in study areas. In on-station condition this clone gave average of 24.7 tons per hectare tuber yield, whereas check variety Kufri Sindhuri gave 18.9 t/ha and Desiree 11.7 t/ha and Khumal Seto-1 19.1 t/ha, respectively. Under on-farm conditions, average yields of IPY-8 was recorded 26.9 t/ha, whereas with varieties Kufri Sindhuri, Desiree, farmers' local, Khumal Seto-1 and Cardinal, average yields were obtained 20.8, 20.9, 16.6, 22.4 and 11.7 t/ha, respectively (Table 1, 2 and 3). Farmers' preference assessed for this clone showed that plants and taste of this clone was rated as very good compared to check varieties Kufri Sindhuri and Desiree (Table 3).

Recommended domain: Terai and inner terai of Nepal
Cropping season: Winter main season (November planting)
Moisture regime: Irrigated conditions
Growing seasons: Better in winter season
Cropping pattern: Rice-potato
Rice-potato-summer vegetables
Rice-potato-maize
Recommended fertilizer dose: 100:100:60 NPK kg + 20 tones compost/FYM per hectare
Economical rating: profitable

Yield and quality

In main crop-season trials conducted during 1993/94 to 1996/97 under on-station irrigated conditions from terai and inner Terai, yield data indicated that 388572.4k is generally a high yielder clone. If averaged between the years and locations, this clone gave 38.8% higher yields than check variety Kufri Sindhuri, and 80% higher than Desiree (Table 1). In all the locations where the experiments were undertaken, this variety was found superior to all of the check varieties, however, a considerable variation was observed between year to year and locations to locations in the yields. Yield data if averaged between the years 1993/94, 1994/95, 1995/96, 1997/98 and 1998/99, tested clone CIP 388572.4k yielded highest (26.1 t/ha) followed by Kufri Sindhuri (18.8 t/ha) and Desiree (14.5 t/ha) respectively (Table 1).

Table 1: On-station yield performance of clone 388572.4k compared with three commercial check varieties during main winter season in terai and HCRP Kabre

Cultivars	RARS Parwanipur		RARS Nepalgunj		RARS Tarahara		HCRP Kavre	Average
	1993/94	1994/95	1995/96	1996/97	1996/97	1996/97	1996/97	(t/ha)
388572.4k	43.0	20.7	38.1	23.8	17.5	21.8	17.5	26.1
K. Sindhuri (ch)	27.4	-	23.6	19.0	15.8	13.6	13.5	18.8
Desiree (ch)	-	9.8	26.8	13.4	11.3	11.5	13.9	14.5
Khumal Seto (ch)	-	19.1	-	-	-	-	-	19.1

As in on-station conditions, the clone 388572.4k performed better in tuber yields under on-farm conditions also (Table 2). Highest yields were obtained from tested clone 388572.4k (26.3 t/ha), followed by the check varieties Kufri Sindhuri (20.5 t/ha), Desiree (22.0 t/ha)

and farmers' local (15.8 t/ha). In all the years and in both of the domains clone 388572.4k was found superior to all of the three check varieties. The yield was 28.3% higher than Kufri Sindhuri, 19.5% higher than Desiree and 66.5% higher than farmers' local. Except in the year 2000/01 from RARS Tarahara site, all three check varieties were inferior to this clone in all the sites and years tested.

Table 2: On-farm yield performance of clone 388572.4k compared with commercial varieties as CFFTs at different OR sites from regional research stations

Cultivars	RARS Nepalgunj			RARS Tarahara					Avg. yield
	1999/00	2000/01	2004/05	1999/00	2000/01	2001/02	2004/05	2005/06	(t/ha)
388572.4	29.1	28.1	27.6	32.5	24.7	23.7	26.4	18.0	26.3
K. Sindhuri (ch)	21.6	21.9	22.4	23.3	24.4	16.2	22.5	12.0	20.5
Desiree (ch)	19.1	20.7	26.4	17.3	27.6	20.6	22.6	-	22.0
Farmers' local (ch)	18.9	-	-	11.8	16.8	-	-	-	15.8

Results on farmers' preference ranked as good (G), fair (F) and very good (VG) are presented in Table 3. The results showed that plant appearance and taste at harvest ranked VG with clone 388572.4k by the participating farmers from OR site of RARS Tarahara whereas variety Kufri Sindhuri was inferior in tuber assessed, whereas variety Desiree was preferred for its tuber appearance and taste.

At OR site of RARS Nepalgunj, yield of tested clone CIP 388572.4k and Desiree one of the check variety was highly preferred and ranked as very good by the participating farmers but all of other parameters were ranked good (G). If averaged over the sites and parameters assessed, the clone CIP 388572.4k and Desiree were categorized as good as and better than Kufri Sindhuri (Table 3).

Table 3: Farmers' preference on CIP 388572.4k compared with 2 commercial varieties

Cultivars	OR site of RARS Tarahara				OR sits of RARS Nepalgunj				
	Plant	Tuber	Yield	Taste	Plant	Tuber	Yield	Taste	Average
388572.4k	VG	G	G	VG	G	G	VG	G	GOOD
K. Sindhuri (ch)	G	F	G	G	G	G	G	G	GOOD
Desiree (ch)	G	VG	F	VG	G	G	VG	G	GOOD

Farmers' preference ranking: G= good, F= fair, VG= very good

CIP 388572.1k (Khumal Laxmi)

Plant characteristics

Plant growth habit: Tall, vigorous, erect, open with medium compactness

Stems: Medium thickness, 3 - 5 stems/plant, slightly hairy stem and some pigments on stem, wings are wavy, broad and prominent on stem,

Leaves: Ovate with medium developed lateral leaflets, open leaves with dropping disposition, rough surface and dark green foliage entire leaf margin and moderate number of folioles.

Flowers: Reddish pink petal flower, profused in number and berry set in long-day conditions, few flower in short day conditions

Tubers: Small to large size, round/red skin, smooth surface, creamy white flesh and floury texture, 10 to 15 tubers/plant, medium and well distributed eye depth.

Sprouts: Bulbous type of sprout, very intense blue-violet color with many root hairs.

Maturity: Medium (100-120 days) in terai and long (120-140 days after planting) in the hills
Stem density: 3 to 5 stems/plant
No. of tubers/plant: 10-15
Dormancy period: Medium (6 to 8 weeks after emergence)
Average yield: 24-28 t/ha
Response to diseases: Wart and late blight resistant, early blight tolerant
Response to the pests: Not studied
Response to abiotic factors: not studied
Response to climate: Not studied

Special feature

- Can be successfully grown from terai to high hills
- High yielder than all of the previously released varieties such as Kufri Jyoti, Desiree and Kufri Sindhuri
- Good yielder even in drought condition
- Economically profitable
- Red skinned tubers
- Highly preferred by the farmers

Reason for Recommendation

Clone CIP 388572.1k released as Khumal Laxmi has red skinned tuber which is highly preferred characters of potato consumers in Nepal. Eye-depth is medium which is another preferable character since deeper eyes have higher peel loss. Cooking quality, taste, aroma and flavor like characters are also preferable in this clone. Plants are resistant to wart and moderately resistant to late blight diseases. This is medium maturing variety and yields are higher than almost all of the check varieties. Cultivation is profitable and farmers' preference on the appearance of plant, tuber, taste and tuber yield is higher than check varieties Kufri Jyoti and Desiree.

Recommended domain: Wide adoptability (Terai to mid and high hills)
Moisture regime: Partially irrigated, good yield even in drought conditions,
Growing season and condition: Better for spring planting in hills and mid-hills and winter planting in terai
Cropping pattern:
Mid-hills: rice-potato-maize
High hills: Maize-potato
Terai: Rice-potato-summer vegetables
Rice-potato-maize

Recommended fertilizer dose: 100:100:60 kg NPK + 20 tones compost/FYM/ha
Economic analysis: Profitable
Tuber color:: Red skinned
Tuber shape: Round
Tuber size: Red
Eye depth: Medium
Farmers' preferences: High

On-station yield and quality

Tuber yield data from on-station trials carried out at NPRP Khumal, Nucleus Seed Potato Farm (NSPF) Nigaley, RARS Lumle and ARS Pakhribas during the years 1993/94-1995/96 showed that clone 388572.1k is very high yielder compared to check varieties Kufri Jyoti and Desiree. Average yields from all the experimentation years in the hills were 26.2 t/ha with CIP 388572.4k which was 86.6% higher than Kufri Jyoti and 90.6% higher than Desiree (data not shown). Tuber yields of Kufri Jyoti and Desiree were 14.2 t/ha and 13.9 t/ha, respectively (Table 4).

Table 4: On-station yield performance of clone 388572.1k compared to 3 check varieties in the hills of Nepal

	NPRP Khumal		NSPF Nigaley	RARS Lumle	ARS Pakhribas	Average
Clone	1993/94	1994/95	1993/94	1995/96	1995/96	(t/ha)
CIP 388572.1	28.2	24.0	30.0	27.2	23.0	26.2
Kufri Jyoti (ch)	15.5	-	20.0	10.6	10.7	14.2
Desiree (ch)	-	11.7	-	14.4	15.6	13.9

Same set of on-station varietal trials were conducted in terai during 1994/95 to 1997/98 and results showed that the clone CIP 388572.1k performed better in tuber yields at HCRP Kabre Dolakha also (Table 5). Average yields of 30.4 t/ha was obtained from tested clone whereas in Desiree and Kufri Sindhuri, 11.9 t/ha and 16.2 t/ha, respectively. Site to site variation in tuber yield was very high in tested clone than in the check varieties. The yield in tested clone was 155.4% higher than variety Desiree and 87.6% higher than Kufri Sindhuri.

Table 5: On-station yield performance of clone CIP 388572.1k compared to 2 check varieties in winter season planting

Clone	RARS Parwanipur Bara		RARS Tarahara Sunsari		RARS Nepalgunj	HCRP Kabhre Dolakha	Average (t/ha)
	1994/95	1995/96	1996/97	1997/98	1997/98	1997/98	
CIP 388572.1k	26.9	41.8	39.9	29.3	23.5	21.1	30.4
Desiree (ch)	10.1	11.5	11.5	13.4	11.5	13.9	11.9
K. Sindhuri (ch)	20.4	13.1	13.6	20.3	13.6	16.3	16.2

On-farm yield and quality

On-farm experiments on promising clones were undertaken in different OR sites and farmers fields of RARS Nepalgunj, RARS Tarahara and RARS Parwanipur representing terai domain during the years 1998/99 to 2006/07 and OR sites of RARS Lumle, ARS Pakhribas and NPRP Khumal representing hill domains during the years 1996/97 to 2005/06. Results revealed that in the hills and terai both conditions, the tested clone was superior to all of the check varieties (Tables 6 and 7). Yield average of tested clone (CIP 388572.1k) in Terai was highest (28.9 t/ha), whereas farmer local produced 14.3, Desiree produced 19.9 and Kufri Sindhuri 19.8 t/ha, respectively. The yield was superior to all of the check varieties throughout the experimental years and experimental sites.

In the hills, the yield in all sites and experimental years was very high in the tested clone compared to all of the check varieties. Clone CIP 388572.1k produced 24.4 t/ha tuber yield, whereas in Khumal Seto-1, 17.8, Kufri Jyoti 19.1, NPI T/0012 15.7, Desiree 17.7 and farmers local 10.9 t/ha, respectively (Table 7). In terai on-farm trials, the average yield on tested clone was 102.4% higher than farmers' local, 45.2% higher than Desiree and 45.9% higher than Kufri Sindhuri (data not shown), whereas in the hills, this clone gave

37.1% higher yield than Khumal Seto-1, 27.7% higher than Kufri Jyoti, 55.4% higher than NPI T0012, 37.8% higher than Desiree and 123.8% higher than farmers' local (Table 7).

Table 6: On-farm yield performance of clone CIP 388572.1k compared to 3 check varieties under different OR sites of RARS from terai (1998/99 to 2006/07)

Clone	OR site Nepalgunj					OR site Tarahara				OR site Parwanipur		Average (t/ha)
	98/99	99/00	01/02	03/04	04/05	99/00	01/02	02/03	04/05	05/06	06/07	
388572.1	30.8	26.9	34.1	35.6	34.0	36.3	23.4	37.4	25.9	17.6	16.3	28.9
Local (ch)	16.9	21.6	-	-	-	11.8	-	-	-	-	6.9	14.3
Desiree (ch)	19.6	19.1	20.3	21.7	26.4	17.3	20.6	20.2	22.6	12.0		19.9
K.Sindhuri (ch)	15.0	18.9	23.1	25.9	22.4	23.3	16.2	27.3	22.5	12.0	11.4	19.8

Table 7: On-farm yield performance of clone CIP 388572.1k compared to 5 check varieties under different OR sites of ARS from hills from the year 1996/97 to 2004/05

Clones	OR site of Lumle			Farmers' fields of NPRP Khumaltar				OR sites of ARS Pakhribas		Average (t/ha)
	1996/97	97/98	04/05	97/98	98/99	03/04	05/06	96/97	97/98	
CIP 388572.1	39.1	30.6	21.5	25.5	26.2	20.3	23.2	19.2	14.3	24.4
Khumal Seto (ch)	25.7	24.3	-	22.3	-	-	-	10.2	6.6	17.8
K. Jyoti (ch)	28.9	26.5	-	20.6	20.7	17.4	18.8	11.6	8.7	19.1
NPI T/0012 (ch)	21.9	9.6	-		-	-	-	-	-	15.7
Desiree (ch)	-	-	17.7	-	20.8	16.3	16.0	-	-	17.7
Local (ch)	-	-	-	10.5	21.7	-	10.8	7.1	4.8	10.9

Table 8: Farmers' preference ranking on plant and tuber appearance, taste and yield of clone CIP 388572.1 compared to check varieties (1996/97 to 2004/05)

	Farmers' preference ranking			
Clones	Plant appearance	Tuber appearance	Taste	Yield preferences
CIP 388572.1	VG	VG	G	G
Desiree (ch)	VG	VG	VG	G
Kufri Sindhuri (ch)	G	F	G	G
Local (ch)	G	F	VG	F

Farmers' preference ranking: G= good, F= fair, VG= very good

Table 9. Farmers' preference ranking on plant and tuber appearance, taste and yield of clone CIP 388572.1k compared to check varieties (1996/97 to 2004/05)

Clones	OR sites ARS Pakhribas				OR sites RARS Lumle				Farmers' fields of NPRP Khumal			
	Plant	Tuber	Taste	Yield	Plant	Tuber	Taste	Yield	Plant	Tuber	Taste	Yield
CIP 388572.1k	VG	G	G	G	VG	G	G	VG	G	G	G	G
Kufri Jyoti (ch)	G	G	G	G	-	-	-	-	VG	G	F	F
Desiree (ch)	-	-	-	-	G	VG	VG	G	VG	G	G	G
Khumal Seto (ch)	G	G	G	G	-	-	-	-	-	-	-	-

Farmers' preference assessed on plant, tuber appearances, taste and yield at harvest from all of the OR sites revealed the results that the clone 388572k.has almost similar preference to Desiree however, Desiree and farmers' local had comparatively better taste. Yield of this

clone was comparative to all of the check varieties (Table 8). Farmers local had comparatively inferior tuber yield.

Farmers' preference from OR site at ARS Pakhribas, RARS Lumle and NPRP Khumal from the hills showed that tested clone 388572.1k had comparatively better plants appearance than the checks (Table 9). All other parameters were also comparable.

CONCLUSION

On the basis of the superiority in plant growth, yield characteristics and farmers' preference including resistance level to the major diseases such as late blight and wart, clones CIP 388572.1k and CIP 388572.4k were proposed from NPRP for releasing on the occasion of International Potato Year 2008. Variety Approval, Release and Registration Sub-committee (VARRS) Nepal released clone CIP 388572.4k as "IPY-8" (the abbreviated form of International Potato Year-2008) and CIP 388572.1k as "Khumal Laxmi" (Laxmi, in the honor of late potato scientist Mr. Laxmi Prashad Khairgoli). Variety IPY-8 has been recommended for terai and inner terai cultivation and variety "Khumal Laxmi" can be cultivated successfully from terai to high hills. Both of these varieties were bred in International Potato Center (CIP), Lima, Peru and tested in Nepal following variety evaluation scheme of NPRP Khumaltar for several years. Both of these varieties are profitable and expected to give 3 to 6 tons higher tuber yield per hectare compared to the previously released potato varieties of Nepal and tolerant to late blight disease.

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Evaluation of Different Rootstocks for their Graft Compatibility and Resistance to Bacterial Wilt on Tomato

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ABSTRACT

Four eggplant and nine tomato rootstocks were evaluated for their resistance to bacterial wilt and compatibility with tomato scion 'Ogata fukuju' in Tsukuba International Training Center, Tsukuba from June to October 2010. Grafting was conducted two times and the method was tube grafting. All combinations were evaluated in terms of graft success, plant growth, stem thickness, evapotranspiration and incidence of bacterial wilt in naturally infested soil. Success percent in the two grafting batch was not similar in terms of different graft combinations. Eggplant rootstocks contributed for the overgrowth on stem diameter of scion, however no wilt symptoms due to incompatibility could be observed. Plants grafted on Tolban vigor, Tonasim, B-barrier and BF-Okitsu showed no bacterial wilt symptoms whereas that on Doctor-K, Taibyo Shinko No.1 and non-grafted control resulted in 100% disease incidence. Remaining rootstocks showed partial wilt incidence. Grafting thus can be taken as an important tool for managing bacterial wilt disease. However, further investigation is recommended for evaluating graft incompatibility.

Key words: grafting, incompatibility, *Ralstonia solanacearum*, rootstock, scion

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) is one of the most important vegetable crops of Nepal. It is commercially grown in plain and hills of Nepal for fresh consumption as well as for processing. Statistics show that in Nepal, tomato was grown in 15,572 ha of land and the total production was 219,194 M.ton in 2008/09 with the average yield of 14.1 M.ton/ha. (VDD, 2009) which was quite low as compared to other countries. Among the reasons, diseases caused by fungi, bacteria, virus and nematode play a major role. Bacterial wilt caused by *Ralstonia solanacearum* is one of soil borne diseases that causes for the yield decrease in tomato. The disease can bring about almost total destruction of the crop during summer and rainy season.

Mid-hills of Nepal has good potential for off-season tomato production under plastic house during rainy season. However, there are many problems faced by the farmers growing rainy season tomato under plastic houses. One of the major problems is the soil borne disease bacterial wilt. The problems of this disease are more common in non-flooded uplands where solanaceous vegetables are grown continuously without crop rotation. However, control of bacterial wilt with crop rotation is still difficult because of the wide host range of the pathogen and long-term persistence in soils (Adhikari and Basnyat, 1998). Even when crop rotations could be practiced, the long intervals required between similar crops result in an economic loss to the grower.

Control of soil-borne pathogens by fumigation with methyl bromide inside greenhouses is widely practiced in many countries (Besri, 2002; Bletsos, 2005). But in case of Nepal it is not common and is not affordable for the small scale farmers. The use of resistant variety to control bacterial wilt in the field has been very difficult due to the nature of the pathogen and host resistance in tomato (Scott *et al.*, 2005). The complex diversity of pathogenic

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Ralstonia strains has led to the development of resistant lines, which are effective in some growing regions and not effective in others (Scott, 1996). It is generally accepted that resistance from various sources is controlled multi-genetically and usually the resistance is not complete and breaks down to some extent when conditions favor the pathogen (Hartman and Elphinstone, 1994).

Although the integration of resistance genes into modern tomato cultivars has been difficult, the use of grafted transplants has historically been very effective for managing bacterial wilt in the field worldwide. Grafting vegetable crops have been used extensively in greenhouse and tunnel production not only to manage soil borne diseases but also to achieve greater crop yields, higher salinity tolerance, increased heat and cold tolerance, and enhanced drought and flood resistance (Black, 2003; Estan *et al.,* 2005; Lee, 1994; Oda, 1999). Investigations on the mechanisms for disease resistance suggested that resistant rootstocks physically limit the movement of the bacteria from the growing media to the scion (Grimault and Prior, 1994).

A successful graft union requires the formation of new connections between vascular strands at the callus graft interface via differentiation and lignification (Fernandez-Garcia *et al.*, 2004). Failure of a graft union to successfully develop may be due to a lack of cellular recognition, the growing stage of the respective plants, interference of the wounding response or growth regulators, incompatibility toxins, or an unfavorable grafting environment (Andrews and Marques, 1993; Davis *et al.*, 2008). Many reports can be found on rootstock/scion incompatibility, which induces undergrowth or overgrowth of the scion, leading to decreased water and nutrient flow through the grafted union, causing wilting. However, overgrowth or undergrowth alone cannot be taken as a specific because this can also occur due to genetic differences in relative growth rate between the scion and the stock (Westwood, 1988).

Graft incompatibility as reviewed by Andrews and Marquez (1993) is differentiated from graft failure, which often results from environmental factors or lack of skill of the grafter. Oda *et al.* (2005) reported delayed graft incompatibility in tomato and the symptom being sudden wilting of grafted plant after a long-term normal growth. Oda *et al.* (2005) found symptoms of delayed graft incompatibility when tomato plants were grafted onto scarlet eggplant (*Solanum integrifolium*). The stem diameter of rootstocks was smaller than that of tomato scion and tomato stem swelled immediately above the union. Symptoms of delayed graft-incompatibility can be found in many of the fruit trees. Grafted tree after 20 or more years of normal growth and bearing fruits, begins with a thin layer of cambium and phloem cells died at the graft union. The necrosis develops around the trunk until tree becomes girdled and dies soon (Hartmann *et al.,* 1990). The mechanism of graft-incompatibility in vegetable crops is still a complex one because of its short growing period.

The objective of this study was to evaluate the graft compatibility and disease resistance of some rootstocks for tomato.

MATERIALS AND METHODS

The experiment was carried out at Tsukuba International Training Center (TBIC), Japan from June to October 2010. Thirteen rootstocks were selected for evaluation (Table 1). To ensure similar stem diameters at the grafting time, seeds of Tolban vigor and Tonasium were sown one month before sowing the seeds of scion and seeds of Daitaro and Akatora were sown 15 days before scion. Similarly, all tomato rootstocks were sown 3 days before seeds of scion. Grafting was done two times. First batch grafting was done on second week

of June and second batch grafting was conducted on second week of October. The following rootstocks and scion were used for this experiment.

Table 1: Different combinations between rootstocks and scion (treatments)

S. N.	Rootstocks	Scion	B. wilt resistance*	Fusarium resistance*		TMV resistant gene*
				Race1	Race2	
1.	Tolban Vigor (*S. torvum*)	Ogata fukuju	√			
2.	Daitaro (eggplant)	Ogata fukuju	√			
3.	Tonasium (*S. torvum*)	Ogata fukuju	√			
4.	Akatora (eggplant)	Ogata fukuju	×			
5.	Helper M (tomato)	Ogata fukuju	√	√	√	TM1
6.	Anchor T (tomato)	Ogata fukuju	√	√	√	TM2a
7.	B-barrier (tomato)	Ogata fukuju	√	√	√	TM2a
8.	Doctor K (tomato)	Ogata fukuju	×	√	√	TM2a
9.	BF Okitsu (tomato)	Ogata fukuju	√	√	√	TM2a
10.	Volante (tomato)	Ogata fukuju	√	√	√	TM2a
11.	Taibyo Shinko No. 1 (tomato)	Ogata fukuju	×	√	√	TM1
12.	LS-89	Ogata fukuju	√	×	×	TM1
13.	Gardener	Ogata fukuju	√	√	√	TM2a

* : based on claimed by the seed company (Takii Seed Co)

Grafting method

The cleft grafting using tube method was employed for the experiment. Grafted seedlings were put inside plastic insulated tunnel and kept under shade with high humidity for about 3 days for the healing of the graft union. After 3 days of healing process, the plastic tunnel was gradually opened and after 8th day, fully open to get acclimatized to outside environment. Number of grafts was 40 in the first and 20 in the second batch. Success percentages of grafting were recorded.

Transplanting to the poly-pot

All the non-grafted seedlings of scion varieties were transplanted to 12cm poly-pots in June 28. The grafted seedlings were transplanted in the 1st week of July. The poly-pots were filled with sterilized soil. Length of the stem at one month interval was recorded for five plants in each treatment.

Stem thickening

Diameter of the stem 3cm above and below the graft interface was measured two months after grafting on five plants in each treatment. Ratio of rootstock and scion diameter was calculated and compared with non-grafted control. Diameter at the thickest part of the stem was also measured.

Measurement of evapotranspiration

Two months after grafting, five potted plants of each treatment were watered fully and after 2 hours, weight of the potted plants was recorded. After 24 hours, again the weight was measured. The weight difference was calculated as evapotranspiration of 24 hours. Evapotranspiration was taken as indicator for the water movement through the graft union. Higher value of evapotranspiration was expected with highly compatible rootstock-scion combinations.

Transplanting to the infested soil

The experimental seedlings were transplanted to the field in Arakawaoki, Tsuchiura City, Japan on July 23. Some test plants were transplanted in that field in first week of June 2010 for the confirmation of the presence of pathogen on that soil. Wilting symptoms were

observed in 2nd week of June and finally all the test plants were found wilted. The stem of wilted plants were cut and dipped into the test-tube filled with water for bacterial oozing test. All the wilted plants showed positive results towards the test, which confirmed the presence of the pathogen *Ralstonia solanacearum* in that field.

Field experiment was carried out in Randomized Complete Block Design with 12 treatments replicated three times. There were two plants in each plot. Transplanting was done on July 23, 2010. Fertilizer was applied at the rate of NPK 20:15:20 kg/10a. Silver color plastic mulch was used to protect the plants from aphid. All plants were trained as single vine system. Other cultural practices were applied as per standard. The number of wilted plants was recorded at regular time interval.

Statistical analysis

All data were analyzed using analysis of variance (ANOVA) to examine treatment effects and means separated by Tukey's multiple range test at $P<0.05$ by using software developed by Dr. Mitate Yamada, Technical Advisor, TBIC, Japan.

RESULTS AND DISCUSSIONS

Grafting

Table 2 shows the percentage of successful graft-combinations after 7-8 days of acclimatization from two successive batch of grafting. The overall percent of successful graft was 50% in first batch and 83% in second batch. The combination of Akatora as rootstocks showed the highest percent of graft success followed by BF-Okitsu in first batch. The rootstocks Gardener showed the lowest percent of success followed by LS 89. Similar kind of result was observed by Valdez (2008) when rootstock LS 89 was grafted with scion variety Momotaro. Result of second batch was not similar with that of first batch. Tonasium resulted highest success followed by Daitaro, Akatora, and Volante. Lowest success was found with BF Okitsu. The lower success rate of grafting in first batch may be due to the skill of the participant and higher temperature on the month of June. This inconsistent result of graft success, therefore, could not be accounted for graft-incompatibility. Because of the low percentage of success rate of grafting on LS 89 and Gardener with Oogata fukuju in the first batch, these two rootstocks were not included for further investigation.

Table 2: Rootstocks performance on graft-success

S.N.	Combinations		% Successful Grafting	
	Rootstocks	Scion	1st batch (June)	2nd bach (October)
1	Tolban vigor	Ogata fukuju	60.0	100.0
2	Daitaro	Ogata fukuju	65.0	95.0
3	Tonasium	Ogata fukuju	47.5	90.0
4	Akatora	Ogata fukuju	75.0	95.0
5	Helper M	Ogata fukuju	60.0	80.0
6	Anchor T	Ogata fukuju	47.5	90.0
7	B-barrier	Ogata fukuju	32.5	75.0
8	Doctor K	Ogata fukuju	62.5	75.0
9	BF Okitsu	Ogata fukuju	75.0	60.0
10	Volante	Ogata fukuju	50.0	95.0
11	Taibyo Shiko No. 1	Ogata fukuju	57.5	75.0
12	LS 89	Ogata fukuju	17.5	70.0
13	Gardener	Ogata fukuju	0.0	85.0
	Total		50.0	83.5

Plant growth

No Significant difference was observed on the growth of plant height during one month, among the grafted combinations and non-grafted Ogata fukuju (Table 3). However, maximum increase in height was obtained by Taibyo Shikno No.1 (24cm) followed by Helper M (22.4cm). Lowest growth was obtained from Doctor K (14.4cm). Significant growth differences in diameter of the rootstock and scion was observed

among the treatments. All eggplant rootstocks contributed highest stem thickening on the scion as compared with the tomato rootstock (Fig. 1). However diameter of rootstock was lowest in eggplant rootstocks as compared with the tomato rootstocks. The ratio of rootstock to scion indicates the non-uniformity of stem growth on rootstock and scion part of the seedling which was found higher in eggplant rootstocks. The result indicated that eggplant rootstocks resulted in overgrowth of scion diameter and undergrowth of rootstock diameter itself. Oda *et al.* (2005) also found similar kind of result when tomato plants were grafted onto scarlet eggplant. Hartman and Kester (1975) stated such kind of overgrowth as a characteristic of graft incompatibility which is associated with poor connection of vascular bundles between scion of rootstock. However, no adverse effect on plant growth or wilt symptoms was observed due to such abnormal stem thickening.

Evapotranspiration

Mixed results were obtained from the evapotranspiration record. Highest value was obtained from Tolvan vigour followed by non-grafted control. It showed that evapotranspiration depends mostly on the overall plant growth. The highest value obtained from Tolban vigor rootstock attributed to its highest plant height (45.4cm) and highest stem diameter (8.5 mm). On the other hand, non-grafted control resulting second highest value in evapotranspiration in spite of its comparatively poor growth proved that graft union creates a barrier for the water flow through the xylem vessels to some extent. However, this parameter also could not be used as indicator for graft-incompatibility.

Table 3. Plant growth and evapo-transpiration affected by different rootstocks

Treatments	Plant height (cm)			Stem diameter (cm)				Evapo-transpiration in 24 hrs (ml.)
	12-Jul	12-Aug	Growth	Scion (S)	Thickest part (G)	Rootstock (R)	Sion Rootstock Ratio (S/R)	
Taliban vigor	23.2 ab	45.4	22.2	8.5 a	11.1 a	5.8 abc	1.5 abc	330 a
Daitaro	25.6 a	41.8	16.2	7.9 ab	9.9 ab	5.1 bc	1.5 ab	203 bcd
Tonasium	20.9 ab	39.2	18.3	7.8 abc	11.2 a	4.6 c	1.7 a	245 abcd
Akatora	23.4 ab	44.0	20.6	7.1 abcd	9.4 abc	5.5 bc	1.3 bcd	290 ab
Helper M	18.6 b	41.0	22.4	6.4 bcd	7.6 cd	5.9 abc	1.1 d	232 abcd
Anchor T	21.8 ab	40.8	19.0	6.3 d	6.7 d	5.7 abc	1.1 d	255 abc
B-barrier	18.0 b	38.2	20.2	6.4 cd	7.7 cd	5.3 bc	1.2 cd	150 cd
Doctor K	21.4 ab	35.8	14.4	6.4 bcd	6.8 d	5.5 abc	1.2 cd	157 cd
BF Okitsu	18.8 ab	35.8	17.0	6.7 bcd	8.2 bcd	6.1 ab	1.1 d	145 d
Volante	19.8 ab	38.0	18.2	7.0 abcd	8.3 bcd	5.7 abc	1.2 bcd	225 abcd
Taibyo Shiko No. 1	19.6 ab	43.6	24.0	6.7 bcd	7.7 cd	5.8 abc	1.2 cd	240 abcd
Non-grafted	20.0 ab	36.4	16.4	6.8 bcd	8.0 cd	6.8 a	1.0 d	303 ab
HSD 5%	6.83	n.s.	n.s.	1.49	1.83	1.32	0.32	0.10

Mean followed by the same letters are statistically not significant according to Tukey's multiple range test *(P<0.05)*

Incidence of bacterial wilt

Eighteen days after transplanting to the infested field, DoctorK, Taibyo Shinko No. 1 and non-grafted control showed first wilt symptoms (Table 4). In the final observation, 11 weeks after transplanting, they were completely destroyed by the pathogen. Yamakawa (1982) also reported the rootstock Taibyo Shinko No. 1 as susceptible to bacterial wilt.

Both rootstock Taibyo Shinko No. 1 and Doctor K was also referred as susceptible by the seed company (Table 1). After 11 weeks, disease incidence on resistant rootstocks Daitaro, HelperM, AnchorT and Volante were 33.3, 83.3, 50.0 and 33.3 percent respectively. Besides, the tomato plants grafted on Akatora which was supposed to be susceptible to bacterial wilt did not show any wilt symptoms until 9 weeks after transplanting. In the final observation, 16.67% plants grafted on Akatora were found infected with the pathogen. Tomato plants grafted on Tolban vigor, Tonasium, B-barrier, BF-Okitsu did not show any wilt symptoms till final observation.

Fig.1: Typical overgrowth of tomato scion grafted on eggplant rootstocks

Table 4: Percentage of bacterial wilt incidence on different rootstocks

	Percentage of wilted plants								
Rootstocks	18-DAT	24-DAT	34-DAT	38-DAT	45-DAT	53-DAT	57-DAT	64-DAT	77-DAT
Tolban vigor	0.00 b	0.00 b	0.00 b	0.00 c	0.00 c	0.00 b	0.00 c	0.00 c	0.00 d
Daitaro	0.00 b	0.00 b	0.00 b	0.00 c	33.33 abc	33.33 ab	33.33 bc	33.33 bc	33.33 cd
Tonasium	0.00 b	0.00 b	0.00 b	0.00 c	0.00 c	0.00 b	0.00 c	0.00 c	0.00 d
Akatora	0.00 b	0.00 b	0.00 b	0.00 c	0.00 c	0.00 b	0.00 c	0.00 c	16.67 cd
Helper M	0.00 b	16.67 ab	33.33 ab	50.00 ab	50.00 abc	50.00 ab	66.67 ab	66.67 ab	83.33 ab
Anchor T	0.00 b	0.00 b	0.00 b	0.00 c	0.00 c	33.33 ab	50.00 abc	50.00 abc	50.00 bc
B-barrier	0.00 b	0.00 b	0.00 b	0.00 c	0.00 c	0.00 b	0.00 c	0.00 c	0.00 d
Doctor K	33.33 ab	50.00 a	66.67 a	66.67 a	66.67 ab	66.67 a	83.33 ab	83.33 ab	100.00 a
BF Okitsu	0.00 b	0.00 b	0.00 b	0.00 c	0.00 c	0.00 b	0.00 c	0.00 c	0.00 d
Volante	0.00 b	0.00 b	0.00 b	16.67 bc	16.67 bc	33.33 ab	33.33 bc	33.33 bc	33.33 cd
Taibyo Shiko No. 1	50.00 a	50.00 a	50.00 a	83.33 a	83.33 a	83.33 a	100.00 a	100.00 a	100.00 a
Non-grafted	16.67 ab	16.67 ab	50.00 a	66.67 a	66.67 ab	66.67 a	66.67 ab	83.33 ab	100.00 a
HSD 5%	34.70	34.70	34.70	49.07	54.87	60.10	54.87	54.87	49.07

Mean followed by the same letters are statistically not significant according to Tukey's multiple range test (*P<0.05)*

From the results of field performance of the different rootstocks; it is clear than the resistant rootstocks viz. Daitaro, Akatora, Anchor T and Volante were not found fully resistant to the pathogen, hence they can be referred as moderately resistant. As in cases of Tolban vigor, Tonasium, B-barrier and BF Okitsu, which did not show any wilt symptoms till final observation, could be categorized as highly resistant rootstocks. The above result proved that disease resistance by rootstocks is a complex phenomenon and is strongly influenced by environmental conditions. In heavily infested soils and under extremely unfavorable environments, the so-called resistant plants become diseased. Intensive

successive cropping of the same rootstock provide opportunity for the occurrence of new pathogenic types with increased virulence qualitatively and quantitatively (Yamakawa, 1982). The reason of Akatora rootstock showing less wilt incidence as compared to other so-called resistant rootstocks could not be understood.

CONCLUSION

Tomato when grafted on suitable resistant rootstocks could overcome the problem of bacterial wilt incidence. However, resistance of the rootstocks is not absolute phenomenon. Resistance of rootstocks depends on wide range of environmental factors and field conditions. Therefore, it is highly advisable that the rootstocks are needed to be tested on different environmental and soil conditions for their resistance levels before making recommendation to the farmers. The occurrence of incompatibility in terms of graft success was not clearly observed in the experiment. The success or failure of grafting seemed to be more affected by the environmental conditions and skill of the grafter. Symptoms of delayed graft incompatibility could not observe due to short duration of this study. As far graft-incompatibility is concerned, it is recommended to conduct a series of experiments under various environmental conditions and long duration field test under uninfested soil condition.

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Influence of Time and Intensity of Pruning on Quality and Postharvest Performance of Cut Rose

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ABSTRACT

A field investigation was carried out during July 2008 to April 2009 in the farmer field of Gunjanagar-5, Chitwan, Nepal to evaluate the influence of time and intensity of pruning on quality and postharvest performance of cut rose cv. Super Tata (Rosa hybrida). The field experiment was laid out in a completely randomized block design with nine treatment combinations and replicated thrice. The treatments comprised of three dates of pruning i.e. 30th July, 15th August and 30th August and three pruning intensities i.e. heavy (6 buds per plant), medium (12 buds per plant) and light (18 buds per plant). Postharvest study was conducted in all the above treatments and repeated thrice at the central laboratory of IAAS, Rampur. Both time and intensity of pruning significantly affected quality and postharvest performance. Flowers stem diameter, fresh and dry weight of flower stem were found higher in July 30th pruned rose plants while, flower stem length was found longer (47.67cm) in August 15th ones. Flowers stem length (50.33cm) and diameter (0.60cm), length (2.91cm) and diameter (2.29cm) of floral bud, fresh and dry weight of flower stem were found highest from heavily pruned plants. The flowers from heavily pruned plants had early bud opening (4.53 days), highest floral diameter (9.13cm) and longest vase life (10.64 days). From this study, it revealed that highest quality cut flowers can be produced by heavy pruning whereas more quantity can be achieved by light pruning.

Key words: Time of pruning, intensity of pruning, vase life of flower

INTRODUCTION

Roses are symbol of beauty, fragrance and are used to convey the message of love (Arora, 2007). Rose is one of the nature's beautiful creations and is universally acclaimed as the Queen of Flower (Yadav *et al.,* 1989). The demand of rose cut flower is 2500-4000 sticks per day in Kathmandu and about 180 ropanies land is covered under rose cultivation (Joshi, 2009). Pruning is a major horticultural practice in rose cultivation (Edmond *et al.,* 1994). The different dates of pruning seem to have influenced flower yield and quality subsequently (Mukhophadhyay, 1990. Pruning rose plants in different dates was helpful in staggering the harvest of cut flowers. Several researchers have reported increased flower production with light pruning and quality blooms with severe pruning.

Postharvest life of cut flower is an important aspect in cut rose production. The specific Preharvest factors affecting vase life of cut flowers are genetic (Gelder, 1998), environmental (Mortensen and Fjeld, 1998) and agronomic factors such as soil, fertilizer, pruning, irrigation, plant protection measures and harvesting practices (Nowak and Rudnicki, 1990). Flower production is highly technical; lack of knowledge on these aspects leads to the poor quality of the produce and also increases the cost. Farmers get very low price of their produces. Availability of cut flower in market is low in quality as well as in quantity. There is no standard time and intensity of pruning for the market oriented quality rose production in Nepal. Therefore, this research was conducted to determine the optimum time and intensity of rose pruning for efficient growth, yield and quality of cut flower in a farmer's field in Gunjanagar-5, Chitwan, Nepal from July 2008 to March 2009.

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MATERIALS AND METHODS

The commonly grown rose cultivar in Chitwan 'Super Tata' having yellow color flower, one year old rose plants were taken as a test crop for the experiment. The treatment combinations of time and intensity of rose pruning were selected as treatments. There were 9 plants in each experimental plot and observation was taken from 3 middle plants. The individual plant was pruned three times at 15 days interval viz. Pruning on 2008 July 30, Aug. 15 and Aug. 30 to different intensities i.e., 6, 12 and 18 buds in each plant. The field experiment was laid out in a completely randomized block design having two factors with nine treatment combinations replicated thrice.

The rose plants were pruned to allow the intensity as desired. After pruning, cut ends were painted with fungicide paste (Bordeaux paint). All the intercultural operations such as hoeing, weeding, topdressing, irrigation, earthing up and mulching were done regularly. Flowers were harvested from Nov. 2008 to Apr. 2009 manually during evening retaining 10-12cm stem from the branch attachment. Observations were recorded for several vegetative, yield and quality parameters.

Postharvest study was conducted with five replications, repeating thrice at the central laboratory of IAAS, Rampur. The research material was cut rose stems from nine different treatment combinations of time and intensity of pruning. Glass bottles 320ml volume were taken as vase and distilled water was used for evaluation. In the laboratory, the harvested flower stems were given slant cut at uniform length of 30cm. Leaves were trimmed from the lower section of the stem retaining the uppermost three lobed leaves (Halevy and Kofranek, 1977). Dethroning was done to make easy handling of rose stems. After putting the cut flower (10cm dipped), the level of distilled water was maintained at 300ml in glass bottle. The head of the glass bottle was wrapped with aluminum foil and covered with cotton scab to prevent evaporative loss. Flowers were kept for evaluation in a well-ventilated room. The source of light was day light and from fluorescent tube light and the day length was maintained at 12hr. Temperature and relative humidity of the test room were measured daily with the help of thermo hygrometer. The transpiration loss of water was refilled everyday with the help of measuring rod. Flower vase life was measured 24hr after keeping the cut flowers in the vase. Each day, flowers were inspected for the vase life, bud opening, diameter of flower, water up-take, neck bending and flower quality.

RESULTS AND DISCUSSION

Quality parameters

Flower stem characteristics

The rose plants pruned on August 15 produced flowers having longest stem (47.67cm) which was at par with rose plants pruned on July 30 (47.11cm) and shortest stem (42.00cm) was produced from rose plants pruned on August 30 (Fig. 1) after harvest. Deepauw (1985) reported that the stem length of rose was only slightly affected by time of pruning.

The rose plants pruned retaining 6 buds produced flowers having longest stem (50.33cm) whereas shortest stem (41.00cm) was produced from rose plants pruned retaining 18 buds (Fig. 2). The rose plants pruned on July 30 produced flowers having highest stem diameter (0.58cm) and smallest stem diameter (0.48cm) was produced from rose plants pruned on August 30 (Fig. 1). Fig. 2 showed that the rose plants pruned retaining 6 buds produced flowers having highest stem diameter (0.60cm) and smallest stem diameter (0.47cm) was produced from rose plants pruned retaining 18 buds.

This might be due to the availability of more nutrients to each stem on rose plant that under heavy pruning than light pruning. Similar result was found by Bajwa *et al.,* (1998). The increase in flower stem length and diameter may be due to lesser number of stem produced and therefore, more nutrients coming to the share of each stem on heavily pruned rose plant. Similar result have been reported by Bajawa and Sarowa, 1977; Gupta and Singh, 1987.

Fig.1: Effect of time of pruning on flower stem length and flower stem diameter of cut-rose cv. Super Tata (*Rosa hybrida*) in Chitwan (2008/09).

Fig.2: Effect of intensity of pruning on flower stem length and flower stem diameter of cut-rose cv. Super Tata (*Rosa hybrida*) in Chitwan (2008/09).

The rose plants pruned retaining 6 buds produced flowers having highest leaf numbers in flower stem (15.67) whereas lowest leaf numbers in flower stem (11.33) was produced from rose plants pruned retaining 18 buds. This result might be due to the production of longer stem by the heavily pruned rose plants and thus has higher surface area for the production of leaves than light pruned.

Table 1: Effect of intensity of pruning on flower bud characteristics and fresh and dry weight of cut rose stem cv. Super Tata (*Rosa hybrida*) in Chitwan (2008/09).

Intensity of pruning	Flower bud characteristics		Fresh and dry weight of cut rose stem	
	Length of flower bud (cm)	Diameter of flower bud (cm)	Fresh weight (gm)	Dry weight (gm)
6 buds	2.911a	2.298a	14.53a	3.556a
12 buds	2.578b	2.043b	12.12b	3.013a
18 buds	2.233c	1.900c	10.30c	2.310b
CV%	10.92	6.72	11.16	18.45

[a] Means in the column followed by same letter in each treatments do not differ significantly at (p=0.05) by DMRT. SEM=Standard error of mean, LSD=Least significant difference and CV=Coefficient of variance.

Flower bud characteristics and fresh and dry weight of cut rose stem

The rose plants pruned retaining 6 buds produced flowers having highest flower bud length (2.91cm) and diameter (2.29cm) whereas smallest flower bud length and diameter (2.23cm and 1.90cm) was produced from rose plants pruned retaining 18 buds(Table 1). Higher amount of carbohydrates available for the individual flower stem in heavily pruned rose plants might have contributed to better vigor of plant having longer and bigger flower bud. Mukhopadhyay *et al.,* (1987) also agreed with this result.

The statistical analysis showed that, fresh and dry weight of cut rose flower was found to be significantly influenced by different intensities of pruning (Table 1). The rose plants pruned retaining 6 buds produced flowers having highest fresh and dry weight (14.53 gm and 3.55 gm) whereas lowest fresh and dry weight (10.30 gm and 2.31 gm) was produced from rose plants pruned retaining 18 buds. Higher fresh and dry weight of flower stem in heavily pruned rose plants might be related with higher stem length, stem diameter, leaf number in flower stem and flower bud length and diameter than medium and lightly pruned rose plants.

There was progressive increment in the number of petals per flower with increase in severity of pruning.

Postharvest performance

The longest vase life was found in the rose flowers produced from heavily pruned plants (10.64 days) followed by medium (9.87 days) and shortest vase life (9.05 days) was found from the lightly pruned ones. The variation in vase life of cut rose may be due to the availability of carbohydrate concentration for metabolic reactions. The flowers from heavily pruned plants have higher stem length and diameter, bud length and diameter. Thus, this might be contributed for the higher concentration of carbohydrate. Vase life of cut flowers is positively correlated with sugar concentration in petals (Ichimura *et al.,* 1999).

Effect of carbohydrate on the extension of flower vase life is known to be associated with improved water balance and inhibition of ethylene production (Dilley and Carpenter, 1975). Low level of carbohydrates induces endogenous ethylene production and increases flower senescence (Fjeld, 1991).

Table 2: Effect of intensity of pruning on postharvest performance of cut-rose cv. Super Tata (*Rosa hybrida*) in Chitwan (2008/09).

Treatments (Intensity of pruning)	Vase life (days)	Duration of bud opening (days)	Floral diameter (cm)
6 buds	10.64a	4.539c	9.139a
12 buds	9.870b	5.025b	8.593b
18 buds	9.058c	5.473a	8.139c
CV%	6.25	8.11	5.47

[a] Means in the column followed by same letter in each treatments do not differ significantly at (p=0.05) by DMRT. SEM=Standard error of mean, LSD=Least significant difference and CV=Coefficient of variance.

The earliest bud opening was found in the flowers from heavily pruned (4.53 days) followed by medium (5.02 days) whereas, longest time to bud opening was observed from the lightly pruned rose plants (5.47 days). Variation on days to flower bud opening might be influenced by carbohydrate concentration and similar variation has been observed in rose varieties (Ichimura *et al.,* 2002).

The highest floral diameter was found in the flowers from heavily pruned rose plants (9.13cm) followed by medium pruned (8.59cm) and lowest floral diameter was found from the lightly pruned rose plants (8.13cm). This variation might be due to variation in size of flower stem and bud. The variation in floral diameter has influence on the water uptake and that influence the vase life (Pun *et al.,* 2009).

CONCLUSIONS

Time of pruning affects all the quality parameters of rose. The early pruned (July 30) rose plants performed significantly better as compared to other dated of pruning in all aspects. Similarly, the performance of rose flowers was also found significantly different with various intensities of pruning. Among the three intensities, heavily pruned (6 buds in each plant) rose plants performed better in all vegetative growth, yield and quality attributing characteristics. Likewise, postharvest performance of flowers produced from heavily pruned rose plants was found superior as compared to other two intensities. This suggests that pruning of rose is an important aspect in cut flowers production. Sequential pruning can produce rose flowers at successive desired time. Grower should prune heavily to produce quality cut flowers whereas higher quantity of rose flowers can be achieved by

light pruning. In Chitwan condition, cut rose growers can prune their rose plants after rainy season to produce cut rose targeting festivals and marriage months leaving 10-12 buds in each plant for quantity and quality of cut flower.

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Screening of Potato Clones against Wart (*Synchytrium endobioticum*) Disease under Naturally Infested Field Condition

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ABSTRACT

Field experiment was conducted at Nigale, Sindhupalchok located at 2450 masl during 2007 and 2008, with the objective of identifying potato clones resistant to wart (*Synchytrium endobioticum*). Nigale is one of the wart disease prone areas of the country. A total of 80 potato clones in 2007 and 45 clones in 2008 were planted in an augmented experimental design on a severely wart infested farmer's field. Commercially grown, locally adopted and highly wart susceptible potato cultivar 'Rosita' was used as check and crop was grown under rain fed condition. Susceptible cultivar was planted after each nine-test row. Experiment was planted during first fortnight of February in both the years and harvested in first week of July. Apparently healthy and wart infested tubers were counted and wart incidence percent was obtained at the time of harvest along with tuber yield per plot. Clones with complete absence of wart on the surface of tubers were considered as wart resistant. Thirty eight CIP accessions and five national crosses i.e C x LBr 44.14, D x LBr40.10, D x LBr43.12, D x LBr43.13, D x LBr44.6 were found resistant to wart, whereas, potato clones Kufri-Chipsona-2, 393637.10, 394007.55, 392236.6, 388572.4 and 393280.64 were found highly susceptible to wart under field conditions.

Key words: Potato clones, Rosita, *Synchytrium endobioticum*, wart screening

INTRODUCTION

Potato is one of the important food crops after rice, maize and wheat which occupy total area of 1,56,737 hectares with the productivity of 13.11 t/ha (ABPSD 2007). Share of Mountain alone for potato growing area and production is 18% and 14 % respectively as compared to National area and production. *S. endobioticum* originated from the Andean region of South-America, from which it was introduced into Europe in 1880s now almost worldwide distribution in cooler areas where potatoes are cultivated. In Nepal it was introduced probably from India via Darjiling and Sikkim to Ilam. This disease has been established in few potato growing areas of Ilam, Panchthar, Dolakha, Sindhupalchok, Dhading and Gorkha districts with the estimated yield loss ranging 20-90% (Khairgoli 1997) particularly at the high altitudes ranging 2000 to 3000 m a s l. Aerial symptoms are usually not apparent although plant vigor reduction may be observed. The fungus affects basal stems, stolons and tubers but not roots. Tubers' eyes are the main center of infection that develop into cauliflower-like warty appearance, which are initially whitish but on exposed to light changed into green and gradually darken and in advance stage get rot and disintegrate (Stuart *et al*., 2008).

This fungus causes substantial yield losses when soil gets severely infested. Ninety percent farmers of Mudhe and Nigale area grow potato variety "Rosita" which is highly susceptible to this disease with a incidence of 20-40 % (NPRP 2007) and an estimated yield loss ranging 20 to 30 percent annually. No effective fungicide has been reported against this fungus however some cultural practices can minimize the losses. The most

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effective and practical remedy of this problem is the use of resistant varieties. All the released potato varieties in Nepal are resistant to wart but farmers of that area have not been attracted to adopt these varieties. The possible cause could be either farmer are not getting their desirable characters into these varieties or lack of awareness towards this disease.

OBJECTIVES

Farmers' participatory wart screening experiment was conducted at Nigale at an altitude of 2450masl in order to identify high yielding, wart-resistant and farmers preferred potato varieties under farmer's field conditions, and to create awareness towards the nature of disease with respect to pathogen dispersal and longevity of its resting spores.

THEORETICAL FRAMEWORK

Potato wart caused by *Synchytrium endobioticum* (Schilb) Perc. is a disease of quarantine significance due to the production of persistent resting spores and lack of effective chemical control measures (Putnam and Sindermann,1994, Hehl *et al*., 1998). Wart is the most serious disease of potato particularly in the cooler region of the country. S. endobioticum an obligate parasite does not produce hyphae but forms sporangia containing 200 to 300 motile zoospores. The most favorable conditions for its development are warm temperatures (but not over 20°C) with enough humidity. Winter sporangia can remain viable for more than 40 years (Sturt *et al*., 2008) and survives at depths of 50cm in the soil. Sporangia are released into soil after the decay of host tissue and are disseminated on tuber surface, via soil movement and perhaps by wind. Once introduced into an area, the contamination can not be eradicated. Use of reistant varieties is only the best options of wart management. Six potato varieties have been released for commercial cultivation with the yield potentiality of 20-30 t/ha. None of these varieties are adopted by Nigale farmers. To enhance the adoption of new varieties and the technologies, participatory approach has been found effective in other commodities. The participatory process narrow downs the gap between research organizations and farmers' realities by ensuring direct farmer involvement at different stages of the research process (Sharma *et al*., 2007).

METHODOLOGY

Experiment was conducted on highly wart-infested soils, identified during the previous crop harvesting time. In 2007, eighty test genotypes along with previously released seven wart resistant potato varieties i.e. Kufri Jyoti, Janak Dev, Khumal Seto-1, Khumal Rato-2, NPI-106, Cardinal and Desiree were planted. Whereas in 2008, test clones were 45 and compared with wart susceptible check variety 'Rosita'. Sources of test genotypes were International Potato Center (CIP) and National Potato Research Programme (NPRP). Experiment was planted at the farmer's field at Nigale Sindhupalchok during first fortnight of February in both the years 2007 and 2008.

Susceptible check variety was planted after each 9 test entries and was made it's borderline in both the years. Experiment was in rod row augmented design (Scott and Milliken,1993, Burgueno *et al*., 2005) susceptible check was repeated 5 to 6 times depending on the size of the experimental blocks. Plot size was a row length of 2.5 m long and 0.6 m width and planted in a spacing of 25cm X 60cm. Field was prepared as furrow and ridges with a spacing of 60cm. Compost @ 10 t/ha and fertilizer @ 150:100:60 Kg N: P_2O_5: K_2O/ha were applied as basal. Intercultural operations were followed as per farmers' practice. Fungicides were not applied throughout the crop period. Wart incidence was recorded at

the time of harvesting based on the number of infected symptomatic tubers and apparently healthy tubers produced per 1.5 m^2 plots. Tuber yield including infected ones was recorded per plot.

RESULTS AND DISCUSSION

A total of eighty potato clones were exposed to wart-infested soils in 2007 and forty two clones in 2008. Thirty-two clones were repeated in both the years. A sum of 37 clones was found resistant to wart under field conditions remaining were susceptible showing wart incidence ranging 1.2 to 100 percent. Among the wart resistant, DxLBr40.10 (3.2 kg), CxLBr40.14 (2.6 kg), CIP-392661.18 (2.0 kg) and CIP-394038.105 (2.3 kg) clones were of high yielding (>2kg/1.5 m^2) clones. Some of the genotypes CIP-390347.50, CIP-394007.55 and CIP-392236.6 showed 100% wart incidence followed by CEZ-69.1 (81.8%), CIP-385556.4 (66.7%), CIP-393280.64 (65.4%) and CIP-388572.4 (65.0%). All these clones showed more susceptibility to wart than existing cultivar 'Rosita' (61.5.4%). Data are presented in Annex1. All the previously released varieties i.e Kufri Jyoti, Janak Dev, Khumal Seto-1, Khumal Rato-2, NPI 106, Cardinal and Desiree showed resistant to wart but showed poor performance with respect to tube yield (<1.0 kg/1.5 m2) even after a long period of release.

The clones such as LBr40, CIP-392657.8, CIP-393280.57, CIP-394321.15, CIP-392617.54, CIP-391058.35 and CIP-392637.10 (Annex 1) found promising with respect to late blight resistance at Khumaltar and Chitwan conditions were susceptible to wart. Clones showing wart symptoms on tubers were rejected for further evaluation and recommendation for the hills. Potato clones LBr40, CIP-392657.8 and CIP-394321.15 were the farmers preferred clones in terai and mid hills for their yield performance but found susceptible to wart. Experiment showed that these potato clones should not be recommended for commercial cultivation in the hills. Tuber yield, late blight and wart disease resistance are the major criteria of potato genotype selection especially for the high hills.

Performance of promising potato clones to wart disease and yield

Seventeen promising potato clones, which had been under initial evaluation trial (IET) and coordinated varietal trial (CVT) for multi location testing, were also included in the screening. Of them only three genotypes CIP-394005.115, Kufri Giriraj and CIP-393674.72 B were found to be resistant to wart under high altitude (>2450 masl) wart infested soil conditions. With respect to tuber yield, all these clones produced tuber yield less than or comparable yield with locally adopted cultivar ‘Rosita’ (Fig.1). Despite of wart susceptibility, farmers prefer this variety because of having three most desirable plant characters profuse branching, high yielding, late blight tolerant and red skinned tuber.

Hypothetically wart incidence and tuber yield should have negative correlation. Simple linear correlation coefficient (r) computed based on the data of Fig 1 showed very poor positive correlation (r = +0.17). If clones get infected by S. endobioticum at the early stage of crop generally leads to formation of wart structures on stolons instead of tuber formation and cause heavy yield loss. Later stages of infection may not affect significantly on yield, however diseases incidence percent may be higher. Clones CIP 393280.64 and Rosita have high yielding capacity along with wart susceptibility (Fig 1) which might influence to show positive relation. It may be the reason that 'Rosita' still not rejected by farmers of Nigale and Kharidhunga area despite of high wart incidence and simultaneously there is lack of new wart resistant varieties to replace the existing variety.

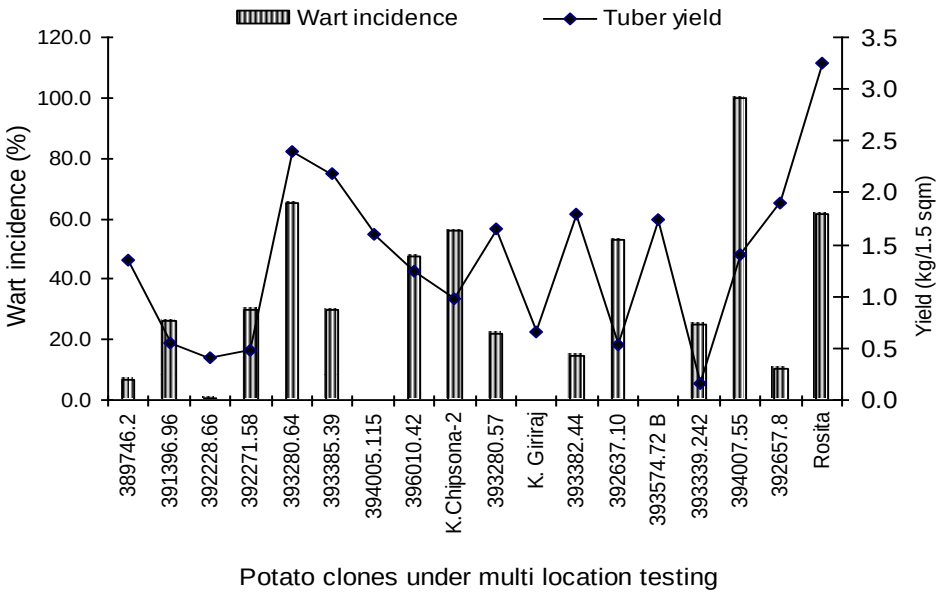

Fig.1: Performance of sixteen promising potato clones against wart incidence and tuber yield under Nigale condition in 2007 and 2008.

Performance of NPRP crosses to wart disease and yield

Among the NPRP crosses, DxLBr44.6, DxLBr40.10, DxLBr40.14, DxLBr43.13, DxLBr43.12 were found resistant to wart. However other crosses showed minimum level of wart incidence as compared to 'Rosita'. Regarding with the tuber yield, two wart resistant clone JDxLBr40.5 and CxLBr40.14 produced comparable yield with Rosita (Fig. 2). Despite of wart susceptibility, farmers prefer this variety because of having three most desirable plant characters profuse branching, high yielding, late blight tolerant and red skinned tuber.

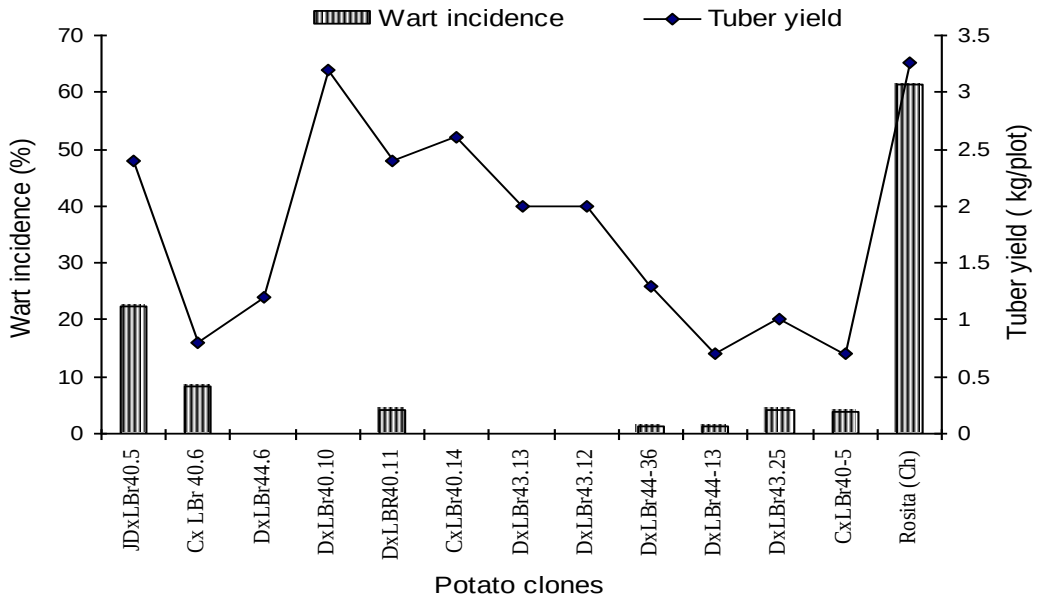

Fig.2: Performance of NPRP crosses potato clones against wart infested field conditions of Nigale in 2007 and 2008.

All of these high yielding genotypes were found to be susceptible to wart indicating that there was no significant effect of wart incidence on tuber yield. But it does not exactly hold true, when wart infection starts early during the tuber formation stage there will be no tuber development and that lead to formation of wart instead of tuber. Under such circumstances yield loss reaches maximum. Tuber yield per plot includes both infected and healthy. When warty structures are removed, total produce can be marketed. On use of warty tubers as seed material for succeeding crop season would enhance severity of wart under favorable soil and weather conditions.

CONCLUSION

In addition to released potato varieties, three potato genotypes DxLBr40.10, CxLBR40.14 and CIP-394038.105 were found to be resistant to wart with considerable tuber yield ranging 15 to 21 t/ha. Out of these three clones, participating farmers selected DxLBr40.10 because of red skin tuber and comparable tuber yield with their existing cultivar 'Rosita'. Screening of potato clones against wart and late blight diseases should be continued in order to get at least 50% more yield than the existing cultivar under high altitude conditions.

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Authors are thankful to the innovative farmers Mr Bhakta Bahadur Shrestha of Nigale and Mr Man Bahadur Lama of Mudhe for managing wart screening field experiment and actively participation in selecting wart resistant potato clones in their own field.

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Annex 1. Performance of potato clones against wart disease at Nigale during 2007-08

Acc. No.	Infected tubers (No.)		Healthy tubers (N0)		Wart incidence %			Tuber yield (kg/plot)		
	2007	2008	2007	2008	2007	2008	Mean	2007	2008	Mean
378711.7	0	0	9	50	0.0	0.0	0.0	0.1	1.2	0.6
383178.22	0	0	29	38	0.0	0.0	0.0	0.3	1.0	0.7
384321.15	2	6	22	73	8.3	7.6	8.0	1.0	2.5	1.7
384329.21	0	0	26	22	0.0	0.0	0.0	0.6	0.6	0.6
385021.12	1	2	4	8	20.0	20.0	20.0	0.1	0.6	0.4
388576.3	3	11	10	4	23.1	73.3	48.2	0.3	0.8	0.5
389746.2	1	2	17	24	5.6	7.7	6.6	1.1	1.6	1.4
391002.6	2	7	13	24	13.3	22.6	18.0	0.3	0.8	0.5
391046.2	1	10	4	17	20.0	37.0	28.5	0.1	0.5	0.3
391396.96	1	11	3	10	25.0	52.4	38.7	0.1	1.0	0.6
391617.54	6	13	18	28	25.0	31.7	28.4	1.4	1.4	1.4
392228.66	0	0	9	54	0.0	0.0	0.0	0.1	0.7	0.4
392243.17	0	0	21	10	0.0	0.0	0.0	1.1	0.4	0.7
392243.52	0	0	33	36	0.0	0.0	0.0	1.0	1.5	1.3
392271.58	4	5	10	11	28.6	31.3	29.9	0.4	0.6	0.5
392637.10	1	12	16	0	5.9	100.0	52.9	0.6	0.5	0.5
392657.8	7	2	26	11	21.2	15.4	18.3	2.0	1.85	1.9
392661.18	0	0	54	51	0.0	0.0	0.0	2.1	1.9	2.0
393077.54	7	5	17	39	29.2	11.4	20.3	0.8	2.5	1.6
393280.64	25	53	56	0	30.9	100.0	65.4	2.8	2.0	2.4
393385.39	41	11	54	55	43.2	16.7	29.9	2.3	2.1	2.2
394005.115	0	0	50	44	0.0	0.0	0.0	1.5	1.7	1.6
394051.4	3	2	32	20	8.6	9.1	8.8	0.8	0.4	0.6
396010.42	14	25	15	28	48.3	47.2	47.7	0.9	1.6	1.3
393574.72 B	0	0	30	45	0.0	0.0	0.0	1.6	1.9	1.8
K.Chipsona-2	6	29	19	4	24.0	87.9	55.9	0.7	1.3	1.0
RW-8201.19	9	9	15	24	37.5	27.3	32.4	0.3	1.1	0.7
LBr-40	40	4	16	35	71.4	10.3	40.8	3.4	3.1	3.2
392227.15	15	2	20	5	42.9	28.6	35.7	1.0	0.1	0.6
394038.105	0	0	38	33	0.0	0.0	0.0	2.4	2.2	2.3
388572.4	3	68	7	0	30.0	100.0	65.0	0.1	1.7	0.9
BR 63/65	8	17	65	20	11.0	45.9	28.5	0.7	1.4	1.0
396233.38	0	-	7	-	0.0	-	0.0	0.1	-	0.1
800982	0	-	18	-	0.0	-	0.0	0.8	-	0.8
384331.10 LB	1	-	11	-	8.3	-	8.3	0.1	-	0.1
388572.1	0	-	15	-	0.0	-	0.0	0.1	-	0.1
388574.6D	0	-	71	-	0.0	-	0.0	0.7	-	0.7
388578.2 D	1	-	19	-	5.0	-	5.0	0.2	-	0.2
AKK-69.1	11	-	27	-	28.9	-	28.9	0.6	-	0.6
CEZ-69.1	18	-	4	-	81.8	-	81.8	1.6	-	1.6
Curza-27	2	-	18	-	10.0	-	10.0	0.6	-	0.6
K.Chipsona-1	5	-	16	-	23.8	-	23.8	0.9	-	0.9
Kinga	3	-	8	-	27.3	-	27.3	0.1	-	0.1
390347.50	11	-	0	-	100.0	-	100.0	0.2	-	0.2
T-55X TPS-67	3	-	38	-	7.3	-	7.3	0.5	-	0.5
388580.6	0	-	18	-	0.0	-	0.0	0.6	-	0.6
LBr-20	7	-	46	-	13.2	-	13.2	1.2	-	1.2
LBr-43	7	-	25	-	21.9	-	21.9	1.2	-	1.2
LBr-44	17	-	30	-	36.2	-	36.2	2.0	-	2.0
NPI-106	0	-	54	-	0.0	-	0.0	1.7	-	1.7
Mineara	0	-	35	-	0.0	-	0.0	0.6	-	0.6
388764.26 LB	23	-	31	-	42.6	-	42.6	1.4	-	1.4
Andinita	0	-	35	-	0.0	-	0.0	0.1	-	0.1
DxLBr44-36	1	-	79	-	1.3	-	1.3	1.3	-	1.3

Acc. No.	Infected tubers (No.)		Healthy tubers (N0)		Wart incidence %			Tuber yield (kg/plot)		
	2007	2008	2007	2008	2007	2008	Mean	2007	2008	Mean
DxLBr44-13	1	-	70	-	1.4	-	1.4	0.7	-	0.7
DxLBr44.6	0	-	46	-	0.0	-	0.0	1.2	-	1.2
DxLBr40.10	0	-	72	-	0.0	-	0.0	3.2	-	3.2
DxLBR40-11	3	-	69	-	4.2	-	4.2	2.4	-	2.4
DxLBr43.13	0	-	82	-	0.0	-	0.0	2.0	-	2.0
DxLBr43.12	0	-	84	-	0.0	-	0.0	2.0	-	2.0
DxLBr43.25	2	-	46	-	4.2	-	4.2	1.0	-	1.0
CxLBr40-5	1	-	25	-	3.8	-	3.8	0.7	-	0.7
Cx LBr 40.6	2	-	22	-	8.3	-	8.3	0.8	-	0.8
CxLBr40.14	0	-	73	-	0.0	-	0.0	2.6	-	2.6
JDxLBr40-5	13	-	45	-	22.4	-	22.4	2.4	-	2.4
386201.3	0	-	8	-	0.0	-	0.0	0.2	-	0.2
391058.35	8	-	16	-	33.3	-	33.3	0.7	-	0.7
392240.29	3	-	12	-	20.0	-	20.0	0.2	-	0.2
392258.11	4	-	7	-	36.4	-	36.4	0.1	-	0.1
393280.57	8	-	28	-	22.2	-	22.2	1.7	-	1.7
393339.242	2	-	6	-	25.0	-	25.0	0.2	-	0.2
395014.97	2	-	12	-	14.3	-	14.3	0.5	-	0.5
396082.7	-	0	-	43	-	0.0	0.0	-	0.83	0.83
394007.55	-	28	-	0	-	100.0	100.0	-	1.40	1.40
392270.32	-	0	-	37	-	0.0	0.0	-	0.85	0.85
385556.4	-	20	-	10	-	66.7	66.7	-	1.15	1.15
Panauti	-	0	-	22	-	0.0	0.0	-	2.05	2.05
392236.6	-	51	-	0	-	100.0	100.0	-	1.73	1.73
BSUPO-3	-	33	-	38	-	46.5	46.5	-	2.19	2.19
K. Giriraj	-	0	-	25	-	0.0	0.0	-	0.66	0.66
394005.12	-	4	-	39	-	9.3	9.3	-	2.02	2.02
388764.26	-	0	-	41	-	0.0	0.0	-	1.60	1.60
393077.16	-	4	-	31	-	11.4	11.4	-	2.30	2.30
393382.44	-	5	-	29	-	14.7	14.7	-	1.80	1.80
392206.35	-	0	-	67	-	0.0	0.0	-	1.90	1.90
Khumal- Seto-1 (Ch)	0	-	51	-	0.0	-	0.0	0.2	-	0.2
Kufri Jyoti (Ch)	0	-	43	-	0.0	-	0.0	0.6	-	0.6
Janak Dev (Ch)	0	-	45	-	0.0	-	0.0	2.6	-	2.6
Kufri Jyoti (Ch)	0	-	36	-	0.0	-	0.0	0.8	-	0.8
Khumal Rato-2 (Ch)	0	-	30	-	0.0	-	0.0	0.9	-	0.9
Cardinal (Ch)	0	-	54	-	0.0	-	0.0	0.8	-	0.8
Desiree (Ch)	0	-	37	-	0.0	-	0.0	0.8	-	0.8
Rosita (Ch)	55	48	40	26	57.9	64.9	61.4	3.0	3.51	3.26

Total test entries in 2007 were 80 and 45 in 2008. Plot size 1.5 m^2

Mother Tree Selection of Mandarin Orange (*Citrus reticulata* Blanco) for Varietal Establishment

Ram Badal Shah[1]

ABSTRACT

Mandarin orange is the second largest commercially grown fruit crop of Nepal. It is indigenous to Nepal, but none of its variety is recognized because of variations in external and internal characters prevailing in mandarin growing areas of Nepal. To produce uniform fruits acceptable to internal as well as external quality sensitive markets,this problem must be overcome. This study was carried out to select mother stocks from local cultivars and to establish 'true to the type' genome that can produce quality fruits of uniform characters. For this study, 10 and 11 pre-identified mandarin trees were selected in Dhusa (Dhading) and Khoku (Dhanakuta) respectively. Qualitative and quantitative characters of fruits like shape, base, rind color, size and weight of fruits, number of seeds and segments, pulp color, rind thickness, juice percent, total soluble solid : total acid ratio were examined. Among the 11 trees of Khoku (Dhankuta) sample Krishna 1 stood on top with the largest fruit of 155.365g, juice content 32.67% and TSS:TA ratio 58:1. This was followed by Kewal 1 with fruit weight of 132g, juice content 40% and TSS:TA ratio 14.2:1. Khambjit 3b, Khambjit 1, Hikmat 4 and Khambjit 2 appeared almost similar with little variation in fruit weight, Juice percent and sweetness ratio. Therefore, above six trees and other two trees (Hikmat 2, Gajar 1) were recommended for at least one more investigation for final confirmation. Among 10 sample trees of Dhusa, Chiranjibi 2 was found superior quality with the largest fruit (232.5g), high juice content (50.86%) and TSS:TA ratio (19:1). Other seven samples namely Ran Bahadur 1, Kedar 1, Lila 1 & 2, Raghunath 1, Chiran 1 and Chiran 3 seemed almost similar (some with large fruit some with very juicy and some with high to very high sweetness ratio). Those samples were recommended for further investigation to confirm final selection of mother tree(s). The selected mother stocks (trees) would be recommended for varietal recognition and thereby to use as source plant for disease free true to the type sapling production.

Key words: high quality, mandarin orange, mother tree, selection, variation.

INTRODUCTION:

Although there is a controversy about the origin, citrus species is believed to be native to the tropical and subtropical parts of the Himalayan region, South East Asia and the Malayan Archipelago. Nepal is situated in the eastern Himalayan region. According to De Condole (1886), citrus originated some where in the eastern part of India, Siam or South China (Cochin China). Shan people, who migrated towards the south-west (Asam) from South-East China, might have brought it to India prior to the Christian era. According to Bonavia (1890), mandarins were found in semi-wild conditions in Butwal (Nepal), and Tanaka (1929) concluded that mandarin is indigenous to Nepal (NCDP, 1992). This indicated that mandarin is the oldest member of all commercial citrus fruits grown in Nepal, which is in general grown in the middle mountain region of the country from east to west.

Table 1: Area and production of Mandarin orange in Nepal (2007/08)

Particular	Area (ha)	Share (%)	Production (mt.)
All fruits	100099.0	100	630562
All citrus	30790	30.76	226404
Mandarin	20167	20.15	150737

(Source: FDD, 2010)

[1] Former co-coordinator in National Citrus Development Program, Dhankuta.

It occupies 20167 ha, 65.5% of the total citrus area (30790 ha) and 20.15% of total fruit area (100099.0 ha) in the country (FDD, 2010; NCDP, 1990).

Increasing population, peoples' changing food habit, developing road links, expanding cities, increasing tourism and development of fruit processing industries and cold stores have created a big internal demand of fruits especially for mandarin orange. These factors have encouraged planners and farmers to extend more and more areas under this crop. At present very small fraction of the mandarin orange is reaching to the external/Indian market near boarders. Nepalese mandarin orange has big internal and external markets, because the ripening season of Nepalese mandarin orange does not coincide with the harvesting season of the same in India. Government plan has always emphasized to increase production of this fruit for self sufficiency as well as for external markets. Along with the overall development of the country it has also obtained a very high commercial value. However, any produce cannot be accepted in the external or quality conscious markets unless it meets the quality standard of such markets. To produce high quality fruits, a plant must have such genetic character. Since centuries, mandarin orange is being grown by using seedling plants in Nepal. Therefore, variation in fruit characters and qualities is natural. Differences on fruit appearance (shape, size and color), rind surface and thickness of peels, internal quality of fruits such as total soluble solid (TSS), total acidity (TA), juice percent and number of segments and seeds per fruit and time of fruit maturity are clearly seen in mandarin in every citrus growing area of Nepal

Fig.1: Mandarin fruits showing variation in shapes, bases and sizes.

Another big problem of citrus industry in the country is the greening disease, which spreads from one area to other mainly with the movement of saplings. Minimizing the problem is also important. Essentially major tasks to overcome the problems are selection and identification of mother stocks having desirable qualities in major mandarin growing districts and production and maintenance of pathogen free true to the type clone for clean source at suitable locations (altitude). Therefore, the study was carried out to achieve the first goal that is mother tree selection of mandarin orange for varietal establishment and standardization.

MATERIALS AND METHODS:

The study was carried out in Khoku VDC of Dhankuta district and Dhusa VDC of Dhading district during late eighties. A total of 21 trees with highly sweet fruits were selected and evaluated for the study. Eleven mandarin trees of seven orchards (farmers) in Khoku and ten trees of nine orchards (farmers) in Dhusa were selected based on local informants' and field-tests. All the trees were of seedling origin. According to the farmers, age of the trees ranged from 25–40 years. Equipments such as hand refractometer, acidometer, measuring

cylinder, beakers, glass rod, dropper, knife, juice extractor, tissue paper, camera, balance and scale were used in the assessment.

The main season of mandarin harvesting is suggested from last week of November to the last week of December. This may slightly vary with altitude of mandarin growing area (Renther et al., 1967; Tomiysau et al., 1998). When fruits are harvested earlier or later than the period, juice reduction and/or looseness in fruits are noticed (HDP, 1997; Tomiysau et al., 1998). In late Jan–Feb, fruits with loose and partially dried segment show regreening of fruits on the tree. These criteria for the study were determined following the citrus description given in Renther et al. (1967). As the fruits from sunny side have higher sweetness and better color, five fruits from each of the sample tree were picked up from the northern side of the trees. Observations taken for external and internal qualities were fruit appearance, (shape, base, apex, color and rind surface), fruit size, pulp texture and color, adherence of segments with peel, number of seeds and segment per fruit, thickness of rind, TSS, total acid and their ratio and juice percentage.

RESULT AND DISCUSSIONS

Fruit appearance (shape, apex and color) of mandarin orange is very important factors for market acceptance specially for the quality sensitive markets. No distinctive differences in fruit shape, rind color and pulp color were noticed among the samples. Rind color and pulp color in all cases were orange. Rind surfaces were also smooth in most samples except in few. Difference in other characters like fruit size and weight, rind thickness number of segments number of seeds, TSS and TA,juice percent were found among the samples as given in tables 2,3,4 and 5. Pulp of one sample in Khoku was found granulated and pulp of two samples in Dhusa were also found granulated.

Khoku mandarin orange

Qualitative fruit characters

No distinctive differences in fruit shape, rind color and pulp color were noticed among the samples. Rind color and pulp color in all cases were orange. Rind surface was also smooth in most of the samples. Apices of fruits varied from sample to sample. Fruit shapes in all samples were oblate (height less than diameter) but the appearances of the fruits differed from each other due to the base, neck size and types of shoulder. Fruit base, color, neck size are presented in Table 2.

Table 2: Qualitative (external) fruit characters of Khoku mandarin orange

Farmers' name (orchard)	Sample no.	Base	Apex
Hikmat Bahadur Karki	2	Rounded/flat, short necked	Depressed
Hikmat Bahadur Karki	4	Rounded/flat, short necked	Depressed
Krishna Bahadur Rai	1	Rounded/flat, short necked	Slightly depressed
Krishna Bahadur Rai	2	Necked	Depressed
Kewal Man Rai	1	Rounded, slight necked	Slightly depressed
Gajar Singh Rai	1	Obliquely necked	Slightly depressed
Khambjit Rai	1	Low collard short necked	Depressed with pitted surface
Khambjit Rai	2	Flat, slight necked	Depressed
Khambjit Rai	3B	Short necked	Depressed
Ram Lal Majhiya Rai	1	Moderately depressed	Slightly depress
Biman Bahadur Rai	1	Rounded short necked	Depressed with pitted surface

Quantitative Fruit Characters

Average fruit size varied from 5.5cm to 7.32cm, Likewise average fruit weight varied from 67.18g to 155.36g. Krishna1 fruit was the largest and the smallest one was Krishna 2.

Average fruit weight of six samples (Krishna 1, Rewal 1, Hikmat 4, Khambjit 3B, Biman 1 and Khambjit 2) were above 100g and that of Krishna 2 and Ram Lal 1 were below 80g. Rest two (khambjit 1 and Hikmat 2) weighed 97.82 and 96.75g respectively. Average rind thickness ranged from 2.2mm to 4.08mm. Average seed number per fruit varied from 7.5 to 16.3, however the actual number of seed ranged from 4 to 24 per fruit. Maximum seed was found in Krishna 1 (8-24) and the lowest one in Krishna 2 (4 to14). Variation in segment number was not much. It ranged from 8 to12. This seems to be normal in Nepalese mandarin orange (Tomyasu et al., 1998). Average TSS (Brix) ranged from 10.6 (Gagar 1) to 14.4 (Khambjit 1), while TA (Total acid) ranged from. 0.2 (Krishna 1) to 0.95 (Biman 1). Fruits having comparatively low TSS (11.6 or 10.6) with very low TA (0.2 or 0.65) gave highest and higher ratio of 58 and 16.3 but fruits having very high TSS of 14.0 with high TA of 0.95 resulted in low ratio of 14.74 and tasted soury. Fruits having TSS and TA ratio below 15 were found soury and above that were sweet and very sweet (2,6). Krishna 1 was recorded with highest TSS:TA ratio of 58, followed by khambjit 1, Krishna 2 and Hikmat 2 having the sweetness ratio of 20.57, 18.57 and 17.60 respectively. Gagar 1, Hikmat 4 and Ram lal 1 were sweet enough having TSS:TA ratio 16.31, 15.29, 15.0 respectively. Highest juice content was found 40% in sample kewal 1 followed by 39.48, 39.47, 38.55, 37.23 in Khambjit 3B, Gagar1, Khambjit 2, Khambjit 1 respectively. Juice in other samples were found below 35 percent (Table 3). A survey of citrus fruit in four districts of Nepal also showed an average of 34.8 % juice in mandarin orange (2, 6).

Table 3: Quantitative fruit characters of Khoku mandarin orange

Farmers	Sample no.	Fruit size (cm)	Fruit wt. (g)	Rind thick (mm)	No. of seed	No. of segments	Juice%	TSS Brix	TA	TSS: TA
Hikmat	2	5.50	96.75	3.4	13	9-10	34.17	13.2	0.75	17.6 :1
	4	5.82	109.85	3.8	15.2	8-10	29.47	13.0	0.85	15.29
Krishna	1	7.32	155.36	3.4	8.5	8-11	32.67	11.6	0.20	58.0
	2	5.62	67.18	4.08	11.2	8-10	21.7	13.0	0.70	18.57
Kewal Man	1	6.66	132.0	2.2	12.8	9-10	40.0	11.4	0.80	14.20
Gagar Singh	1	6.27	92.7	2.62	12.5	8-11	39.47	10.6	0.65	16.31
Khambjit	1	6.2	97.82	2.9	10.6	8-12	37.23	14.4	0.7	20.57
	2	6.39	100.58	3.9	16.3	10-11	38.55	12.4	0.9	13.78
	3B	6.31	104.0	3.0	16.25	8-11	39.48	12.8	0.9	14.22
Ram Lal	1	5.76	75.8	3.0	8.6	8-10	28.76	12.0	0.8	15.0
Biman	1	6.4	101.2	2.8	7.5	9-11	32.23	14.0	0.95	14.74

Dhusa mandarin orange

Qualitative characters

Table 4: Qualitative (external) fruit characters of Dhusa mandarin orange

Farmers (orchards)	Sample no.	Base	Apex
Chiranjili silwal	1	Rounded to flat, slight neck	Depressed
Chiranjili silwal	2	Rounded low collared (short neck)	Depressed
Chiranjili silwal	3	Flat short necked	Depressed
Raghunath silwal	1	Low collared short neck	Depressed
Lila Nath silwal	1	Low collared necked & short necked	Depressed
Lila Nath silwal	2	Moderately depressed slight neck	Depressed
Babu Ram silwal	1	Flat to moderately depressed	Depressed
Hem Prasad silwal	1	Moderately depressed	Depressed
Ran Bahadur thapa magar	1	Depressed	Depressed
Kedar Nath silwal	1	Flat/Rounded slight neck visible	Depressed

Rind and pulp color in all cases were orange and fruit shapes in all samples were oblate (height less than diameter). But the appearances of fruits differed from sample to sample due to the types of base, neck size and types of shoulder. Variation in bases and necks (rounded/flat, low collared, moderately depressed, necked, short or slightly necked) and apices (depressed) were found as in table 4.

Quantitative fruit characters

Average fruit size ranged from 6.0cm to 8.4cm. Likewise average fruit weight ranged from 103.6 to 232g. Chirangibi 2 fruit was the largest weighing 232g followed by Ram Bahadur weighing 207.5g and the smallest one was Baburam1 103.6g. All samples showed average fruit weight above 100g (Table 5). Average rind thickness varied from 3.0cm to 4.37mm which is normal for a good mandarin (2,6). Average seed number per fruit varied from 9.4 to 19.6. The actual number of seeds varied from 5 to 25 per fruit. Maximum average seed per fruit recorded in Lila Nath1 was 19.6 and the lowest one was 9.4 in Ragu Nath 1. Variation in the number of segments recorded was from 8 to14. Average TSS (Brix) ranged from 10.92 (Chirangibi 1) to 13.2 (Babu Ram 1) and that of TA (total acid) ranged from 0.46 (Ragu nath 1) to 1.5 (Lila 2). All the samples except one showed TSS and TA ratio above 15. Lila 2 sample with even higher TSS of 12.34 had very high TA of 1.5 resulting in very low ratio of 8.23 and tasted sour. Fruits having TSS and TA ratio above 15 were found sweet and very sweet (2,6). Raghunath 1 was recorded with highest TSS:TA ratio of 24.35 followed by 19.56, 19.5, 19.06, 18.21, 17.94, 17.77, 16.72 and 15.73 (Table 5). Highest juice content (56.58 %) was found in sample Lila 2 followed by 55.0, 54.6, 54.5, 54.25, 53.00, 50.86, 49.0, 48.93 and 46.0 of Baburam 1, Ragunath 1, Kedar 1, Hem 1, Ran Bahadur 1, Chirangibi 2, Chiragib 3, Lila 1 and Chirangibi1 respectively (Table 5). A survey of citrus fruit in four districts of Nepal showed an average of 34.8 % juice content in mandarin orange (Tomyasu et al., 1998). Percentage of juice in Dhusa mandarin orange recorded higher than Khoku and average of other 4 districts (Dhankuta, Sinduli and Tanhu) (2, 6).

Table 5. Quantitative fruit characters of Dhusa mandarin orange

Farmers	Sample no.	Fruit size (cm)	Fruit wt. (g)	Rind thick mm	No. of seed	No. of segments	Juice %	TSS Brix	TA	TSS:TA
Chirangibi	1	7.4	146.75	3.57	13	8-10	46.0	10.925	0.6	18.21:1
	2	8.4	232.0	4.20	17.2	10-11	50.86	11.44	0.6	19.06:1
	3	7.0	137.5	3.25	14.5	9-10	49.0	11.7	0.6	19.5:1
Raghunath	1	6.95	136.6	3.80	9.4	9-10	54.6	11.25	0.46	24.35
Lila nath	1	7.42	177.8	3.81	19.6	10-12	48.93	12.56	0.7	17.94:1
	2	7.24	155.6	3.30	14.0	10-10	56.58	12.34	1.5	8.23
Babu Ram	1	6.0	103.6	3.17	12.0	10-10	55.0	13.32	0.68	19.56
Hem Prasad	2	6.24	110.6	3.0	13.0	8-10	54.25	12.72	0.87	15.73
Ran Bahadur	1	8.55	207.5	4.37	18.0	10-12	53.0	11.37	0.68	16.72

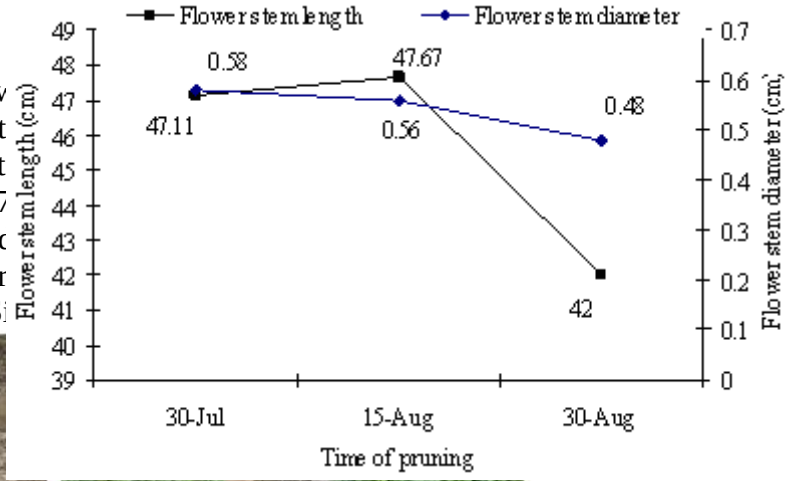
Selection of mother trees

As mentioned above, a lot of variations were seen both in qualitative and quantitative characters of fruits, specially base shoulder and neck size; and rind thickness, size, weight, TSS:TA ratio and juice percentage of fruits. Size of fruits varied even on the same tree and from tree to tree to some extent. The gradual change occurring in fruit color TSS, TA, juice content and other component is a natural phenomenon. Due to that , in the process of maturity (fruit ripening), rind color changes from green to yellow and orange, juice percent and TSS increases and TA declines. In Nepal, orange color of rind is taken as the sign of full maturity and high sweetness. Consumers prefer highly sweet taste with little

acid blend although Nepalese mandarin orange having orange color, round or flat base with short neck looks attractive and are liked by consumers but higher sweetness in juice gets the first priority. It was assumed that thick rind, higher number of seeds and segment cover (septa) are reflected in juice percentage of fruit. Therefore for selection, trees were compared mainly on the basis of fruit weight (size), high TSS:TA ratio and juice percent and they were ranked on the basis of score

Khoku

Fruit shape of all the samples v
(155g) with highest TSS:TA rat
(32:67). Its fruit shape was oblat
were very sweet (TSS:TA=20.57
Fruits were oblate with rounded
fruits with the highest juice per
rounded base and slight neck. S



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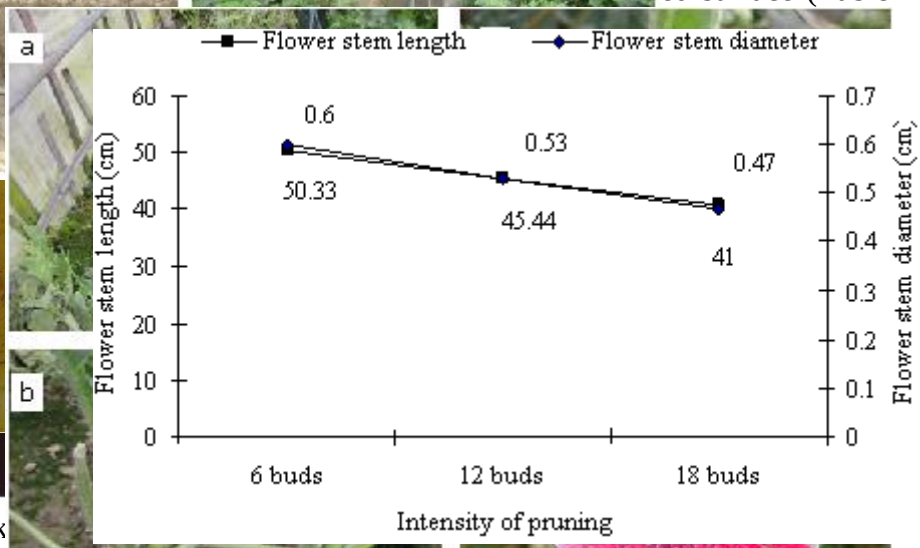

Fig.2: Krishna1 (Khok

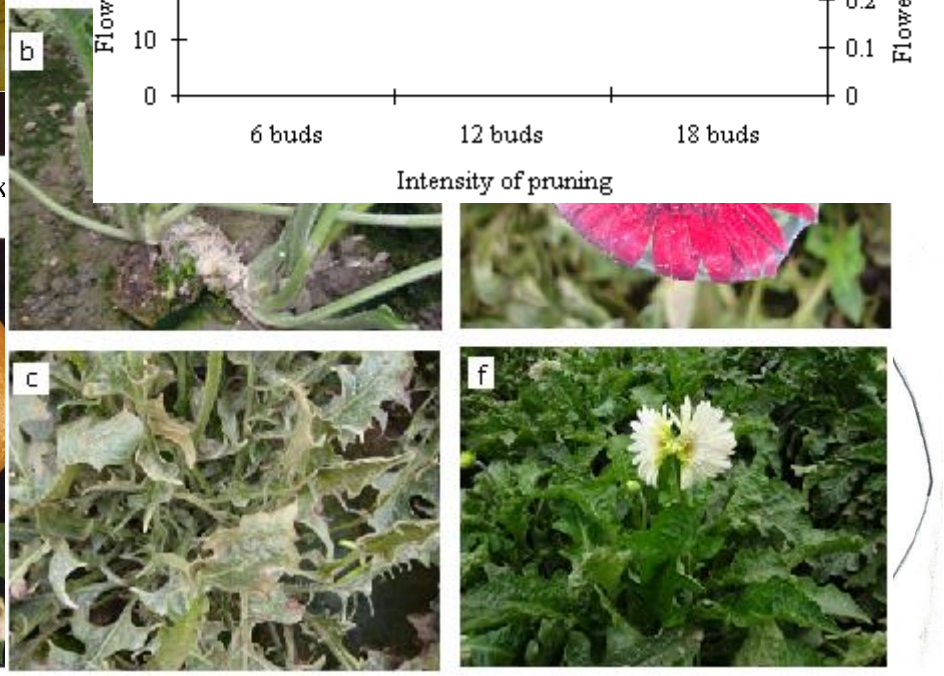

Fig.3: Kewal Man 1 (Khoku), fruit showing rounded and slightly necked base.

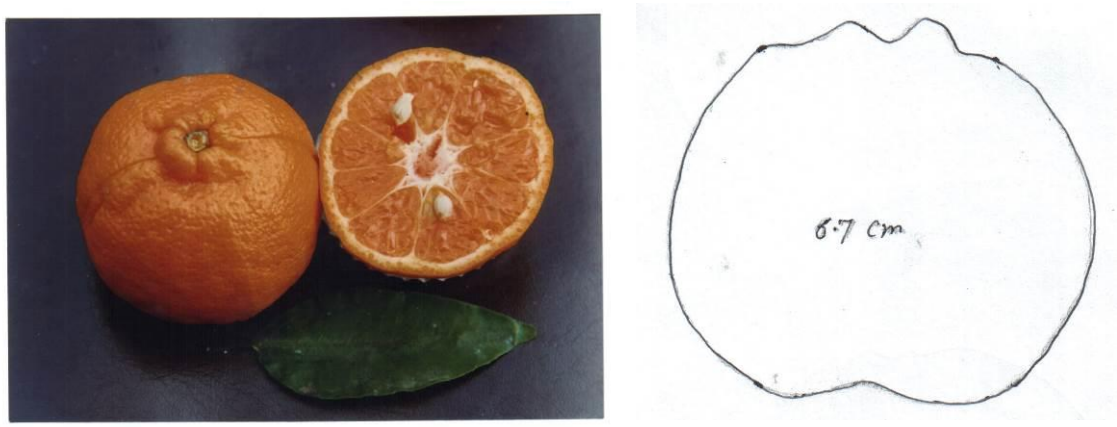

Fig.4: Khambjit 1 (Khoku), fruit with short necked low collared base, pitted surface showing fine vertical groove.

Table 5: Mother tree selection of mandarin orange, Khoku, Dhankuta

Farmers	Sample no.	Fruit base	Fruit wt (g)	Juice %	TSS Brix	TA	TSS:TA ratio	Total score
Krishna	1	Flat rounded	155.36	32.67	11.6	0.2	58.0	246.03
Kewatman	1	Rounded,low collared slight neck	132.0	40	11.4	0.8	14.2	186.0
Khambjit	3B	Depressed sl. Neck	104.0	39.48	12.8	0.9	14.72	157.7
Khambjit	1	Low collared, pitted surfaces, fine groove across	97.89	37.23	14.4	0.7	20.57	155.69
Hikmat	4	Flat round, short neck	109.85	29.47	13.0	0.85	15.29	154.61
Khambjit	2	Rounded slt neck	100.58	38.55	12.4	0.9	13.78	152.91
Hikmat	2	Flat round, short neck	96.75	34.17	13.2	0.75	17.6	148.52
Gajar singh	1	Rounded necked	92.7	39.47	10.6	0.65	16.31	148.48
Biman	1	Roundedpitted suface	101.2	32.23	14.0	0.95	14.14	147.17
Ram lal	1	Moderately depressed	75.8	28.76	12.0	0.8	15.0	119.56
Krishna	2	Necked	67.18	21.7	13.0	0.7	18.57	107.45
Average			103.03	33.97	11.64	0.746	19.84	

Dhusa

Fruit sizes of all the samples were above 100g. The average fruit size, juice content and TSS:TA ratio was 159g, 52.27 % and 17.89:1 respectively. Fruit Sample Chiranjibi 2 showed the largest size of fruit (232g), high juice percent (50.86) and higher level of sweetness; thus scored first among the 10 samples. This was followed by Ran Bahadur 1 with average fruit weight 207 g, very high juice content (53%) and sweet (TSS:TA ratio 16.72) in taste. Two samples namely Kedar 1 and Lila 1 found very similar having fruit weight 182g and 178g, Juice % (54.5 and 49) and TSS and TA ratio (17.77 and 17.94) respectively. Fruit base of Kedar 1 was low collared and that of Lila 1 was round is sort neck. Four samples Lila 2, Raghunath 1, Chiran1 and Chiranjibi 3 could be put under one category by score while other two samples Hem Prasad 1 and Baburam 1 grouped under same rank (Table 6).

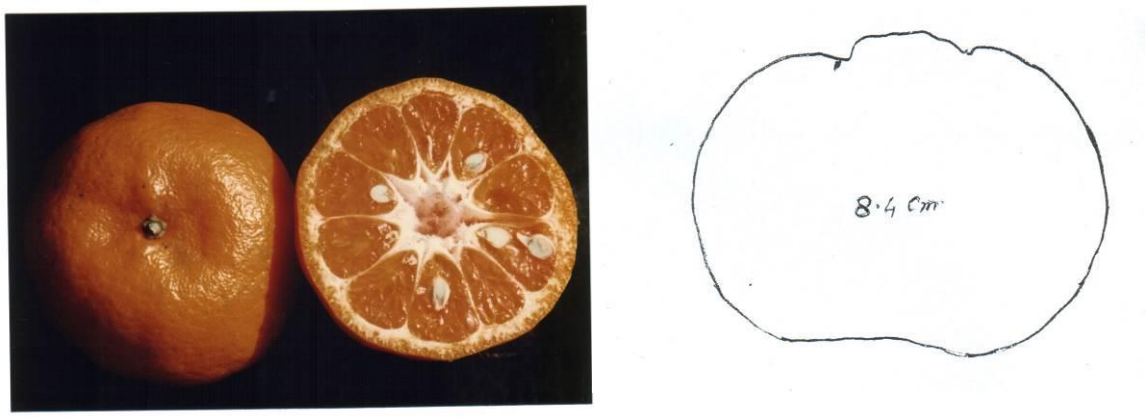

Fig..5 Chiranjibi 2 (Dhusa), fruit showing flate & low collared base with trace of neck.

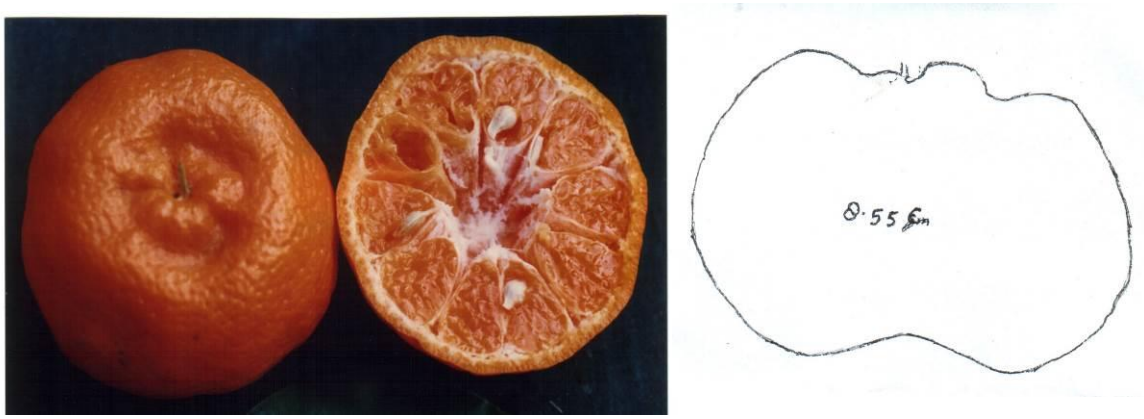

Fig.6: Ran Bhahadur 1 (Dhusa), fruit showing moderately depressed base with short neck

Table 6: Mother tree selection of mandarin orange, Dhusa (syadul), Dhading.

Farmers	Sample no.	Fruit base	Fruit wt (g)	Juice %	TSS Brix	TA Acid	TSS:TA ratio	Total score
Chiranjibi	2	Flat low collared slight neck	232.0	50.86	11.44	0.6	19.06	301.92
Run Bahadur	1	Moderately depress	207.5	53.0	11.37	0.68	16.72	277.22
Kedar	1	Flat low collared	189.0	54.5	12.62	0.71	17.77	261.27
Lila nath	1	Rounded low collared necked	177.8	48.93	12.56	0.7	17.94	244.67
Lila nath	2	Moderately depressed	155.6	56.58	12.34	1.5	8.23	220.41
Raghunath	1	Rounded low collared	136.6	54.6	11.25	0.46	24.45	215.55
Chiranjibi	1	Flat slight neck	146.75	46.0	10.92	0.6	18.2	210.96
Chiranjibi	3	Low collared short neck	137.5	49.0	11.7	0.6	19.5	206.0
Hem Prasad	1	Flat slightly depressed	110.6	54.25	12.72	0.87	14.62	180.58
Babu Ram	1	Moderately derpressed	103.6	55.0	13.32	0.68	19.59	178.19
Average			159.0	52.27	11.64	0.746	17.89	

CONCLUSIONS

Mandarin orange is said to be indigenous to Nepal. It is a very important and second largest commercial fruit crop being grown all over mid-hills of Nepal. However, a wide

variation in fruit characters or less uniform produce does not satisfy the choice of quality sensitive internal as well as export markets. This study was the first attempt to select mother stocks from local cultivars and to give recognition to the Nepalese mandarin orange with high qualitatives characters. Fruit shape of all the samples was oblate (height less than diameter) while base of the fruit differed from sample to sample (Table 6,7). Form Khoku, sample Krishna 1 ranked the first position followed by Kewalman 1. Though Khambjit 3B Showed higher in juiciness but sweetness near to the average. Fruit of khambjit 1 was juicy and very sweet but little smaller while the fruit of Hikmat 4 was sweet and good size but little less juicy than average. Khambjit 2 had average fruit size and juicy but sour. From Dhusa (syadul), sample Chiranjibi 2 was on the top position with the largest fruit high juice % and very high TSS:TA ratio. Ran Bahadur1, Kedar1 and Lilanath1 seemed very similar with large fruit high juice content high level of sweetness (TSS:TA). Lilanath 2 had comparatively large fruit and very high juice % but sour. All the rest 5 samples had fruits over 100g, very high juice and sweet but Hem Prasad1 was little sour.

Top five trees of KHOKU (Dhanuktta) and top four trees and other four trees (Raghunath 1, Chiranjibi 1, Chiranjibi 3 and Babu ram 1) Of Syadul (Dhading) are rocomended for forther investigation . Further investigations are needed to confirm this result because some variation may occur due to weather conditions and other factors. Such studies are also recommended to conduct for other major mandarin growing districts. These selected mother stocks (trees) will be used as source plants from where diseases free true to the type sapling will be multiplied for commercial fruit production of uniform and high quality mandarin orange.

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Effect of Integrated Nutrient Management on Tree Growth, Yield and Quality of Walnut (*Juglans regia* L.)

B.P. Bhattarai[1] and C.S. Tomar[2]

ABSTRACT

The study was conducted in 10 years old walnut orchard in Dr.Y. S. Parmar University of Horticulture and Forestry, Nauni-Solan(H.P.) to find out the effect of integrated nutrient management on tree growth, yield and nut quality of walnut (Juglans regia L.). There were 13 different treatments in combination of organic and inorganic fertilizers. Changes in tree-height, trunk-girth and protein and oil contents in nuts were recorded in percentage and shoot extension in meter. Statistical analysis of the data was carried out as per the method described by Cochran and Cox (1963). Recommended dose of NPK with 50 kg vermicompost produced highest increase in tree height, trunk girth and shoot extension. However, highest improvement in nut yield and quality were observed with three fourth of recommended NPK and 68.75 kg vermicompost.

Key words: Integrated-nutrient-management, NPK, neem-cake, vermicompost, walnut, Himachal Pradesh.

INTRODUCTION

Walnut (*Juglans regia* L.) is one of the important high value and suitable income generating crops to high mountain farmer of Nepal and India. The yield of walnut in the countries is very low as compared to USA, China, France and others developed countries (Chaudhary *et al.,* 2004). Due to lack of appropriate management practices, suitable varieties and market linkages, the mountain farmers are not encouraged to grow the tree crop in commercial scale despite a day-by-day increasing demand for walnut in market.

It has been reported that vermicompost and neem-cake are good sources of nutrients for excellent yield and quality of different crops (Arancon *et al.,* 2003; Kumari *et al.,* 1999). Likewise, various organic manures are excellent nutrients sources to increase yield and quality of coconut (Ram and Rajput, 2002). Integrated nutrient management is one of the most important technologies in walnut production. However, little information is available in this area. In view of which, this study was designed and conducted to identify the effect of integrated nutrient management on growth, yield and nut quality of walnut.

MATERIALS AND METHOD

The study was conducted during 2004-2005 at walnut orchard of the Department of Pomology in Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni-Solan (H.P.), India. Ten years old walnut trees were selected for the experiment. The experiment was laid out in randomized block design with three replications. There were 13 treatments as follows, all applied per tree basis in December 2004.

T_1= Recommended dose of NPK + 100kg FYM (750g :375g :750g)
T_2= Three fourths of the recommended NPK +137.5kg FYM
T_3= Half of the recommended NPK + 175kg FYM
T_4= Recommended dose of NPK+10kg Neem cake

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T_5= Three fourths of the recommended NPK + 13.75kg neem cake
T_6= Half of the recommended NPK + 17.5kg neem cake
T_7= Recommended dose of NPK +50kg vermicompost
T_8=Three fourths of the recommended NPK+68.75kg vermi-compost
T_9= Half of the recommended NPK + 87.50kg vermicompost
T_{10}=15kg neem cake
T_{11}= 75kg vermicompost
T_{12}= 150kg FYM
T_{13}= Recommended dose of NPK

Increment in trunk girth, tree volume, shoot extension, yield and nut-quality were recorded. Tree height of each experimental tree was measured above ground level with a graduated staff, and the trunk girth was measured 10cm above the graft union. Tree canopy volume was calculated using following formula as suggested by Westwood (1993).

$$\text{Tree canopy volume} = 4/3\ \pi(\text{tree height}) \times (\text{tree width})^2$$

For shoot extension, ten annual shoots were randomly selected from all over the periphery of each experimental tree, and length of the shoots was measured with a measuring tape at the end of growing season (November). The per tree basis yield was recorded after crop harvesting and sun-drying of nuts for five days. Kernel protein was assessed by the method given by Khanizadeh *et al*. (1995) and the percentage oil content on weight basis by Soxhlet apparatus method (Ranganna, 1997). The data were analyzed by using the statistical techniques describe by Cochran and Cox (1963). The treatment effects were tested at five percent level of significance.

RESULTS AND DISCUSSIONS

Growth

The **o**rganic manures applied in combination with the inorganic fertilizers (NPK) significantly increased the growth of walnut tree measured in terms of tree height, trunk girth, cross sectional area, tree volume and shoot extension. A combination of full dose of NPK and 50kg of vermicompost was found superior to the rest of the treatments (Table 1). Marimuthu *et al.* (2001) and Murarkar *et al.* (1998) also reported similar results in tree growth due to application of organic manures in combination with fertilizers respectively on coconut and mulberry.

Better efficiency of organic manures in combination with inorganic fertilizers in increasing tree growth and yield could be due to various micronutrients provided to the trees in optimum range. Application of organic manures would have helped in the nourishment of the trees with the supplemental micronutrients contained in the organic manures. As reported by Nandhakumar (1997), the organic manures would enhance metabolic activity in the trees during early growth phase through the supply of such micronutrients, which in turn could have encouraged overall tree growth in the later stage also.

Yield and nut quality

The maximum fruit yield was recorded with the application of three fourths of the recommended NPK and 68.75kg of vermicompost, which was statistically superior to other treatments. The minimum yield was in the trees treated with three fourths of the recommended NPK and 137.5kg FYM (Table 2). The increased yield with application of three fourths of the recommended NPK and 68.75kg of vermicompost might be attributed to the possible effect of vermicompost on transforming plant nutrients into soluble forms

and chelating them to increase the uptake by the trees. Vermicompost is also a rich source of micro flora such as *Azosprillium*, *Actinomycetes* and *Phosphobacillus*, which multiplies faster through digestive system of earthworms. Beyond helping in nutrients transformation, these microbes also released hormone like substances to help in the tree metabolism, growth, development and yield (Tomati *et al*., 1988).

Table 1: Effect of integrated nutrient management on the growth of walnut (*J. regia* L.)

Treatment	Increment in tree height (%)	Increment in trunk girth (%)	Tree volume (m^3)	Shoot extension growth(m)
T_1=Rec. NPK + 100kg FYM	15.22	0.75	34.97	0.67
T_2=3/4th rec. NPK +137.5kg FYM	13.7	0.8	26.02	0.58
T_3= 1/2 rec. NPK + 175 kg FYM	8.48	0.68	22.36	0.27
T_4= Rec. NPK+10kg Neem cake	14.54	0.91	29.97	0.61
T_5= 3/4t^{h} rec. NPK+ 13.75 kg Neem cake	13.86	0.8	29.3	0.58
T_6= 1/2 rec. NPK + 17.5kg Neem cake	9.17	0.7	23.13	0.28
T_7= Rec. NPK +50kgvermicompost	15.9	0.96	36.36	0.77
T_8=3/4th rec. NPK+68.75kgvermi-compost	15.48	0.86	32.51	0.75
T_9= 1/2 rec. NPK + 87.50kg vermicompost	12.36	0.75	23.7	0.57
T_{10}= 15 kg Neem cake	11.37	0.75	22.99	0.46
T_{11}= 75kg vermicompost	12.74	0.87	24.13	0.57
T_{12}= 150kg FYM	9.72	0.7	23.01	0.38
T_{13}= Rec. NPK	9.47	0.7	23.19	0.48
$CD_{0.05}$	0.50	0.06	NS	0.29

Table 2: Effect of integrated nutrient management on the yield and nut quality of walnut (*J. regia* L.)

Treatment	Yield (kg/tree)	Kernel protein (%)	Kernel oil (%)
T_1=Rec. NPK + 100kg FYM	0.87	11.02	53.31
T_2=3/4th rec. NPK +137.5kg FYM	0.72	10.96	57.76
T_3= 1/2 rec. NPK + 175 kg FYM	0.9	14.12	57.86
T_4= Rec. NPK+10kg Neem cake	0.97	11.99	57.18
T_5= 3/4t^{h} rec. NPK+ 13.75 kg Neem cake	1.02	11.93	60.63
T_6= 1/2 rec. NPK + 17.5kg Neem cake	1.93	11.08	61
T_7= Rec. NPK +50kgvermicompost	1.43	14.21	62.35
T_8=3/4th rec. NPK+68.75kgvermi-compost	2.68	13.75	58.17
T_9= 1/2 rec. NPK + 87.50kg vermicompost	1.15	12.53	61.66
T_{10}= 15 kg Neem cake	1.28	10.94	59.51
T_{11}= 75kg vermicompost	1.2	11.24	59.18
T_{12}= 150kg FYM	0.97	13.6	59.94
T_{13}= Rec. NPK	1.05	10.88	52.15
$CD_{0.05}$	0.82	0.58	2.06

The kernel protein was registered maximum in the treatment with recommended dose of NPK and 50kg vermicompost and minimum with recommended dose of NPK (control). Treatment with full NPK and 50kg vermicompost should have enhanced the uptake of nitrogen and its assimilation into amino acids and finally into protein in conformity to the findings of Sharma *et al*. (2002).

The treatments significantly affected the oil content in walnut kernels. The lowest oil content was recorded in the treatment with recommended dose of NPK. The highest oil percentage was recorded in the treatment with recommended dose of NPK and 50kg vermicompost, which was statistically at par with half of the recommended NPK and 17.5kg Neem cake and half of the recommended NPK and 87.50kg vermicompost. This might be due to higher contents of nitrogen, phosphorus, potash and cupper in the treatment with recommended dose of NPK and 50kg vermicompost, which might have triggered metabolic pathways synthesizing fats in the kernels (Randhawa, 2004).

CONCLUSIONS

Walnut is one of the important high value cash crops, and high mountains of Nepal and India are potential for its commercial production. According to this research, use of recommended dose of NPK (750g: 375g: 750g) with 50kg vermicompost increased the growth of walnut tree significantly. However, kernel yield and quality were improved by application of vermicompost in the walnut trees combined with three fourths of recommended dose of NPK. Moreover, use of the organic fertilizer in soil would reduce mining of soil tilth, maintain adequate level of plant nutrients in the soil pool and improve soil aeration, drainage and water-holding capacity in walnut orchard.

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Response of Eggplant as Rootstock for Tomato

Suraj Raj Poudel[1] and Wen-Shann Lee[2]

ABSTRACT

With the aim of determining whether grafting could improve the agronomic behavior of tomato, an open field experiment was carried out to determine growth, yield and fruit quality of tomato cv. 'ASVEG10' either non-grafted, self grafted or grafted onto two eggplant rootstocks cvs. 'EG203' and 'VFR Takii'. Vegetative growth tended to be depressed, the incidence of blossom end rot (BER) and soluble solid concentration (Brix) of fruits were increased by grafting on eggplant rootstocks. Total yield and average fruit weight were significantly influenced by eggplant rootstock, whereas no significant difference was observed on fruit number per plant. The increment in the total fruit yield of the non-grafted plant resulted into 14.23% and 12.62% more fruit weight per plant than the 'VFR Takii' and 'EG203', respectively. Both the fresh weight and dry weight of leaves, stems and fruits were significantly higher in non-grafted control. Reduction in fruit yield and /or fruit quality of tomato grafted on eggplant rootstock may have been due to differences in the requirements for assimilates and mineral nutrients between tomato and eggplant.

Key words: Blossom end rot, grafting; rootstock, yield

INTRODUCTION

Tomato (*Solanum Lycopersicum* L.*)* is a crop of high importance in many countries; according to FAOSTAT 125 million tons of tomatoes were produced in the world in 2005. China, the largest producer, accounted for about one-fourth of the global output, followed by United States and Turkey.

Viewing recent data concerning the Mediterranean area by Leonardi and Romano (2004), it was reported that Spain is the most important country for the spreading of vegetable grafting with mainly tomato and watermelon, with 40 and 52% of the total of 154 million plants in 2004, respectively. They also indicated that in Italy an increasing dissemination of the grafting technique increased the number of the vegetable grafted plants from 4 million in 1997 to 14 million in 2000.

Although in the beginning, tomato grafting was adopted to limit the effects of Fusarium wilt (Lee, 1994), the reasons for grafting have increased dramatically over the years. For example, grafts have been used to induce resistance against low (Bulder *et al.,* 1990) and high (Rivero *et al.,* 2003) temperatures; to enhance nutrient uptake (Ruiz *et al.,* 1997); to improve yield when plants are cultivated in infected soils (Bersi, 2002); to increase the synthesis of endogenous hormones (Proebsting *et al.,* 1992); to improve water use (Cohen and Naor, 2002); to increase flower and seed production (Lardizabal and Thompson, 1990); to enhance vegetable tolerance to drought, salinity and flooding (AVRDC, 2000; Estan *et al*., 2005). Moreover, many researchers reported that an interaction between rootstocks and scions exists resulting in high vigor of the root system and greater water and mineral uptake leading to increased yield and fruit enhancement (Lee, 1994; Oda, 1995; Bersi, 2002). On the contrary, Romano and Paratore (2001) stated that vegetable grafting does not improve the yield when the selection of the rootstock is not suitable, for example the self-grafted plant 'Rita x Rita' had a lower yield than the non-grafted plants. Also there

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are some contradictory results about the fruit quality traits and how grafting affects them. For example, Traka-Mavrona *et al*. (2000) reported that the solutes associated with fruit quality are translocated in the scion through the xylem, whereas Lee (1994) states that quality traits e.g. fruit shape, skin color, skin or rind smoothness, flesh texture and color, soluble solids concentration etc. are influenced by the rootstock. However, other researchers showed that grafting did not affect fruit quality (Romano and Paratore, 2001).

The aim of this study was to evaluate a popular Taiwanese commercial tomato ASVEG 10 self-grafted and grafted on two eggplant rootstocks (EG203 and VFR Takii) for yield and fruit quality attributes.

MATERIALS AND METHODS

Plant material

The commercial tomato (Solanum lycopersicum L.) hybrid cv. 'Taichung AVRDC No 10' (ASVEG 10) was used as self-grafted and non-grafted control, while two eggplants (Solanum Melongena L.) cvs. 'EG203' and 'VFR Takii' were used as rootstocks. To obtain equal stem diameters at grafting, seeds of eggplant were sown earlier than those of tomato. When the plants of eggplants and tomato had 3 to 4 unfolded true leaves, tomato scions were grafted onto tomato and eggplant rootstocks at first internode of the rootstock and scion by tube grafting (Oda, 1995). The later, an elastic tube was mounted on the slant cut end of the rootstock in the tube. The grafted plug seedlings were sprayed with water, placed in healing tunnel covered with a black polyethylene film to keep the relative humidity above 95% and create darkness inside the tunnel. After acclimatization, the grafted plug seedlings were kept under full sunlight in the greenhouse for 7 days and transplanted 14 days after the grafting to the open-field at the National Chung Hsing University on Nov. 8, 2008. Normal cultural practices were followed for irrigation, fertilizer and pesticide application. A randomized complete block design was adopted with 4 replications, each consisting of 12 plants, spaced at 0.5x1.0 m.

Growth of grafted plants and Stem thickening at scion bottom

Stem length (cm) from graft interface, number of leaves, circumference (mm) at the thickest part of the stem (G) at the graft union, 3cm above (S) and below the graft interface were measured on 12 grafted plants in each scion/rootstock combination at three different dates 26, 44 and 62 days after grafting. Index of stem thickening (IST) was calculated as follow: IST = G/S.

Fruit quality and yield

Fully-mature fruits were harvested on the same day and juice of sample fruits were used directly for the determination of total soluble solids (TSS) using refractometer (N-1, Atago Co. Ltd.,Tokyo) and expressed as Brix%. Six fruits (first fruit of first cluster) were harvested from each replication and were used for determination of Brix percent before that the same fruits were used to determine the fruit firmness using Sun Rheo meter Compact-100 (Scientific Co., LTD.) and expressed as (Kg/cm2).

For the determination of vitamin C the equipment RQflex Reflectometer was used. Fully-mature six fruits from each treatment from cluster 3 and 4 were randomly selected and sliced along the equator at 1cm thickness. Twenty-four fruits from each treatment were used for the measurement of pericarp thickness with the used of instrument digital vernier caliper.

Fruits were harvested at the mature stage starting from Feb. 10 to 23 March, 2009. Yield was measured from the 12 plants from each treatment. The harvested fruits were counted and weighted to determine number of fruit per plant and fruit weight up to 140 days after grafting. BER percentage was measured on the harvested fruits from the 12 plants from each treatment. The infected fruits were counted to determine the percent BER per plant.

Fresh weight and dry weight

The fresh weight was determined for plants that were harvested at graft union and separated into leaves, stem but in case of fruits immediately after harvest weight and took it to oven dry. Samples of 8 plants from each treatment were used for fresh and dry weight. For the dry-weight determination, the plant tissues were dried in a ventilated oven at 90oC for 48h.

Inorganic mineral nutrient concentrations

From the eight plants, three sample leaves (just below the pinched portion after fifth cluster) of each of the graft combinations were collected together with final harvest 140 days after grafting.

Total nitrogen content of plant samples was determined by Kjeldahl method (Bremner *et al*., 1965). Total phosphorus contents of plant samples were estimated by perchloric acid digestion assay method (Yamakawa, 1992). Total K, Ca, Mg, Fe, Mn, Zn & Cu contents of plant samples were determined by Atomic Absorption Spectrophotometer digestion assay.

Statistical analysis

All data were analyzed using Analysis of Variance (ANOVA) and a mean separation test was carried out by using procedure of statistic Analysis System (SAS; SAS Institute, Cary, NC USA; version 9.1) followed by least significant difference (LSD) test ($P < 0.05$).

RESULTS

Growth of grafted plants and stem thickening at scion bottom

Both the Plant height and number of leaves of non-grafted were significantly greater than the eggplant rootstocks at three different dates 26, 44 and 62 days after grafting (Table 1). The maximum plant height 117.81cm was gained by non-grafted plant and 'VFR Takii' gained lowest height 87.75cm at 62 days after grafting. Furthermore, the non-grafted plant always showed the highest value of plant height than all other grafted plants in all above three days. The highest number 13.37 of leaves per plant was noted in non-grafted which were statistically identical with self-grafted 13.18 and the lowest number of leaves 12 was found in 'VFR Takii' at 62 DAG. Both eggplant rootstocks showed the statistically identical leaf

Table 1: Leaf number and plant height of the tomato (cv. ASVEG10) plants

Treatments	Days After Grafting		
	26	44	62
Leaf number			
Non-graft	5.2	9.9	13.4
Self-graft	5.4	9.1	13.2
EG 203	5.0	8.2	12.1
VFR Takii	5.4	8.0	12.0
LSD0.05	0.4	0.7	0.7
Plant height (cm)			
Non-graft	28.0	69.5	117.8
Self-graft	27.6	68.3	112.9
EG 203	21.4	51.7	91.3
VFR Takii	20.3	49.6	87.7
LSD0.05	1.81	3.30	2.97

number at 44 and 62 DAG (Table 1). At the beginning, 26 DAG the leaves number of no-graft and self- grafted tomato plants were statistically identical to 'VFR Takii' but that was different with 'EG203'.

Table 2: Circumference of stems, scion/rootstock ratio and stem thickening index in the tomato (cv. ASVEG10) plants 26 and 80 days after grafting

Rootstock	Stem circumference (mm)			Ratio of scion and rootstock (S/R)	Index of stem thickness (G/S)
	Root (R)	thickest part (G)[a]	scion (S)		
26 days after grafting					
Non-grafted	8.3	9.2	9.0	1.09	1.02
self-grafted	7.0	9.3	7.8	1.10	1.21
EG203	5.1	7.6	5.9	1.17	1.31
VFR Takii	4.5	7.5	5.9	1.31	1.28
LSD	0.6	0.8	0.8	0.10	0.08
80 days after grafting					
Non-grafted	14.4	14.5	14.5	1.01	1.00
self-grafted	13.4	17.1	13.6	1.02	1.27
EG203	11.5	20.7	13.6	1.23	1.53
VFR Takii	11.1	20.1	14.4	1.26	1.40
LSD	1.1	1.6	1.3	0.09	0.09

[a] 3-cm above and below the graft interface.

Circumferences at the thickest part of the stem (G), at around graft interface, at 3cm above (S) and below (R) the grafts interface, 26 and 80 days after grafting onto eggplant rootstocks are shown in Table 2. At the beginning (26 DAG) circumference at G was smallest 7.51 mm in VFR Takii rootstock and largest 9.41 mm in tomato rootstock. As increasing the days the circumference at G was increasing on the two eggplant rootstocks. At 80 DAG circumference at G was significantly smallest 17.26 mm in self-grafted plants. Likewise those at S and R were also significantly different between tomato and two eggplant rootstocks in all cases. The ratio of S/R was almost one in self-grafted plant at 80 DAG onwards. But the ratio of S/R in eggplant rootstocks remains higher than selfgraft. The index of stem thickening (G/S) was smaller in tomato graft on tomato rootstock than both eggplant rootstocks. In comparison to eggplant rootstocks 'EG203' rootstocks showed the higher G/S value in all consecutive days. These results show that stem thickening at the graft union differs, depending on rootstocks used. In plants grafted on eggplant rootstocks, stem diameter of the rootstocks was smaller than that of tomato scion.

Fruit yield

The number of fruits harvested per cluster was statistically not significant among the rootstocks. Maximum fruit numbers of 31.56 were harvested from non-grafted (Table 3). Present study showed that the number of fruits per plant was not significantly difference among the rootstocks as shown in Table 3. The highest number of fruit of 31.56 was recorded in non-grafted and the lowest number of fruit of 28.9 was recorded in self-grafted. There were significant differences between the tomato and eggplant rootstocks in respect of average fruit weight. Maximum fruit weight of 137.42 g was found in non-grafted tomato which was statistically identical to self-grafted of 135.9 g however, the tomato grafted on eggplant rootstock showed almost same weight of 128.2 g that was significantly difference with that non-graft and self-graft (Table 3).

Fruit yield records of tomato plants grafted on eggplant rootstocks revealed that yield on eggplant rootstocks was significantly lower than that on tomato rootstocks (Table 3). The highest yield of 4336 g/plant was recorded in non-grafted which is significantly higher than from two eggplant rootstocks. Interestingly, the lowest yield of 3719 g/plant was

recorded in 'VFR Takii' and was statistically identical to self-grafted and 'EG203'. Rootstock did not significantly impact fruit per cluster and number of fruit harvested (Table 3). Yield differences were just because of small size fruit.

A negative effect of grafting was shown when eggplants were used as rootstock. The total fruit yield of non-grafted plants was significantly higher in comparison with that of the plants grafted onto both rootstock cultivars. Finally, these increases in the total fruit yield of the non-grafted plant resulted into 14.23% and 12.62% more fruit weight per plant than the 'VFR Takii' and 'EG203', respectively, whereas self-grafted plants show not significantly different production to both eggplant rootstocks (Table 3).

Table 3: Fruit number, weight and yield from the tomato plants (cv. ASVEG10)

Rootstock	Total yield (g/plant)	Fruit no /plant	Fruit /cluster	Average fruit weight(g)
Non-grafted	4336	31.6	6.18	137.4
Self-grafted	3925	28.9	5.98	135.9
EG203	3789	29.6	5.91	128.2
VFR Takii	3719	29.0	6.00	128.2
$LSD_{0.05}$	385	3.1	0.62	8.6

Fruit quality

The fruit size (horizontal and vertical diameter) of tomato grafted on eggplant rootstock was significantly smaller in eggplant rootstocks than non-grafted and self-grafted. Both horizontal and vertical diameter of the fruits of nongrafted and selfgrafted possesses significantly higher vale than tomato grafted on eggplant rootstock. The highest value of horizontal diameter was found in nongrafted of 6.33cm and vertical diameter was found on selfgrafted of 5.48 (Table 4).

Table 4: Fruit diameters (cm) and blossom end rot of tomato (cv. ASVEG10) non-grafted, self-grafted and grafted onto 2 eggplant rootstocks

Rootstock	[y]Horizontal diameter(a)	Vertical diameter(b)	Diameter index(b/a)	BER[z] %
Non grafted	6.33	5.46	0.87	8.52
Self grafted	6.24	5.48	0.88	12.83
EG203	6.04	5.17	0.86	17.29
VFR Takii	6.05	5.15	0.86	22.03
$LSD_{0.05}$	0.18	0.16	0.03	6.18

[y] 48 fruits per treatment randomly selected from 3 and 4 cluster
[z]Blossom end rot, average from 12 plants/ treatment

The incidence of BER was increased significantly on eggplant rootstocks. With in eggplant rootstocks 'VFR Takii' showed the higher percent 22.03% BER than the rootstock 'EG203' which was recorded 17.29% BER. However, the incidence of BER was lowest 8.52% in non-grafted (Table 4). The incidences of BER on the fruit of tomato were quite different according to the harvesting season. At the early stage of the season (Feb 10 to 24) the incidence was quite lower than the BER incidence observed at the end of the season 29th March.

Analyses of fruits from tomato and eggplant rootstocks showed that soluble solid (0Brix) level was increased significantly on eggplant rootstocks (Table 5). The highest value of Brix was recorded on 'EG 203' of 6.04 which was identical to 'VFR Takii' of 5.90. Similarly, the lower value of brix was seen on nongrafted and selfgrafted which were 5.20% and 5.50 % respectively (Table 5). Vitamin C was increased significantly in 'VFR Takii' rootstock of 25.75 mg/100 g fresh weight but in the case of 'EG203' (21.70 %) was not significantly different to both non-grafted and self-grafted plants of 22.00 and 23.14 %

respectively. Fruit firmness and Pericarp thickness, both values were lowest tomato fruit grafted on eggplant rootstocks (Table 5).

Table 5: Soluble solid (Brix), vitamin C, and fruit firmness of tomato (cv.ASVEG10) non-grafted, self-grafted and grafted on 2 eggplant

Rootstock	Soluble solids (Brix %)	Vit. C (mg/100g FW)	Firmness (Kg/cm2)	Pericarp thickness (mm)
Non grafted	5.26	22.00	2.45	6.88
Self grafted	5.50	23.14	2.42	6.95
EG203	6.04	21.70	1.81	6.11
VFR Takii	5.90	25.75	2.13	6.10
LSD0.05	0.28	2.41	0.18	0.30

Dry and Fresh weight

From the data presented in Table 6, it is seen that there were significant differences between the fresh and dry weights of leaves, stems and fruits 140 DAG. The non-grafted plants, which bear a significantly higher fresh and dry weight of all plant parts (leaves, stem and fruits) than other three treatments. This might be due to the depressed growth of grafted plants specially in tomato grafted on to eggplant rootstock.

Table 6: Plant weight of the tomato (cv.ASVEG10) after 140 days of grafting

Treatments	Leaves		Stem		Fruits		Total		
	FW(g)	DW(g)	FW(g)	DW(g)	FW(g)	DW(g)	FW(g)	DW(g)	DW/FW%
Nongrafted	933	131	630	86	4574	377	6137	594	9.70
Selfgrafted	855	119	572	77	3578	326	5005	523	10.46
EG203	569	82	414	65	3044	273	4027	421	10.53
VFR Takii	590	83	474	70	3055	240	4120	393	9.55
$LSD_{0.05}$	142	25	86	15	758	63	852	77	0.62

Inorganic mineral nutrient concentrations

Major and trace elements concentration in grafted tomato plants at final harvest are presented in Table 7. Calcium (Ca) content varied from 2.11 % to 2.60 % and the highest concentration was found in non-grafted where as lowest was in eggplant rootstock cv. 'VFR Takii'. Self-grafted plant showed the moderate concentration of Ca and was not significantly different than others 3 rootstocks. The highest Phosphorus (P) concentration was found in 'VFR Takii', which was statistically different from self-grafted and non-grafted. Potassium (K) contents of the grafted tomato plant varied from 4.57 % in 'VFR Takii' to 4.07 % in 'EG203'. Manganese (Mn) concentrations were significantly lower in 'EG203' rootstock and the highest concentration was seen on self-grafted. The concentration of Zinc (Zn) and Cupper (Cu) were significantly higher in both eggplant rootstocks than non-grafted and self-grafted.

Table 7: Nutrients content in the tomato (cv. ASVEG10) leaves after 140 days of grafting

Rootstock	Major elements (%)					Trace elements (PPM)			
	Ca	N	P	K	Mg	Fe	Mn	Zn	Cu
Non-grafted	2.60	2.17	0.28	4.08	0.65	165.11	101.08	16.59	7.00
Self-graft	2.29	2.24	0.28	4.36	0.62	184.55	110.26	18.91	6.55
EG203	2.16	2.41	0.31	4.07	0.59	149.44	70.18	29.61	21.10
VFR Takii	2.11	2.46	0.37	4.57	0.68	164.33	101.85	33.13	18.76
LSD0.05	0.33	0.36	0.07	0.37	0.14	33.29	33.61	6.17	3.22

DISCUSSION

Plant heights leaf number and maximum leaf length all were significantly smaller in eggplant root stocks. These results indicate that grafting tomato plants on eggplant rootstock depresses the growth of the plants. Tomato stem swelled immediately above the union. This overgrowth is a characteristic of graft incompatibility which is associated with poor connection of vascular bundles between the scion and rootstock (Hartmann and Kester, 1975). The small stem diameter of rootstocks may have resulted in poor development of the root system. Therefore, that water deficiency in plants on eggplant rootstocks was caused by poor connection of vascular bundles and/or a small root system. The growth of scions was depressed and that stems at the graft union thickened markedly 18 weeks after heterografting (Oda *et al*., 2000).

Numbers of fruit per plant in the tomato/eggplant grafts were as high as those of the tomato/tomato grafts; however, reduced fruit yields, smaller fruit, higher percentages of BER, and increased SSC values were observed in tomato fruit in the tomato/eggplant grafts, compared with the tomato/tomato grafts (Kawaguchi *et al*., 2008). Previous research conducted by Cheng and Chua (1976) also revealed reduced yields and smaller fruit sizes in tomato/eggplant grafts.

Soil conditions such as low moisture content (Mitchell *et al*., 1991b), salinity (Mizrahi and Pasternak, 1985;) and low osmopotentials (Ohta *et al*., 1991) generally increase soluble solids or sugar content of tomato fruits but retard vegetative growth of plant and thus fruit production. Water deficiency, salinity and water stress in plant did not reduce solute accumulation but impaired net water import into tomato fruit (Mitchell *et al*., 1991a). These findings indicate that water stress to plants generally increases soluble solids and sugar content of fruits but depresses growth and fruit yield.

Low Ca concentrations in tomato/eggplant scions might result in an increased incidence of BER in this graft combination, as BER is generally thought to be caused by Ca deficiency (Pilbeam and Morley, 2007). Deficiency (Otsuka, 1960b) and increasing concentration (Yamazaki *et al*., 2000) of Ca appeared in tomato scion depending on rootstock species. Increased concentrations of P (Otsuka, 1968) were also observed in heterograft combinations. In melon plants grafted on Cucurbita spp., low nitrate concentration with high nitrate reductase activity, low free amino acid and soluble proteins and high organic N were detected in their leaves (Ruiz and Romero, 1999).

The yield advantage of grafted plants has been shown to be clear when they are grown on infested soil (Poffley, 2003; Besri, 2002). In this experiment, there was no obvious advantage of grafted plants, because the plants were grown in pathogen-free soil. Thus, grafting with resistant rootstocks is recommended only when the risk of the disease is high, because the yield increase might not be significant when disease pressure is low, as we observed in this study. During the field experiments, slower vegetative growth and changes of fruit quality, including smaller size, more blossom end rot, and higher soluble solids were observed when eggplant rootstock was used compared with tomato. When using scarlet eggplant (*Solanum integrifolium* Poir.) as rootstock for tomato, similar results were observed and attributed to poor connection of vascular bundles at the graft union or a poor root system making the plant water deficient (Oda *et al*., 1996). These results highlight the need for screening to identify the scion and rootstock combination with the least detrimental effect on fruit quality as well as the need to develop proper management practices for grafted tomato plants using eggplant rootstocks, such as maintaining higher soil moisture.

The fact that the grafted plants produce better results than non-grafted ones when grown on infested soils indicates the potential economic value for a grower of growing grafted plants (Bletsos, 2003). Since grafting gives increased disease tolerance (Besri, 2002, Poffley, 2003), it should be useful for low-input sustainable horticulture of the future.

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Critical Stage of Boron Application for Reproductive Growth and Seed Quality of Bush Snap Bean (*Phaseolus Vulgaris* L.)

Ram Lal Shrestha[1] and Renato C. Mabesa PhD[22]

ABSTRACT

The experiment were conducted to determine the critical stage of boron(B) application on the seed development and quality of bush snap bean (Phaseolus vulgaris L) grown in the nutrient solution (hydroponic). Boron was applied @ 0.05g/l (50ppm) of water at weekly intervals according to treatments up to the seed physiological maturity stage. The number of flowers and pod set were increased at 0 days and 21 days after sowing (DAS) treatment and decreased continuously as time of B application was delayed. Boron was effective to increase the seed weight 18.8% greater at full B treatment as compared to 0-boron (-B). The quality of seed was greatly reduced in –B solution due to lack of B. Seed germination was 1.24 times greater in laboratory condition and 1.47 times greater under field condition at 0 day treatment than –B treatment. The normal seedling percent was 8.1 times greater in 0 day (8 time applied) treatment than –B under field condition. The seedling dry weight was higher (3.70g) at 21 DAS B applied seed as compared to control (1.73g). Seeds harvested from earlier B applied treatments were higher in quality and produced strong seedlings as compared to -B. The critical stage of B requirements to the Contender bean for reproductive growth and seed quality improvement was identified at 28 DAS. The quality of seed was decreased if B is applied later from 28 DAS. It can be concluded that earlier stage (Vegetative growth) of B application give better yield and quality of seed.

Key words: Boron, physiological maturity, vigor, tissue, germination, emergence, contender, bush-snap bean

INTRODUCTION

The production and quality of snap bean (*Phaseolus vulgaris* L) depends on the quality of seed. Seed quality embraces all physiological, biological, morphological and genetical attributes, which contribute to increase in the final yield of the crop (Basra, 1995). In general, poor quality seed have poor germination and production of abnormal seedlings (Powell *et al*., 1984) results decreased yield. One of the causes of low quality seeds is absent of B in the soil and seeds. Boron plays an important role in the vegetative and reproductive growth in the plant especially in the flowering, pollination, fertilization and seed formation stages. During flowering, low B reduces male fertility primarily by impairing micro-sporogenesis and pollen tube growth (Dell *et al*., 1997). Dear and Lipsett (1987) reported that, soil application of B increased the biomass and seed quality of legumes (clover). The significant effect of B was observed in seed yield of legume crops i.e. in soybean 50%, peanut 45% and black gram 93% (Rerksem *et al*., 1997). In peanut application of 300g boric acid /ha at vegetative growth stage that increased fresh pod yield by 31.7% (Ayo *et al*., 1998).

Sillanappa (1982) reported that B deficiency occurs in almost every country but deficiency was greater in several Asian countries like India, Korea, Nepal, Philippines and Thailand and also in Africa particularly Malawi, Nigeria, Sierra Leone and Zambia. In Nepal most

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legume crops are affected by B deficiency symptoms in vegetative growth stage (reduced apical growth) and reproductive stage (failure of fertilization and seed setting).

Bush snap bean is a short duration crop and can be grown four seasons in a year (winter, spring, summer and autumn) in Nepal. Its cultivation range is wide from Terai (100m) to Higher Hills (1600m). Most of the soils in this range are sandy and calcareous which are lacks of B. Seeds produced from these soils have poor in quality. There is serious problem of seed germination and abnormal seedling under field condition. Higher rate of seed germination is required to maintained optimal plant population. Therefore, there is high demand of bean seed in all of the seasons in Nepal. Most of the seeds are imported and millions of dollars are drained out every year. Imported seeds are more expensive and not always of higher quality. Application of B at the critical stage is more effective to improve the quality of seed and maximize the yield.

Bush snap bean yield is prolific when grown under hydroponics. There was difficulty in getting soil without B to study the effect of B in bush snap bean. So that hydroponics techniques is one of the best methods to study the effect of micronutrient for this crop.

The general objective of the study was to determine the effect of boron application in reproductive growth of bush snap bean. Specifically, the study aimed to determine the critical stage of boron application that improved the seed yield and quality of bush snap bean.

MATERIALS AND METHODS

The commercial variety of bush bean Contender was used in this experiment. The experiment was conducted in the screen house of the Vegetable Crop Division, University of the Philippines, Los Baños, Laguna from June to September 2002 with five treatments in four replications. Analysis of boron in the leaf and seed tissue was done in the chemistry laboratory of Institute of Plant Breeding (IPB). Three-hundred milligram of leaf sample ashed at 550^0C temperature overnight was dissolved in 5ml 0.10 N HCl, filtered and washed with 20ml distilled water in volumetric flask. One milliliter of the aliquot placed in evaporating dish with 4ml cur cumin-oxalic acid solution was evaporated to complete dryness in hot water bath at 55^0C, and was baked for 15 minutes. Then 25ml ethanol (95%) was added and absorbance readings were taken using automatic absorption Spectrophotometer (Model GBC-908). The amount of boron (B) concentration in the seed tissue was determined 14mg kg^{-1} of dry weight before seed sowing.

Plants were grown in the nutrient solution in Styrofoam box (50cm length x 40cm width x 17cm height). All the nutrient solutions were prepared without boron except T_1. Boron at the rate of 0.05g boric acid /l (50ppm) was added in the nutrient solution boxes at weekly intervals up to the seed physiological maturity stage. The treatments were: T_1=start B application from 0 day, T_2=start B application from 21 DAS or 5 times, T_3=start B application from 28 DAS (4 times), T_4=start B application from 35 DAS (3 times), T_5=start B application 42 DAS (2 times) and control without B (-B) in the nutrient solution i.e. included only for comparison.

Preparation of the Solution

The nutrient solution developed by John Mason (1990) for bush bean was used in this experiment. The required amount of reagents was calculated for 400*l* of solutions at initial stage. The required amount of reagents are; monoamonium phosphate 59.2g, potassium nitrate 386.2g, calcium nitrate 400.0g, ammonium sulfate 169.7g, magnesium sulfate

140.0g, iron sulfate 6.0g, copper sulfate 0.077g, zinc sulfate 0.087g, ammonium molybdate 0.037g and manganese sulfate 0.080g. All the chemicals were weighed individually and the required amount of chemicals were mixed in double distilled water in a plastic container and stirred thoroughly until fully dissolved. Micronutrients were added after the major chemicals are fully dissolved and pH was adjusted to 5.5 to 6. Nutrient solutions were placed in the Styrofoam boxes at the rate of 12*l* per box and boric acid 0.60g was added per box according to the treatment wise.

Two seeds were sown in the Styrofoam cup (6.5cm diameter x 9cm height) with coconut coir dust as the medium. The cups were placed in the nutrient solution box with only the base of the cups touching in solution. One healthy plant was maintained per cup and maintained four healthy plants per box or twenty plants per replication. The parameters taken for analysis were; days to 50% flowering, number of flower, pod, pod set efficiency, pod size, number of seed, 100 seed weight, seed B, normal seedling, seedling growth rate, and seed germination. Germination test was done in the laboratory condition and field (soil) condition. Seedling vigor was determined by accelerated ageing test (42^0C temperature, 100% RH for 72 hour) and seeds were subjected to germination in laboratory and field. Seed vigor was evaluated by rating of seedling growth in 3rd and 5th days after sowing in both lab and field condition. Seedlings were categorized in normal (strong >0.5g) medium (0.25-.05g) and abnormal (weak <0.25g) on the basis of weight and development of plumule and primary root. Vigor percent were evaluated from normal seedling under both conditions. Dry weight was taken by placing the seedling (with root) in electric oven at 85^0C temperatures for 24 hour.

The experiment was conducted in Complete Randomized Design (CRD) with four replications and five treatments. Data gathered on all the parameters were analyzed using Analysis of Variance (ANOVA) in the Statistical Analysis System (SAS) Software Package Program (6.12). Treatment means were compared with LSD (least significant different) values at 5 percent level of significance

RESULTS AND DISCUSSIONS

Reproductive Growth Stage

Flowering days and number of flowers

Effect of B on 50% flowering was significant between the 0 DAS and -B treatments. No significant effect of B was observed between the 28 DAS, 35 DAS and -B treatment (Table 1). However the results show that earlier application of B resulted in earlier flower opening of bush snap bean.

The effect of B on number of flowers was varies between the treatments. The number of flowers was two times greater at 0 day (19 plant^{-1}) than at 42 DAS treatment (9 plant^{-1}) and 3.1 times greater in 0 day treatment as compared to -B. Decreasing flower number was observed as times of B application decreased. The results shows that increase the time of B application that increased number of flowers. Singh *et al*. (1984) reported that, in leguminous crops 52-76% of flowers are drops, caused by B deficiency.

Number of pods and pod setting

The number of pod decreased as the time of B application was decreased. There was no effect of B on the number of pods between the 0, 21 and 28 DAS treatments but significant effects was observed during 35 and 42 DAS treatments (Table 1). Higher number of pod sets was observed at 0 days B application (8 plant^{-1}) and lowest number of pod sets (4

plant^{-1}) at 42 DAS treatments. Pod formation was 8 times greater in 0 day treatment as compared to -B treatment. Therefore, B application is more effective when applied during the vegetative stage rather than at the reproductive stage for higher pod setting. Zhang *et al.* (1994) reported that requirement of B is higher for the reproductive part (flower, anther and pistil) development than leaves and shoots.

Non significant effect of B was observed in the percent of pod setting on all treatments but higher percentage of pod sets as compared to –B treatment. It was not affected by the stage of the plant when B application was started. According with Gardener *et al*. (1985) failure of pod set in the plants would be due to flower abscission i.e. lack of pollination, lack of fertilization and abruption of flower.

Pod size and number of seeds

The effect of B on pod length was not significant between 0, 21 and 35 DAS treatment but significant with -B treatments (Table 1). The higher pod length (14.5cm) was observed in 0 day B treatment and lowest pod length (12.8cm) was observed at 28, 42 DAS and the control. In general there was no effect of B in pod size (length and width) at different days of application.

Effect of B on the number of seeds was significant in 0, 21 and 35, 42 DAS but not in -B treatments (Table 1). The number of seeds was 2.5 times greater at 0 day treatment as compared with -B. This result shows that application of B at earlier stage is more effective for number of pods and seed setting in bush snap beans.

Seed weight and boron concentration in seed tissue

The effect of B was not significant in seed weight between the 0 and 21 DAS treatments (Table 1). Highest seed weight (66.5g) was observed at 0 day and decreased 4.3% at 28 DAS, 5.2% at 35 DAS and 17% at 42 DAS and 19% at –B as compared with 0 day B treatment. Thus increase the times of B application that increases the seed weight of bush bean. An earlier application of B was effective to increase seed weight, which indicates that the seeds would be better in quality. Schoon and Voyest , (1990) also reported that B increased the seed weight of legume crops under applied through the leaves during flowering time. Most of the legumes produced abnormal seeds in B deficient condition.

Table 1: Reproductive growth of bush snap bean (*Contender) with* B applications

Growth parameters	Treatments (DAS)[1]						LSD (<0.05)
	0 (8)	21 (5)	28 (4)	35 (3)	42 (2)	Control (-B)	
Number of flowers plant $^{-1}$	19	15	15	10	9	6	2.8
Days to 50% flowering	28	29	30	30	31	30	1.8
Number of pods plant^{-1}	8	6	6	4	4	1	2.2
Percent of pod set	42.1	40.0	40.0	40.0	41.4	16.6	NS
Pod length (cm)	14.5	13.8	12.8	13.4	12.8	12.8	1.3
Pod width (cm)	1.2	1.2	1.2	1.2	1.2	1.1	NS
Number of seeds pod^{-1}	5	5	4	3	3	2	1.1
100 seed weight (g) [2]	66.5	65.3	63.6	63.1	55.2	54	2.8
Seed boron concentration (mg kg^{-1} dry weight)	6.4	4.3	4.2	4.1	3.4	0.3	0.2

[1]Numbers in parentheses refers to the number of B application, [2] Measured at 14% seed moisture level

Keerti-Lasikorn *et al*. (1991) reported that increases in pod and seed size of legume crop were depends on the xylem delivery of B. Those seeds that can acquire sufficient B can accumulate sufficient amount of assimilates and have bigger size, which is correlated with

seedling growth. An increase in the seed size resulted to an increase in germination and seedling vigor.

Concentration of seed boron was higher at 0 day of application as compared to the other treatments (Table 1). The amount of seed B decreased when the times of B application decreased. B was more effective to increase the amount of seed B when it was applied from 0 day. A small amount of B was observed in the seed tissue (0.3mg kg^{-1} dry weight) in –B treatment. That could have the results of existing seed (14mg B kg^{-1} dry weight) before sowing. Therefore, the plant does not show the deficiency symptoms of B in vegetative stage, but there is greatly affect in the reproductive growth i.e. reduced in flower, pod, seed, seed weight and seed B, due to the in sufficient amount of B in the nutrient solution.

Seed quality

Boron deficiency affects mainly the cotyledons of legume seed. However, in severe cases, it affects the plumule growth. After harvest, the quality of seeds was evaluated by accelerated aging test (AAT) and subjected the seeds for germination test and seedling growth under laboratory and field (soil) conditions.

Seed germination

Signs of seed germination (radical opening) were observed under laboratory condition at two days after sowing in 0 day and 21 DAS treatment. The higher percentage of seed germination (99.25%) was observed at 0 day and lowest percentage of germination (95.75%) was observed at 42 DAS (Table 2). There was no effect of B between the 0 day and 21 DAS treatments but significant difference was observed with 35 and 42 DAS treatments. The percentage of seed germination was reduced at the times of B application decreased. Higher concentration of B inside the seed would be high vigour and result in higher percentage germination.

Higher percentage of seed germination (98.25%) at 0 day and 21 DAS treatment and lowest at 42 DAS (68.5%) treatments were observed under field condition (Table 2). Germination % of harvested seeds was 1.2 times greater under laboratory condition and 1.4 times greater under field condition in 0 day treatment as compare –B. Under laboratory condition low vigour seeds were germinated well but under field condition low vigour seed could not germinated well. The critical stage of B application for germination and seedling emergence (visible of cotyledon leaf on the soil surface) was observed at 28 DAS.

Normal seedling

Percentage of normal seedlings was higher at 0 day treatment seed (81%) as compared to the 42 DAS treated seed (15.2%) under field condition (Table 2). There was no effect of B between 0 and 21 DAS treatment in terms of normal seedling growth. Variation of normal seedling was observed 10.5% at 28 DAS, 33.3% at 35 DAS and 65.8% at 42 DAS treatment as compared with 0 day. Normal seedling was 8 times greater under laboratory condition and 6.4 times greater under field condition in 0 day treatment compare with -B. It means decrease seedling vigor if B applied delay. The seedling vigour under laboratory condition was highest at 0 day treatment (91.5%) and lowest in 42 DAS treatment (56.75%) i.e. 37% greater strength of seedling in 0 days B treated seed as compared to 42 DAS.

Seedling vigor under laboratory condition was higher than field condition. Good quality seeds had higher emergence and produced strong seedlings under field condition. Bell *et*

al. (1989) reported that B deficient seed shows normal in size but are weak physiologically. In this study earlier application of B was more effective to improve the seed quality.

Seedling growth

The growth of seedling was evaluated 8 days after seed sowing. Compared with 0 day application, shoot length of normal seedling were decreased 32% in 42 DAS (Table 2). The difference in shoot length was 2.3cm at 35 DAS and 4.5cm at 42 DAS as compared to 0-day treatment. Root length was not significantly different between 0 day and 21 DAS B treated seeds. The variation of root length was 2.5cm, 3.5cm and 6.0cm at 28, 35 and 42 DAS treatment respectively, as compared with 0-day treatment. The differences were 3 times greater at 0-day B treatment as compared to 42 DAS. As time of B application was decreased there was a corresponding decrease in root length.

The total dry matter of the seedlings was not significant between the 0 day treatment and 21 DAS treatment. The differences of seedling dry weight were 0.45g at 28 DAS, 0.87g at 35 DAS and 1.35g at 42 DAS. Compared with 0-day there was an increase in seedling dry weight at later application of B. It means seedling dry matter increased with earlier B application in the nutrient solution. Seedlings dry weight also 2.17 times greater in 0-day B treatment compare with -B. These results indicated that seed B is essential for seedling growth and development.

Vigorous seeds could result to better seedling growth and higher dry weight under field conditions. Vigorous seeds may store sufficient food materials and supply for seedling growth after germination. In this experiment earlier B applied seed was found more vigorous and have better seedling growth. Therefore application of B is essential to improve the seed quality and vigorous seedling production of bush snap bean if B is lacking in the soil.

Table 2: After harvest seed quality and seedling growth of bush snap bean (*Contender*)

Seed vigor parameters		Treatments (DAS) [1]						
		0 (8)	21 (5)	28 (4)	35 (3)	42 (2)	Control	LSD (<0.05)
Germination (%)[2]	- Field (soil) condition	98.2	98.2	84.7	77.5	68.5	66.6	2.8
	- Laboratory condition	99.2	99.0	97.2	95.7	95.7	80.0	1.9
Normal seedling %	- Laboratory condition	91.5	90.2	78.0	70.7	56.7	14.2	4.2
	- Soil (field) condition	81.0	80.2	70.5	44.7	15.2	10.0	3.7
Seedling growth rate[3]	- Shoot length (cm)	14.0	13.7	12.0	11.7	9.5	11.3	2.8
	- Root length (cm)	18.2	17.7	15.7	14.7	12.2	9.5	2.2
	- Dry weight (g plant^{-1})	3.7	3.7	3.2	2.8	2.3	1.7	0.3

[1]Number in parentheses refers to the number of B application, [2]Total No. of seed germinated/ Total No. of seed placed x 100, [3] eight days after sowing under field condition.

CONCLUSIONS AND SUGGESTIONS

Based on the above results, positive effect B on reproductive growth and seed quality improvement was observed. The quality and quantity of pod and seed could improve by the application of B at critical stage. Seed quality was poorer when the B application was later. Without B, reproductive growth is inhibited and seed quality also reduced drastically. The critical stage of B requirement for reproductive growth and seed quality improvement was observed to be at 28 DAS. If B not applied at 28 DAS the quality of seed decreased rapidly. This study proved that B is essential for seed development and application of B in earlier growth stage is more effective.

Findings of this study would be highly applicable to commercial growers to increase the yield and seed enterpriser to improve the seed quality and yield. It would also guide to scientists for further research. Research on the appropriate rates of B application for bush snap bean is still needed. In field grown plants, foliar application of B at different stages of application can also be tried.

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Obituary

Nepal Horticulture Society expresses deep sorrow upon irreplaceable loss of horticulturist,

Mr. Krishna Prasad Adhikari

due to his untimely demise on Poush 25, 2067.

May the departed soul rest in heaven with eternal peace and the Almighty God help his family to bear the loss

Mr. Adhikari, borne in Falgun 10, 2013 in Chhoprak VDC - 7 of Gorkha district, entered civil service (agriculture) as horticulturist in 2039. Having completed graduate (IAAS, Rampur) and post-graduate (Benguet State University, Philippines) studies respectively in 2036 and 2052, Late Mr. Adhikari served Nepal Government for 27years in different capacities. He retired in 2066 working as Senior Agriculture Development Officer. Following his retirement from the government, he had been working in CEAPRED.

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