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Nepal Horticulture Society
उच्च मूल्य कृषि वस्तु विकास आयोजना (HVAP)

आयोजनाको परिचय
उच्च मूल्य कृषि वस्तु विकास आयोजना कृषि विकासका लागि अन्तरराष्ट्रिय कोष (IFAD) को ऋण तथा अनुदान सहयोगमा कृषि विकास मन्त्रालयाद्वारा कार्यान्वयन गरिएको छ। वर्ष (२०६३/६४ तथा २०७३/७४) आयोजना हो। आयोजनाका कार्यान्वयन सान्निध्यात्मक विकास नियोजन (एस.एन.भी.) र नेपाल उद्योग वाणिज्य महासंघ अन्तर्गतको कृषि उद्यम केन्द्र रहेका छ। यस आयोजनाले आयोजनाको कार्यक्षेत्र मध्य पश्चिममार्गल विकास क्षेत्रको तीनवटा सडक खंडहर (छिलु-जाजाङकोट, सुखेंद्र-बेलेख र सुखेंद्र-बुल्ला) आसापासका जिल्लाहरू सुखेंद्र, बेलेख, जाजाङकोट, सन्नप, कालिकोट, बुल्ला, र अझुमग गारी जम्मा ५ जिल्लालाई कार्यक्रम कार्यान्वयन गर्दै आइएको छ।

आयोजनाको उद्देश्य
ग्रामीण क्षेत्रका गारी जनताको विशेष गरी महिलालाई तथा सिमात्विनृत समुदायलाई उच्च मूल्य कृषि वस्तु र गैह काप वन पैदावार र वा भोजन सदृश् वस्‌तुलको मूल्य बढ्दैल र वजामा पहुँच खरेदी उच्च आयामको तथा रोजगारिको अवसर बढाउको लागि वजामा मार्ग र अवसर अनुसार नैनौ कृषि व्यवसायीकरण सम्मोहनको माध्यममा आयोजनाको प्रति वर्ष ३०,००० रु. आयामकरण गर्दै।

आयोजनाका संभागहरू (Components)
१. समूहको मूल्य श्रुश्कला विकास (Inclusive Value Chain Development)
२. सेवा विकास र सेवाहरूको प्रशिक्षण तथा सेवा विकास (Service Market Strengthening)
३. आयोजना व्यवस्थापन (Project Management)

आयोजनाको मुख्य-मूल्य अर्घ्यक (Expected outcomes)
० आयोजना क्षेत्रको स्थानीय समुदायको उच्च मूल्य कृषि वस्तु, खालकटै वन पैदावार र जोडिङ्गलाई नैनौ कृषि व्यवस्थापन आशामार्गको समाधान र सहयोगमा सुधारिएको छ।
० गार्थिएको एवं सिमात्विनृत उपायकारिको वजामा पहुँच र सहभागितामा वृद्धि हुनेछ (५०,००० कृषि परिवार)
० ग्रामीण क्षेत्रका गारी साना उत्पादकहरूको आफ्रिका उत्पादकहरूको परिवर्तन र मूल्यमा वृद्धि हुन गई लाम आइएको हुनेछ (प्रति परिवार वार्षिक रु. ३०,००० तथा आयामकरण गर्दै)

२. स्थानीय संयोजन र समुदायको क्षमताको विकास भएको हुनेछ (१० जिल्लाले उद्योग वाणिज्य संघ, १०० उत्पादन/मूल्य श्रुश्कला समूह, १० स्थानीय गैहजाङ्करको संघ, १०० व्यापारी) गर्दै।

लगायतीला क्षेत्रहरू
आयोजनाले सातवटा वाटिकातहुँदै कृषि व्यवसायीकरणका लागि कृषि कृषि समूह/सहकारिको, व्यापारीको, उद्योगीको, सेवाप्रदायक तथा सम्बन्धात्मक व्यवसायिक समितिहरूलाई निम्न क्षेत्रहरूमा सह-लागायतीलाई गरेको ।

० उत्पादन तथा उत्पादकता वृद्धि कार्यः ।
० साना संचालित विक्रमबाहुः (सहकारिको तथा समुदाय स्तरको)
० संकलन केन्द्र, भण्डारण सुचिको, कृषि वजामा पूर्वाधारहरू (सडक निर्माण वाहेक)
० व्यावसायके, मूल्यमार्गीकरण नामक सहयोगी सामग्री, उपकरण तथा पूर्वाधारहरू
० उत्पादन तथा उत्पादकता कार्यः (सहयोगी समावेश सहयोगी सहयोगी तथा प्रशिक्षण)
० गुणस्तर तथा प्रीडिगरिक प्रमाणधारा एवं कृषि वस्तु व्यवसाय विभागको सम्बन्धी कार्यहरू
० मूल्य श्रुश्कलालाई सम्वदना सेवा प्रदायकहरूको क्षमता अभिभूति ।
० सेवा वजामा संयोजन कार्यः (विभागितक, व्यवसाय व्यवस्थापन आदि)
० मूल्य श्रुश्कलाका क्षेत्रहरूमा विकासको संकेत कार्यहरू (प्रति भण्डारण, वजामा संचालन आदि)

सम्पर्कको लागि: उच्च मूल्य कृषि वस्तु विकास आयोजना (HVAP), आयोजना व्यवस्थापन कार्यालय (PMU), सीमान्त्रनगर, सुखेंद्र। फोन नम्बर: ०८३-५२००३८ / ०८४५२०, ०८३-५५५२०३, ०८३-५५५२००।
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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 programme,
- 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

Nepal Horticulture Society (NHS) is a professional organization that ties up all horticulturists working in Government Sectors, Research Institutions, Universities, I/NGOs, and Private Sectors. From the very beginning of its establishment in 1990, the society has been regularly publishing Nepalese Horticulture Journals, Workshop Proceedings, Members Directory, Brochures, Experience sharing and technical books. I am grateful to present this Nepalese Horticulture (10th volume), where 14 articles with diversified subjects related to fruits, vegetables, flowers, biodiversity, climate change prospects, bio-fertilizer, bio-pesticide and other related subjects are included. I express my sincere thanks to all the authors whose articles are published in this journal. I apologized for those authors whose articles could not be placed in it due to some technical problems.

My sincere gratitude goes to Prof. Dr. Shanta Man Shakya, Editor-in-Chief, and his associates Dr. Krishna Prasad Poudyal, Mr. Indra Raj Pandey and Dr. Bhim Bahadur Khatri for their commendable editorial works. Besides this, I am indebted to Mr. Bashudev Subedi, General Secretary, Mrs. Yam Kumari Shrestha, Treasurer and all other executive members for their valuable suggestions and help to bring this publication in this shape. Last but not the least, I would like to extend my sincere appreciation to the advisors of 8th executive committee, life members and all other members of the society for their continued support and cooperation. The society is thankful to all the stakeholders for their valuable contributions in preparing this volume.

Finally, I hope the contents and findings presented in this issue will be useful to researchers, planners, extension workers, students and several others who are involved in horticulture research and development. I welcome suggestions and comments from the users for further improvement.

Mohan Bahadur Thapa
Editor’s Note

Nepal Horticulture Society (NHS) was established in 1990. Since then this society is publishing its journals and workshop proceedings regularly and manuals and other publications as per the necessity. Among several publications, *Nepalese Horticulture* is an official publication of the society as the journal. Being a professional society, Nepal Horticulture Society holds together all the horticulturists working in diverse fields including private businesses. *Nepalese Horticulture* is the outcome of researchers, reviews, studies and investigations which are very important to achieve developments such as livelihood, food security, poverty reduction, public health and environmental sustenance foreseen by the state policies and plans as well as millennium goals.

The NHS editorial board with gratitude acknowledges the valuable support provided by authors and encourages researchers, development workers and private entrepreneurs for their continued support with their authorship.

The institutions supporting the journal publication with provision of advertisements are also acknowledged. We are also thankful to all subscribers, readers and well-wishers of Nepalese Horticulture. We look forward to your continued supports.

Thanks to all of you again!

Editorial Committee
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 formatted as Heading 1.
3. Author(s)' name should follow the title in new paragraph formatted as Heading 2. Supplementary information such as educational attainment, organization, title/designation and contact address 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, results and discussion and conclusion. Review-based manuscript 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 3 cm and the right and bottom margins at 2.5 cm.
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.
10. Many and large figures and tables in the text should be avoided. Supplementary figures and tables may be placed in annexure.
12. The manuscript must be submitted electronically at *journal.nh@gmail.com*. The Editor-in-Chief deserves final right to accept or reject a submission.
नेपाल सरकार
कृषि विकास मन्त्रालय
ल्याबसायिक कृषि तथा व्यापार आयोजना

ल्याबसायिक कृषि तथा व्यापार आयोजना विधबैठको अर्थित सहायतामा २०६६ कार्तिक २७ गतेदेखि कार्यान्वयनमा रहेको छ। पहिलो चरणको समाप्ति २०७२ आषाढ मसात्मा भई अनुसार हाल दोश्रो चरण कार्यान्वयन भईदेखि छ र यसको अवधि June 2018 सम्म रहेको छ। यो आयोजनाको मूङ्ख उद्देश्य आयोजना लागु भएका जिल्लाका मितिकृषि उपजहरुको मूल्य बढङ्गालमा आवश्यक साना कृषि उद्यमी एवं कृषि व्यवसायीहरुको प्रतिस्पर्धा त्वरक्तक प्रभावालमा सुधार गर्नुहोस् छ। यो आयोजना पहिलो चरण अन्तगत धनुषा, महोत्तरी, सल्लाहो, रौटतह, बाँश, पसाइ, चितवन, धादिङ, काठमाडौँ, ललितपुर, काभ्रेपलाङ्गीको, नवलपाराको, नरेंद्रपुरी, लमजुङ, कास्की, रोपाङ्गा, पातीलो, रुपनेहाँ, कर्षिकातबस्तु, बाङ, बाँश, सुखेल, कल्याणपुर गरी जम्मा २५ वटा जिल्लाहरुमा सञ्चालित थियो र दोश्रो चरण अन्तगत ५५ वटा जिल्लाहरुमा सञ्चालन भईहरुको छ।

तोकिएको उद्देश्य हासिल गर्न आयोजनाले कृषि उत्पादनलाई अवश्यक पनि उन्नत तथा गुणस्तरीय बीएसको सुनिश्चितता एवं उन्नत नस्लका पशुपंकीहरुको उपलब्धता सरल र सुविचार तुल्याऊँदा साथ्रो कृषि गर्मिबाट सेवालाई विस्तार गरेको, कृषको वजारीकरण प्रभाव अभिवृद्धि गरेको, विशेषता को आयोजना तुलनात्मक लामा भएको कृषि तथा पशुजन्य उत्पादन र वस्तुहरुको विशिष्टतावाट लाम नित्र प्रतिस्पर्धी कृषि मूल्य अभिवृद्धि श्रृङ्खलाको स्थापना तथा सुव्यवस्थीकरण गर्ने जस्तो रणनीति अवलम्बन गरेको छ।

हाल कार्यक्रम सञ्चालनमा सहजता ल्याउने उद्देश्यले ५ वटै विकास क्षेत्रहरुमा क्षेत्रिय कार्यालयहरुको स्थापना भई कार्य सञ्चालन भईजिन्दो छ।

सम्पन्न
ल्याबसायिक कृषि तथा व्यापार आयोजना
सल्लाहो, काठमाडौँ
फोन नं. : ०१-४६५०२८/९०
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Effect of Different Sources of Nitrogen on Yield and Quality of Broccoli (*Brassica oleracea* L. Var. *Italica*) Varieties under Gaindakot, Nawalparasi, Nepal

Samjhana Lamichhane¹, M. D. Sharma¹, S.S. Panta¹ and S.C. Shah¹

**ABSTRACT**

The experiment was conducted at farmer’s field of Gaindakot, Nawalparasi during October 2012 to February 2013 to evaluate the influence of different sources of nitrogen and varieties on yield and quality of broccoli. The experiment was laid out in two factorial RCBD with three replications. A total of fifteen treatments with combination of five different sources of nitrogen and three varieties were taken in each replication. The result showed that the variety Premium Crop produced the highest (23.70 t/ha) terminal curd yield in \( N_{50\%\text{Urea}} + N_{50\%\text{Vermi}} \) (20.30 t/ha) whereas Calabrese produced the highest (9.34 t/ha) auxiliary curd yield in \( N_{50\%\text{Urea}} + N_{50\%\text{Vermi}} \) (8.25 t/ha). Green Sprouting produced the highest total yield (25.10 t/ha) in \( N_{50\%\text{Urea}} + N_{50\%\text{Vermi}} \) (28.55 t/ha). Calabrese exhibited higher (13.27%) dry matter and the lowest (18.44%) physiological weight loss of curd in \( N_{100\%\text{FYM}}. N_{50\%\text{Urea}} + N_{50\%\text{Vermi}} \) produced more compact curd while \( N_{100\%\text{Vermi}} \) produced the most appreciable taste, color and overall acceptability of curd. Premium Crop performed better regarding compactness, color and acceptability of curd while Calabrese performed better on taste. Thus, Calabrese along with \( N_{100\%\text{Vermi}} \) or \( N_{100\%\text{FYM}} \) would be suggested for better quality regarding physiological weight loss and taste while Premium crop along with \( N_{100\%\text{Vermi}} \) would be suggested for attractive color and overall acceptability of curd.

**Keywords:** curd quality, FYM, physiological weight loss, Vermi-compost

**INTRODUCTION**

Broccoli is an important vegetable crop which has high nutritional and commercial value (Brahma et al., 2002). It belongs to family *Brassicaceae*. It is a rapidly developing compact floral vegetable that is harvested at compact head and immature bud stage (Gray, 1982). Nutritionally, broccoli is an excellent source of antioxidants, vitamin C, fibre and folate. It contains good levels of iron, calcium, potassium and vitamin A and E (Lister and Bradstock, 2003). It posses cancer fighting properties related to the high levels of active plant chemicals called glucosinolates (Zhao et al., 2007). Broccoli is comparatively a newer winter vegetable in Nepal (Ghimire et al., 1993). MoAD (2013) reported that the total area under broccoli in Nepal in the year 2012/13 was 2138 ha with the production of 26769 mt and productivity 12.5 mt ha⁻¹.

Being a heavy feeder crop, broccoli demands constant supply of large amount of both macro and micro nutrients for its luxuriant growth. Among the essential nutrients, nitrogen plays significant role in metabolism, growth, reproduction and hereditary characters of plant (Dutta, 1998). The indiscriminate use of chemical fertilizers degrades the soil quality, increases susceptibility to pests and diseases and also creates micronutrient deficiencies. Thus, an alternative source of low cost plant nutrient is necessary to search for the maintenance of soil fertility and productivity over a longer period of time minimizing the adverse impact of chemical fertilizer on soil.

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Organic manure is the traditional source of plant nutrient which is most readily available to the farmers (Gaur et al., 1995). The vermin-compost improves the soil physics, chemical structure, and promotes biological properties of it (Suthar, 2008). It contains the plant hormone like substance which may be due to the presence of higher microbial population (Krishnamoorthy and Vajranabhaian, 1986). Application of vermicompost significantly increases the micronutrient in the field soil than with animal manure (Reddy and Reddy, 1999). It acts as a better source of plant nutrient to substitute or complement the chemical fertilizer and may also reduce the need for synthetic pesticides as it also provide resistance to disease and hence help to produce quality curd.

FYM plays an important role in maintaining and improving the soil as it contains all plant nutrients, humus and organic substances. Additionally, it helps in solubilization of plant nutrients and increases the uptake of N, P, K, Ca and Mg during crop growth (Subbiah et al., 1982). It is readily available in the most part of the country.

Neither the chemical fertilizers alone nor organic sources exclusively can achieve the production sustainability of soil as well as crops under high intensive cropping systems (Singh and Yadav, 1992). Quality product along with higher economic return can be obtained without deteriorating the soil condition for subsequent cropping through the judicious application of organic and inorganic fertilizer (Devi et al., 2003).

Broccoli is an important vegetable having shorter shelf life, which hasten the post harvest losses as well as economic loss and make the crop unpopular even then it has greater potential to improve nutritional situation of the country. Moreover, awareness of the consumers towards quality product is increasing day by day in different parts of the country. This indicates the enough scope for its promotional efforts. Not enough work has yet been done to study the effect of nitrogen sources and varieties on yield and quality of broccoli. Every variety does not respond equally to the available nutrients at all places of different climatic condition. Therefore, the suitable variety and appropriate source of nutrient to the plant must be identified to obtain optimum and quality yield with better post harvest life.

METHODOLOGY

The study was conducted at farmer’s field of Gaindakot, Nawalparasi from October 2012 to February 2013. The experiment was laid out in a factorial randomized complete block design (RCBD) with three replications. A total of fifteen treatments with the combinations of five different sources of nitrogen (N100 %Urea, N100%Vermi, N100%FYM, N50% Urea + N50%Vermi and N50% Urea + N50% FYM) and three varieties of Broccoli (Calabrese, Green Sprouting and Premium Crop) were taken in each replication. First two varieties were open pollinated while the third one was hybrid variety. Source of nitrogen was the first factor of experiment while the variety of broccoli was the second under the experiment. There were a total of 45 plots with 4.5 m² of each. Seedlings were transplanted at spacing of 45 x 40 cm in each plot. All the treatments were based on the fulfillment of the required nitrogen by the crop (100 kg ha⁻¹). Required quantity of vermicompost, FYM and chemical fertilizer (urea) was calculated on the basis of total amount of nitrogen present in them. The laboratory analysis of vermicompost, FYM and soil before transplanting of seedlings was done in the regional soil laboratory, Pokhara, Nepal. Data recording was done on various parameters such as curd yield, dry matter content of curd, physiological weight loss, sensory evaluation regarding compactness, color, taste, and over all acceptability of curd of broccoli. Collected data were subjected to analysis of variance and Duncan’s Multiple Range Test (DMRT) for mean separation using MSTAT-C.
Physiological weight loss

A hundred gm of randomly selected curd from each treatment was kept in ordinary room condition for four days until they became unmarketable. Then postharvest loss in weight was calculated to determine the post harvest life of the curd using formula:

\[
\text{Physiological weight loss(\%)} = \frac{\text{initial wt. of sample} - \text{Final wt. of sample}}{\text{Initial wt. of the sample}} \times 100
\]

Sensory evaluation

Sensory evaluation was done to judge the compactness, taste, color and overall acceptability of the curd at harvest stage by a panel of 10 people using hedonic scale of 1 to 9 in which 1 being the poor and 9 being the excellent performance (Acedo and Bautista, 1999). The overall acceptability of curd of broccoli was evaluated based on consumer’s preference to the product. The description of hedonic scale for quality parameter is given below:

Table 1. The description of hedonic scale

<table>
<thead>
<tr>
<th>Scale</th>
<th>Color</th>
<th>Taste</th>
<th>Compactness</th>
<th>Acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-3</td>
<td>Poorest</td>
<td>Poorest</td>
<td>Poorest</td>
<td></td>
</tr>
<tr>
<td>3-5</td>
<td>Poor</td>
<td>Poor</td>
<td>Poor</td>
<td>Poor</td>
</tr>
<tr>
<td>5-7</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>7-9</td>
<td>Better</td>
<td>Better</td>
<td>Better</td>
<td>Better</td>
</tr>
<tr>
<td>9</td>
<td>Best</td>
<td>Best</td>
<td>Best</td>
<td>Best</td>
</tr>
</tbody>
</table>

Source: Hedonic scale (Acedo and Bautista, 1999)

Table 2. Laboratory analysis of vermicompost, FYM and soil before seedling transplanting

<table>
<thead>
<tr>
<th>Manure</th>
<th>Nutrient content percentage</th>
<th>Organic matter</th>
<th>pH</th>
<th>Soil texture</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nitrogen</td>
<td>Phosphorous</td>
<td>Potash</td>
<td></td>
</tr>
<tr>
<td>Vermicompost</td>
<td>1.4(%)</td>
<td>0.71 %</td>
<td>1.98 (%)</td>
<td>-</td>
</tr>
<tr>
<td>FYM</td>
<td>0.67(%)</td>
<td>0.38 %</td>
<td>1.14 (%)</td>
<td>-</td>
</tr>
<tr>
<td>Soil</td>
<td>0.23(%)</td>
<td>967kg/ha (high)</td>
<td>648kg/ha (medium)</td>
<td>4.6 %</td>
</tr>
</tbody>
</table>

RESULTS AND DISCUSSION

Curd yield

Nitrogen source, N_{50\%Urea} + N_{50\%Vermi} recorded significantly (p< 0.01) the higher terminal curd yield (20.30 t ha\(^{-1}\)), auxiliary curd yield (8.25 t ha\(^{-1}\)) and total curd yield (28.55 t ha\(^{-1}\)) (Table 3). The highest terminal curd yield from N_{50\%Urea} + N_{50\%Vermi} was similar to N_{50\%Urea} + N_{50\%FYM}. However, nitrogen source, N_{100\%FYM} recorded significantly lower terminal curd yield (13.28 t ha\(^{-1}\)), auxiliary curd yield (2.81 t ha\(^{-1}\)) and total curd yield (16.09 t ha\(^{-1}\)). These results were in agreement with the findings of Bhattrai and Mishra (2012) that the maximum yield was recorded by the application of 1/2NPK + 2t ha\(^{-1}\)vermicompost whereas the minimum yield was from control in broccoli.

There were significant (p<0.01) effects of different varieties on curd yield of broccoli (Table 3). No auxiliary curd was harvested from variety Premium Crop. Premium Crop produced the highest (23.70 t ha\(^{-1}\)) terminal curd yield whereas Calabrese produced the lowest (10.53 t ha\(^{-1}\)) terminal curd yield. Calabrese produced significantly higher (9.34 t ha\(^{-1}\)) auxiliary curd yield than Green Sprouting (7.09 t ha\(^{-1}\)). Likewise, Green Sprouting produced the highest (25.10 t ha\(^{-1}\)) total curd yield which was similar to Premium Crop (23.70 t ha\(^{-1}\)) whereas Calabrese produced the lowest (19.88 t ha\(^{-1}\)) total curd yield. Although the highest terminal curd yield was recorded from Premium Crop, the highest total curd yield was from Green Sprouting. It
may be attributed to the multiple harvesting in Green Sprouting over a longer period of time but no auxiliary curd harvesting was held from Premium Crop. These results were also similar to the finding of Giri (2007) who found that Green Sprouting produced higher total yield than Calabrese.


<table>
<thead>
<tr>
<th>Treatments</th>
<th>Curd yield (t ha⁻¹)</th>
<th>Terminal</th>
<th>Auxiliary</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source of nitrogen (N)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\text{N}_{100}%\text{Urea})</td>
<td>17.83&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>2.20&lt;sup&gt;c&lt;/sup&gt;(5.54&lt;sup&gt;c&lt;/sup&gt;)</td>
<td>23.36&lt;sup&gt;c&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>(\text{N}_{100}%\text{Vermi})</td>
<td>16.06&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.94&lt;sup&gt;d&lt;/sup&gt;(4.15&lt;sup&gt;d&lt;/sup&gt;)</td>
<td>20.21&lt;sup&gt;d&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>(\text{N}_{100}%\text{FYM})</td>
<td>13.28&lt;sup&gt;d&lt;/sup&gt;</td>
<td>1.68&lt;sup&gt;e&lt;/sup&gt;(2.81&lt;sup&gt;e&lt;/sup&gt;)</td>
<td>16.09&lt;sup&gt;e&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>(\text{N}<em>{50}%\text{Urea} + \text{N}</em>{50}%\text{Vermi})</td>
<td>20.30&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.61&lt;sup&gt;a&lt;/sup&gt;(8.25&lt;sup&gt;a&lt;/sup&gt;)</td>
<td>28.55&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>(\text{N}<em>{50}%\text{Urea} + \text{N}</em>{50}%\text{FYM})</td>
<td>19.60&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>2.38&lt;sup&gt;b&lt;/sup&gt;(6.64&lt;sup&gt;b&lt;/sup&gt;)</td>
<td>26.23&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>SEM±</td>
<td>0.77</td>
<td>0.04(0.23)</td>
<td>0.57</td>
<td></td>
</tr>
<tr>
<td>LSD&lt;sub&gt;0.05&lt;/sub&gt;</td>
<td>2.22**</td>
<td>0.12(0.65)**</td>
<td>1.64**</td>
<td></td>
</tr>
<tr>
<td>Varieties</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calabrese</td>
<td>10.53&lt;sup&gt;c&lt;/sup&gt;</td>
<td>3.05&lt;sup&gt;a&lt;/sup&gt;(9.34&lt;sup&gt;a&lt;/sup&gt;)</td>
<td>19.88&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Green Sprouting</td>
<td>18.01&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.73&lt;sup&gt;b&lt;/sup&gt;(7.09&lt;sup&gt;b&lt;/sup&gt;)</td>
<td>25.10&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Premium Crop</td>
<td>23.70&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.71&lt;sup&gt;c&lt;/sup&gt;(0.00&lt;sup&gt;c&lt;/sup&gt;)</td>
<td>23.70&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>SEM±</td>
<td>0.595</td>
<td>0.03(0.18)</td>
<td>0.59</td>
<td></td>
</tr>
<tr>
<td>LSD&lt;sub&gt;0.05&lt;/sub&gt;</td>
<td>1.72**</td>
<td>0.10(0.51)**</td>
<td>1.70**</td>
<td></td>
</tr>
<tr>
<td>Grand mean</td>
<td>17.41</td>
<td>2.16(5.48)</td>
<td>22.76</td>
<td></td>
</tr>
<tr>
<td>CV (%)</td>
<td>12.88</td>
<td>5.86(12.38)</td>
<td>7.45</td>
<td></td>
</tr>
</tbody>
</table>

Means followed by the same letter(s) within a column are not significant at 5% level of significance as determined by DMRT. SEM = Standard error of mean, LSD = Least significant difference and CV = Coefficient of variance.

Note: Values on auxiliary curd yield were square root transformed at 0.5

**Dry matter of curd, physiological weight loss and shelf life of broccoli**

Nitrogen source \(\text{N}_{100}\%\text{FYM}\) showed significantly higher (13.27%) dry matter percentage of curd whereas \(\text{N}_{100}\%\text{Urea}\) showed lower (10.47%) dry matter percentage of curd (Figure 1). Calabrese recorded significantly higher (13.32%) dry matter percentage of curd, whereas Premium Crop recorded lower (11.00%) dry matter percentage of curd. The highest dry matter percentage from \(\text{N}_{100}\%\text{FYM}\) might be due to the accumulation of higher amount of dry matter during the crop growth period while the lowest dry matter percentage with the chemical fertilizer might be due to lower amount of dry matter accumulation during the crop growth period. Similar results were also observed by Bhattrai (2013) in broccoli.

Application of different sources of nitrogen and varieties had shown significant effects on physiological weight loss of curd in broccoli (Figure 1)). Nitrogen source, \(\text{N}_{100}\%\text{Urea}\) exhibited significantly higher (29.11%) physiological weight loss of the curd than rest of the treatments. Similarly, Premium Crop exhibited the highest (25.40 %) physiological weight loss of curd which was similar to Green Sprouting (22.93 %) whereas Calabrese exhibited the lowest value (19.40%). The reason of the least physiological weight loss from \(\text{N}_{100}\%\text{FYM}\) may be the influence of organic manure on physiological characters of curd and other biochemical properties, reducing respiration rate during storage. These findings were in accordance with the findings of Bhattrai (2013) that maximum physiological weight loss of broccoli curd was from 100%N through chemical and minimum from 100%N through FYM. Physiological weight was higher from Premium Crop than Calabrese (Bhattrai, 2013).
Although there were non-significant effect of different sources of nitrogen and varieties on shelf life of curd of broccoli, nitrogen source, N$_{100\%FYM}$ showed longer shelf life of curd of broccoli whereas N$_{100\%\text{Urea}}$ showed shorter shelf life. Similarly, Green Sprouting showed shorter shelf life followed by Premium Crop and Calabrese.

Figure 1. Effect of a) nitrogen sources and b) Varieties on dry matter and physiological weight loss of curd of broccoli at Gaindakot, Nawalparasi, Nepal during 2012/13

Curd quality characters

Nitrogen source, N$_{50\%\text{Urea} + N_{50\%\text{Vermi}}}$ produced significantly more (7.07) compactness of the curd while N$_{100\%\text{Urea}}$ produced very loose curd (3.64) (Table 4). More compact curd might be due to the nitrogen and other mineral elements required for plant growth supplied to plant from vermicompost. However, poor compactness of curd from N$_{100\%\text{Urea}}$ might be due to the excessive vegetative growth with smaller curd. Likewise, variety Premium Crop produced significantly more compact curd (6.35) than Green Sprouting (5.74) and Calabrese (3.79). This finding was in harmony with the finding of Bhattrai (2013) that the compactness of the curd was more from Premium Crop than Calabrese.

Nitrogen source, N$_{100\%\text{Vermi}}$ showed more tasty curd (7.31) which was significantly higher than rest of other treatments (Table 4). However, N$_{100\%\text{Urea}}$ showed the poorest (4.47) curd taste. Sapkota (2013) also reported that the most appreciable tasty cauliflower curd was obtained from 100% N through vermicompost. The variety Calabrese obtained the highest score (6.67) for curd taste while Premium Crop obtained the lowest score (5.08). Similar finding was also reported by Bhattrai (2013). The color of the curd was significantly influenced by different sources of nitrogen and varieties (Table 4).

Nitrogen source N$_{100\%\text{Vermi}}$ recorded the most appreciable color score (6.19) which was similar to N$_{100\%\text{FYM}}$. However, N$_{100\%\text{Urea}}$ recorded poor color score (3.88) which was identical to N$_{50\%\text{Urea} + N_{50\%\text{FYM}}}$. Sapkota (2013) also reported that the most appreciable color of cauliflower curd
was obtained from 100% N through vermicompost and the lowest color score from 100% N through urea. Premium Crop recorded the most appreciable color score (5.50) which was significantly higher than Green Sprouting (4.11) but at par with Calabrese. Bhattrai (2013) also reported better color from Premium Crop than Calabrese.

Consumer’s preference on the curd size, color, taste and appearance of the curd determines the overall acceptability. There were significant effects of different sources of nitrogen and varieties on acceptability of curd in broccoli (Table 4). Nitrogen source N100%Vermi obtained the highest (5.84) overall acceptability of curd while N100%Urea obtained the lowest (2.49) overall acceptability of curd.

Table 4. Effect of different sources of nitrogen and varieties on curd quality of broccoli at Gaindakot, Nawalparasi, during 2012/13

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Compactness</th>
<th>Taste</th>
<th>Color</th>
<th>Acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source of nitrogen (N)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N100%Urea</td>
<td>3.64c</td>
<td>4.47c</td>
<td>3.38d</td>
<td>2.49e</td>
</tr>
<tr>
<td>N100%Vermi</td>
<td>5.27c</td>
<td>7.31a</td>
<td>6.19a</td>
<td>5.84a</td>
</tr>
<tr>
<td>N100%FYM</td>
<td>4.26d</td>
<td>6.36b</td>
<td>5.55ab</td>
<td>5.04b</td>
</tr>
<tr>
<td>N50%Urea + N50%vermi</td>
<td>7.07a</td>
<td>5.78e</td>
<td>4.73bc</td>
<td>3.98e</td>
</tr>
<tr>
<td>N50%Urea + N50%FYM</td>
<td>6.26b</td>
<td>5.10d</td>
<td>4.01ad</td>
<td>3.12d</td>
</tr>
<tr>
<td>SEM±</td>
<td>0.11</td>
<td>0.10</td>
<td>0.39</td>
<td>0.13</td>
</tr>
<tr>
<td>LSD0.05</td>
<td>0.328**</td>
<td>0.29**</td>
<td>1.13**</td>
<td>0.37**</td>
</tr>
<tr>
<td>Varieties</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calabrese</td>
<td>3.79c</td>
<td>6.67a</td>
<td>4.70ab</td>
<td>3.57c</td>
</tr>
<tr>
<td>Green Sprouting</td>
<td>5.74b</td>
<td>5.65b</td>
<td>4.11b</td>
<td>4.19b</td>
</tr>
<tr>
<td>Premium Crop</td>
<td>6.35a</td>
<td>5.08c</td>
<td>5.50a</td>
<td>4.53a</td>
</tr>
<tr>
<td>SEM±</td>
<td>0.09</td>
<td>0.07</td>
<td>0.30</td>
<td>0.10</td>
</tr>
<tr>
<td>LSD0.05</td>
<td>0.25**</td>
<td>0.22**</td>
<td>0.87*</td>
<td>0.28**</td>
</tr>
<tr>
<td>Grand mean</td>
<td>5.29</td>
<td>5.83</td>
<td>4.77</td>
<td>4.10</td>
</tr>
<tr>
<td>CV (%)</td>
<td>6.42</td>
<td>5.17</td>
<td>24.49</td>
<td>9.33</td>
</tr>
</tbody>
</table>

Means followed by the same letter (s) within a column are not significant at 5% level of significance as determined by DMRT. SEM = Standard error of mean, LSD = Least significant difference and CV = Coefficient of variance.

CONCLUSION

Premium crop produced the highest terminal curd yield, Calabrese produced the highest auxiliary curd yield and Green Sprouting produced the highest total yield with nitrogen source N50%Urea + N50%Vermi. Calabrese exhibited significantly higher dry matter percentage of curd and lowest physiological weight loss in N100%FYM whereas Premium Crop showed lowest dry matter and highest physiological weight loss in N100%Urea. Nitrogen source, N50%Urea + N50%Vermi produced more compact curd while N100%Vermi produced the most appreciable taste, color and overall acceptability of curd. Premium Crop performed better regarding the compactness, color and over all acceptability of curd while Calabrese performed better regarding curd taste. Thus, Calabrese along with the application of N100%Vermi or N100%FYM would be suggested for better quality regarding physiological weight loss and taste while Premium crop along with the application of N100%Vermi would be suggested for attractive color and overall consumer’s acceptability of curd. Broccoli exhibited very short shelf life of only 3-4 days after harvest.
LITERATURES CITED


Effect of Seed Priming on Germination, Field Emergence and Yield in
Carrot (*Daucus carota* L.)

K.K. Poudel\(^1\), S. M. Shakya\(^2\), M. D. Sharma\(^2\) and K.R. Dahal\(^2\)

**ABSTRACT**

A field experiment was carried out at Rampur, Chitwan in split-plot design to study the effect of priming of carrot seed on germination, early emergence, field emergence, plant stand establishment and root yield and quality. The treatments consisted of two commercial varieties of carrot (New Kuroda and Nantes Fancy) as main plot and seven levels of seed priming as sub-plots with 3 replications. The treatment imposed seeds for the field experiment were also used for laboratory test with four replications. New Kuroda exhibited higher vigor index (637.2), faster early emergence (8.33 days), highest field emergence (56.33%) and plant stand (66.67%), thickest cortex diameter (1.70 cm) and higher economic yield of 22.13 t ha\(^{-1}\) (50.65% more than control) in 24 hrs. seed soaking in tap water than in non-primed seeds where as Nantes Fancy showed faster early emergence (8.66 days), highest field emergence (55.33%), higher plant stand (69.33%) and higher yield of 17.69 t ha\(^{-1}\) (9.94% more than control) in 12 hrs. seed soaking in 40\(^\circ\)C warm water.

**Key words:** Carrot, priming, germination, emergence, vigor

**INTRODUCTION**

Carrot is becoming an important commercial crop of Nepalese farmers. It is grown all over the country from temperate region to the tropical. Due to its nutritive and economic value, it has been realized that the crop needs to be improved in order to exploit them to its maximum potentiality. The total cultivated area of carrot in Nepal is about 772.6 ha with 12.5 t ha\(^{-1}\) productivity (VDD, 2006). The commercialization of carrot is directly related with the poverty reduction program due to its higher per unit area production which is 12-15 tons ha\(^{-1}\) (Raut, 1996) as compared to cereal crops and fetches high value in the market.

Among other vegetable crops, the nature of carrot seed is such that it exhibits lower germination capacity of 65 % (SDQCSS, 1995) and takes long duration of at least three weeks to germinate under Nepalese field conditions. ICAR (2002) reported that carrot seed takes 10-20 days for germination in the field condition and suggests seed soaking for 12 to 24 hours before sowing for better germination. Some farmers are using over night seed soaking treatment in Nepal. But the effect of the duration of pre-sowing seed soaking on germination and plant stand establishment and their subsequent effect on the economic yield have not been documented well in Nepal.

Priming is a water-based treatment process that is performed on seeds to increase uniformity of germination and early emergence from the soil. Priming decreases the time span between the emergence of the first and the last seedlings (Hill, 2001). Austin et al., (1969) reported that carrot seed soaking in water at 20 \(^{\circ}\)C for 24 hrs followed by drying at 20\(^\circ\)C resulted in quick germination and the seedlings emerged in the field 3-4 days earlier than untreated seeds.

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\(^1\) HIMALI Project, Hariharbhawan, Lalitpur

\(^2\) Institute of Agriculture and Animal Science, Rampur, Chitawan
Similarly, Pantielev et al. (1976) studied the effect of water soaking with other treatments and found that the soaking in water increased carrot field germination by 13 percent and increased yield as well up to 60 percent.

Shishkina and Galeev (1974) stated that carrot seeds of cultivar Nantes were soaked in Boron (0.01%) solution for 24 hours, dried and sown. The treated seed germinated better in the field and gave a thicker stand of larger roots than the control with 23 percent more yield. The use of 0.25% phosphorus solution as priming treatment in mung-bean seed also increased the yield in Pakistan. Similarly, Hsu et al. (2003) reported that the warm water soaking for four hours at 40°C improved the percentage and mean emergence time of bitter gourd at sub-tropical temperature of 20°C.

By realizing beneficial effect of seed priming on carrot, the present study was planned to study the effect of various priming techniques including local methods which is known to some farmers of Nepal but not verified by scientific study under Nepalese condition. So, this study aims at assessing the effect of various methods of seed priming on carrot seed germination, field emergence, plant stand establishment and, ultimately, the yield and quality of carrot crop.

**MATERIALS AND METHODS**

The study encompassed two sets of works; field experiment to assess field emergence and yield and quality of carrot production and lab experiment to compare the germination percentage and seedling vigor of the treated and untreated seeds. The experiment was conducted at Horticulture Farm of the Institute of Agriculture and Animal Science (IAAS), Rampur, Chitwan. The lab work was done at the Horticulture lab of IAAS.

The treatments consisted of two commercial varieties of carrot viz. New Kuroda (V1NK) and Nantes Fancy (V2NF) as main plots and seven levels of seed priming as sub-plots with 3 replications. Seed priming treatments were: seed without soaking as control (T1C), 12 hours seed soaking in tap water (T212TW), 12 hours seed soaking in 40°C warm water (initially heated up to 40°C) (T312WW), 24 hours seed soaking in tap water (T424TW), 24 hours seed soaking in 40°C warm water (T524WW), 24 hours seed soaking in 0.01% (880 gm borax lt-1 of water) boron solution (T624TW+B) and 24 hours seed soaking in 0.25% (16.5 gm single super phosphate lt-1 of water) phosphorus solution (T724TW+P) each followed by 2 hours shade drying.

The total experimental area was 18.1 m ×13.4 m. The main plot size was 11.4 m × 4.7 m with seven sub plots within each main plot. The sub plot size was 2.52 m². A total of 84 plants were accommodated in a sub-plot plot with 7 rows and 12 plants per row spaced at 30 cm row-to-row and 10 cm plant-to-plant. The area of net observable sub-plot was 1.5 m² with 50 plants.

Priming treatments consisted of soaking the seeds of both the varieties in tap water, warm water, and different micro and macronutrient solutions for 12 and 24 hours followed by 2 hours drying in shade. The warm water was monitored by initially heating up the water to 40°C, pouring seed and leaving it to cool down in the lab room for soaking periods as described in the treatments.

Land ploughing was done by tractor. Weeding, leveling and final land preparation was done manually. Basal application of manure and fertilizers was done at the rate of 20 mt farmyard manure and 30:40:40 NPK per hectare. At forty-five days after sowing, additional dose of nitrogen @ 30 kg ha⁻¹ was top dressed. The seeds were obtained from agro-vet called Nemcol, Kalimati, Kathmandu. Both are popular varieties among the commercial farmers.

Seed sowing was done in the third week of November (Nov 23, 2005). It was done by counting the seeds per hill in all plots. Two seeds per hill at 1 cm depth were sown and there were 168 seeds sown in a sub plot. The spacing was 30×10 cm. Light irrigation was applied
after two days of seed sowing and the irrigation application was followed in every 15 days interval. First light hand weeding was done after two weeks of sowing. Hoeing, weeding and top dressing (ICAR, 2000) was done in forty-five days.

The treatment imposed seeds for the field experiment were also used for laboratory test with four replications. Hundred seeds of each treatment were placed in the petridish containing moist blotting paper with distilled water and the temperature of the germinator was maintained at 20°C.

Observations recorded
Number of seedlings emerged were counted everyday just after the emergence. It was continued till there was 50 percent emergence in each sub-plot and number of days taken was recorded for early emergence. Total number of seedlings emerged were counted on 21st day after sowing (DAS) in each sub-plot where hundred seeds were being sown @ 2 seeds per hill in 50 hills. Total number of plant stand was counted on 45th DAS. Thinning was necessary to observe the total stand establishment of individual sub-plot so it was counted just after thinning.

The total economic yield of each sub-plot was calculated by subtracting the shoot and non-marketable yield of that particular sub-plot. Very small roots, forked roots, splitted roots and disease infected roots were accounted as non-marketable yield. The net area of each sub-plot harvested was 1.5m². After measuring the root diameter at three places, it was cut transversely at those places. Core diameter was recorded and the mean calculated. Thus, average of 5 plants gave core diameter. Likewise, cortex diameter was computed by using the following formula:

\[
\text{Cortex diameter (cm)} = \text{Root diameter} - \text{Core diameter}.
\]

On fourteenth day of the placement of seeds in the germinator number of normal seedlings was counted and the seedling length (root + shoot length) of ten randomly selected normal seedlings under each treatment were recorded and average value was calculated. The vigor index was computed by using the following formula (Abdul-Baki and Anderson, 1973):

\[
\text{Vigor index} = \% \text{ Germination} \times \text{ seedling length (shoot length + root length)}.
\]

Statistical analysis
MSTAT (1990) statistical computer software was used for ANOVA analysis and Microsoft Excel (2000) was used for drawing graphs. The treatment means were compared by DMRT at P = 0.05.

RESULTS AND DISCUSSION

Days to 50% early emergence
The effect of carrot seed priming and variety on days to 50% early emergence is presented in Table 1. Except seed priming treatments, the varieties did not differ in respect of days to 50% early emergence. T312WW took least number of days (9.66) to 50% early emergence than the control T1C (12.33 days), the difference being significant.

Table 1. Effect of variety and seed priming on days to 50% early emergence in carrot crop at IAAS, Rampur, Chitwan,, 2005/06.

<table>
<thead>
<tr>
<th>Priming</th>
<th>V1NK</th>
<th>V2NF</th>
<th>Priming Mean (P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1C</td>
<td>13.67a</td>
<td>11.00cde</td>
<td>12.33a</td>
</tr>
</tbody>
</table>
The interaction between variety and seed priming on days to 50% early emergence was significant. Within variety V1NK, T42TW (24 hrs. seed soaking in tap water) resulted into the lowest number of days (8.33) to 50% early emergence, which was 5.34 days earlier than the control T1C (13.67 days).

Similarly, within variety V2NF, T312WW (12 hrs. seed soaking in 40 °C warm water) took lowest number of days (8.66) to 50% early emergence which was 2.34 days earlier than the control T1C (11.00 days). The difference was significant. The present finding on early emergence agrees with Wilkinson (1918) who reported about the placement of seeds of radish, bean, corn, cucumber and squash in luke-warm water overnight to increase the germination velocity.

The interactive result of variety and seed priming agrees with the findings of Austin et al., 1969 who also reported that soaking carrot seeds at 20 °C for 24 hr resulted into quick germination and the seedlings emerged in the field 3-4 days earlier than untreated seeds. The findings of this study also agree with Nagarajan et al., 2005 who reported that seed priming reduced the number of strong binding sites and the associated water content, and increased significantly the number of weak binding sites and the associated water content. This redistribution of water which increased the availability of seed water may be the reason for the higher speed of germination of primed seeds.

The early emergence of primed seed in the field might be due to the completion of I and II stages of germination process during the priming period. Gray et al., 1990 suggested that during priming the seeds are artificially maintained in phase II of imbibition and the substances generated in this latent period may increase cell wall or remove restrictions for radicle growth.

**Effect on total field emergence (%)**

The effect of seed priming on total field emergence was not significant (Table 2). Likewise, varieties also did not differ. But the variety V1NK showed the higher percentage of plant emergence (48.67%) compared to V2NF (43.05%). Although not significant, T312WW exhibited the highest percentage of field emergence (51.17%) followed by T42TW (48.50%) where as control exhibited (44.83%) only.
In variety V1NK, T424TW exhibited significantly the highest (56.33%) total field emergence of seedling compared to the control T1C (41.33%). Similarly, within variety V2NF, T312WW has resulted the highest (55.33%) field emergence than the control T1C (48.33%) both being at par with each other.

**Table 2.** Effect of variety and seed priming on total field emergence in 21 DAS (%) in carrot crop at IAAS, Rampur, Chitwan, 2005/06.

<table>
<thead>
<tr>
<th>Priming</th>
<th>V1NK</th>
<th>V2NF</th>
<th>Priming Mean (P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1C</td>
<td>41.33&lt;sup&gt;bcd&lt;/sup&gt;</td>
<td>48.33&lt;sup&gt;abcd&lt;/sup&gt;</td>
<td>44.83&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>T212TW</td>
<td>48.33&lt;sup&gt;abcd&lt;/sup&gt;</td>
<td>41.00&lt;sup&gt;bcd&lt;/sup&gt;</td>
<td>44.67&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>T312WW</td>
<td>47.00&lt;sup&gt;abcd&lt;/sup&gt;</td>
<td>55.33&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>51.17&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>T424TW</td>
<td>56.33&lt;sup&gt;a&lt;/sup&gt;</td>
<td>40.67&lt;sup&gt;bcd&lt;/sup&gt;</td>
<td>48.5&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>T524WW</td>
<td>53.33&lt;sup&gt;abc&lt;/sup&gt;</td>
<td>36.33&lt;sup&gt;d&lt;/sup&gt;</td>
<td>44.5&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>T624TW+B</td>
<td>46.33&lt;sup&gt;abcd&lt;/sup&gt;</td>
<td>38.67&lt;sup&gt;cde&lt;/sup&gt;</td>
<td>42.50&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>T724TW+P</td>
<td>48.00&lt;sup&gt;abcd&lt;/sup&gt;</td>
<td>41.00&lt;sup&gt;bcd&lt;/sup&gt;</td>
<td>44.50&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Variety Mean (V)</td>
<td>48.67&lt;sup&gt;a&lt;/sup&gt;</td>
<td>43.05&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
</tr>
</tbody>
</table>

LSD (5%) for variety V: Ns
SE: 2.416
LSD (5%) for priming P: Ns
SE: 3.101
LSD (5%) for V × P: 12.80
SE: 4.386
CV%: 16.56

Figures followed by the same letter(s) are not significantly different at P = 0.05 by DMRT.

ns = non significant (P>0.05). DAS = Days After Sowing

The improvement in total percentage emergence and mean emergence time of bitter gourd soaked in hot water as reported by Hsu et al. (2003) agrees with the highest total field emergence and stand establishment found in T312WW in this study.

The interactive effect of priming and variety on field emergence in this study agrees with the findings of Pantielev et al., 1976 who reported that the carrot seed soaking in water increased field germination by 13 %. In this study variety V1NK (New Kuroda) showed about 36% more seedling field emergence at T424TW than control T1C.

The result exhibited that the variety V1NK preferred 24 hrs seed soaking in tap water while V2NF (Nantes Fancy) preferred the 12 hrs seed soaking in warm water for better field emergence. Carrot seed has low permeable seed coat which delayed the imbibed period and other metabolic activities within the seed. Visual observation shows that the seeds of Nantes have thin pellets than the New Kuroda. So, from this study it can be concluded that the thin pellets of Nantes seed might be the reason for less time needed to imbibe and gain priming benefit.

**Effect on total plant stand establishment (%)**

The varieties did not differ in respect of total plant stand establishment (Table 3). But the variety V1NK demonstrated the higher percentage of plant stand establishment (57.05%) out of fifty plants after thinning as compared to the variety V2NF (53.43%). Priming treatment T312WW showed the highest percentage of plant stand (63.33%) as compared to the control T1C (51.67%).
Table 3. Effect of variety and seed priming on total plant stand establishment (%) in carrot crop at IAAS, Rampur, Chitwan, 2005/06.

<table>
<thead>
<tr>
<th>Total plant stand establishment (%)</th>
<th>Priming Mean (P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Priming</td>
<td>V1NK</td>
</tr>
<tr>
<td>T1c</td>
<td>44.67&lt;sup&gt;cd&lt;/sup&gt;</td>
</tr>
<tr>
<td>T2&lt;sub&gt;12TW&lt;/sub&gt;</td>
<td>58.00&lt;sup&gt;abcd&lt;/sup&gt;</td>
</tr>
<tr>
<td>T3&lt;sub&gt;12WW&lt;/sub&gt;</td>
<td>57.33&lt;sup&gt;abcd&lt;/sup&gt;</td>
</tr>
<tr>
<td>T4&lt;sub&gt;24TW&lt;/sub&gt;</td>
<td>66.67&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
<tr>
<td>T5&lt;sub&gt;24WW&lt;/sub&gt;</td>
<td>64.67&lt;sup&gt;abc&lt;/sup&gt;</td>
</tr>
<tr>
<td>T6&lt;sub&gt;24TW+P&lt;/sub&gt;</td>
<td>55.33&lt;sup&gt;abcd&lt;/sup&gt;</td>
</tr>
<tr>
<td>T7&lt;sub&gt;24TW+P&lt;/sub&gt;</td>
<td>52.67&lt;sup&gt;abcd&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Variety Mean (V) | 57.05<sup>a</sup> | 53.43<sup>a</sup> |

LSD (5%) for variety V ns
SE 2.935
LSD (5%) for priming P ns
SE 4.362
LSD (5%) for V × P 18.01
SE 6.169
cv% 19.34

Figures followed by the same letter (s) are not significantly different at P = 0.05 by DMRT.
ns = non significant (P > 0.05).

The interaction of variety and priming on plant stand was significant. Within variety V1<sub>NK</sub>, T4<sub>24TW</sub> showed highest (66.67%) total plant stand establishment than control T1<sub>C</sub> (44.67%). In case of V2<sub>NF</sub>, T3<sub>12WW</sub> demonstrated the highest percentage (69.33%) of total plant stand establishment than control T1<sub>C</sub> (58.67%).

In this study, total plant stand was recorded about 49% more in treatment T4<sub>24TW</sub> (66.67%) than control T1<sub>C</sub> (44.67%) in variety V1<sub>NK</sub> (New Kuroda) while it was 18% more in treatment T3<sub>12WW</sub> (69.33%) in variety V2<sub>NK</sub> (Nantes Fancy) than control T1<sub>C</sub> (58.67%). The finding of this study agrees with the report of Hill (2001), who has reported that the priming increased the rate of emergence so the stand establishes itself faster.

The germination capacity and energy of the primed seed enhance the seedlings growth uniformly so that the growth of a plant is not affected by the shading effect of its neighboring plant. It shows that the priming treatment increases the probability of plant stand as compared to non primed one.

Effect on economic yield

Table 4 showed that varieties did not differ in respect of economic yield and so was the case among the priming treatments. Comparatively, V1<sub>NK</sub> yielded higher (16.92 t ha<sup>-1</sup>) than V2<sub>NF</sub> (15.41 t ha<sup>-1</sup>). Among priming treatments, T4<sub>24TW</sub> gave the highest yield (18.22 t ha<sup>-1</sup>) followed by T3<sub>12WW</sub> (17.42 t ha<sup>-1</sup>). The lowest yield was produced by the treatment T7<sub>24TW+P</sub> (14.69 t ha<sup>-1</sup>) followed by T5<sub>24WW</sub> (14.79 t ha<sup>-1</sup>).

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Table 4. Effect of variety and seed priming on economic yield (t ha⁻¹) in carrot crop at IAAS, Rampur, Chitwan, 2005/06.

<table>
<thead>
<tr>
<th>Priming</th>
<th>V1NK</th>
<th>V2NF</th>
<th>Priming Mean (P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1C</td>
<td>14.69ᵇ</td>
<td>16.09ᵃᵇ</td>
<td>15.39ᵃ</td>
</tr>
<tr>
<td>T2₁₂TW</td>
<td>16.29ᵃᵇ</td>
<td>15.96ᵃᵇ</td>
<td>16.12ᵃ</td>
</tr>
<tr>
<td>T3₁₂WW</td>
<td>17.16ᵃᵇ</td>
<td>17.69ᵃᵇ</td>
<td>17.42ᵃ</td>
</tr>
<tr>
<td>T4₂₄TW</td>
<td>22.13ᵃ</td>
<td>14.31ᵇ</td>
<td>18.22ᵃ</td>
</tr>
<tr>
<td>T5₂₄WW</td>
<td>16.76ᵃᵇ</td>
<td>12.82ᵇ</td>
<td>14.79ᵃ</td>
</tr>
<tr>
<td>T6₂₄TW+B</td>
<td>17.31ᵃᵇ</td>
<td>15.69ᵇ</td>
<td>16.50ᵃ</td>
</tr>
<tr>
<td>T7₂₄TW+P</td>
<td>14.09ᵇ</td>
<td>15.29ᵇ</td>
<td>14.69ᵃ</td>
</tr>
</tbody>
</table>

Variety Mean (V) 16.92ᵃ 15.41ᵃ

LSD (5%) for variety V Ns
SE 1.062
LSD (5%) for priming P Ns
SE 1.346
LSD (5%) for V × P 5.555
SE 1.903
CV% 20.40

Figures followed by the same letter (s) are not significantly different at P = 0.05 by DMRT.

ns = non significant (P > 0.05).

The interaction of variety and priming treatments on economic yield showed that in V₁ NK, treatment T₄₂₄TW gave highest economic yield (22.13 t ha⁻¹) as compared to the control T₁C (14.69 t ha⁻¹) and T₇₂₄TW+P (14.09 t ha⁻¹). In variety V₂NF, the highest economic yield was recorded from T₃₁₂WW (17.69 t ha⁻¹) as compared to the control T₁C (16.09 t ha⁻¹). The lowest yield was recorded from T₅₂₄WW (12.82 t ha⁻¹).

The finding of this study on economic yield as affected by priming treatments showed 18.39 % more root yield due to T₄₂₄TW (24 hr seed soaking in tap water) over the control T₁C. Similarly, the interaction of variety and seed priming on economic yield showed that, in variety V₁NK (New Kuroda), treatment T₄₂₄TW gave 50.65 % more yield than the control while in variety V₂NF (Nantes Fancy) 9.94 % more yield was recorded by the treatment T₃₁₂WW (12 hrs seed soaking in warm water) than control but it has recorded 37.98 % more yield than the treatment T₅₂₄WW.

The present finding of variety V₁NK and priming effect agrees with the report of Pantielev et al. (1976) who reported that the carrot seed soaking in water increased yield up to 60%. However, the result was not encouraging in case of variety V₂NF. The result of variety V₂NF was similar to findings by Austin et al., 1969, who reported the yield of carrot roots from the hardened seeds was 64 t ha⁻¹ compared to 59.2 t ha⁻¹ from untreated seeds.

The treatment T₄₂₄TW i.e. seed soaking in tap water for 24 hrs in the variety V₁NK (New Kuroda) showed consistence level of the highest record in most of the parameters except the important parameter root length but the difference was not big. Early emergence, total field emergence, total plant stand establishment and number of leaves per plant with plant height to yield parameters were leading with this treatment. Similar trend can be observed in the variety V₂NF (Nantes Fancy) with the treatment T₃₁₂WW i.e. 12 hrs seed soaking in warm water. So,
traditional practice of one night seed soaking by farmers and favorable results due to 24 hrs seed soaking as reported by different scientists seem true but it varies with the cultivars.

**Effect on cortex diameter**

Cortex diameter in V1NK (1.60 cm) was comparatively bigger than that in V2NF (1.35 cm), the difference being non significant (Table 5). However, priming effect on cortex diameter was significant. Treatment T424TW produced the highest cortex diameter (1.56 cm) as compared to the control T1C (1.29 cm). All the priming treatments were at par with T424TW. All priming treatments except phosphorus solution (T724TW+P) showed significantly bigger cortex diameter than control.

In interaction of variety and priming on cortex diameter, T424TW produced the highest cortex diameter (1.703 cm) as compared to the control (1.360 cm) in variety V1NK. In variety V2NF, T624TW+B produced the highest (1.450) cortex diameter as compared to the control T1C. The difference was not significant. All other treatments were at par with the treatment T624TW+B.

**Effect on vigor**

Varieties did not differ with respect to vigor index (Table 6). Variety V1NK showed the highest vigor index (525.9) as compared to variety V2NF (493.1). The priming effect on vigor index was significant. Treatment T424TW resulted into significantly the highest index of 564.2 as compared to the lowest record of treatment T624TW+B (389.0).

The interaction showed that vigor index was the highest (637.2) in T424TW in variety V1NK. Treatment T424TW was found significantly higher (637.2) than the treatment T624TW+B with index 278.6 which was lower than control T1C (452.3). All other treatments were at par with the treatment T424TW. In variety V2NF, T724TW+P resulted into the highest index of 527.7 followed by T312WW (511.8). Both gave higher value as compared to control T1C (452.3) but they were not significantly different.
Table 5. Effect of variety and seed priming on cortex diameter (cm) in carrot crop at IAAS, Rampur, Chitwan, 2005/06.

<table>
<thead>
<tr>
<th>Priming</th>
<th>V1NK</th>
<th>V2NF</th>
<th>Priming Mean (P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1c</td>
<td>1.360&lt;sup&gt;cd&lt;/sup&gt;</td>
<td>1.230&lt;sup&gt;e&lt;/sup&gt;</td>
<td>1.295&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>T2&lt;sub&gt;2&lt;/sub&gt;TW</td>
<td>1.633&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>1.403&lt;sup&gt;bcd&lt;/sup&gt;</td>
<td>1.518&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>T3&lt;sub&gt;2&lt;/sub&gt;WW</td>
<td>1.690&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.277&lt;sup&gt;e&lt;/sup&gt;</td>
<td>1.483&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>T4&lt;sub&gt;2&lt;/sub&gt;TW</td>
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<td>T5&lt;sub&gt;2&lt;/sub&gt;WW</td>
<td>1.617&lt;sup&gt;abc&lt;/sup&gt;</td>
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<td>1.503&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>T6&lt;sub&gt;2&lt;/sub&gt;TW+B</td>
<td>1.643&lt;sup&gt;ab&lt;/sup&gt;</td>
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<td>1.547&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
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<td>T7&lt;sub&gt;2&lt;/sub&gt;TW+P</td>
<td>1.567&lt;sup&gt;abcd&lt;/sup&gt;</td>
<td>1.333&lt;sup&gt;de&lt;/sup&gt;</td>
<td>1.450&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Variety Mean (V) 1.602<sup>a</sup> 1.358<sup>a</sup>

LSD (5%) for variety V
SE 0.05255

LSD (5%) for priming P
SE 0.05627

LSD (5%) for V × P
SE 0.2323

CV% 9.36

Figures followed by the same letter(s) are not significantly different at P = 0.05 by DMRT.

ns = non significant (P>0.05).

Table 6. Effect of variety and seed priming on vigor index in carrot seed at IAAS laboratory, Rampur, Chitwan, 2005/06.

<table>
<thead>
<tr>
<th>Priming</th>
<th>V1NK</th>
<th>V2NF</th>
<th>Priming Mean (P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1c</td>
<td>554.3&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>452.3&lt;sup&gt;b&lt;/sup&gt;</td>
<td>503.3&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>T2&lt;sub&gt;2&lt;/sub&gt;TW</td>
<td>518.2&lt;sup&gt;ab&lt;/sup&gt;</td>
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<td>491.2&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>587.9&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>511.8&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>549.8&lt;sup&gt;a&lt;/sup&gt;</td>
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<tr>
<td>T4&lt;sub&gt;2&lt;/sub&gt;TW</td>
<td>637.2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>491.1&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>564.2&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>T5&lt;sub&gt;2&lt;/sub&gt;WW</td>
<td>573.5&lt;sup&gt;ab&lt;/sup&gt;</td>
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<td>539.3&lt;sup&gt;a&lt;/sup&gt;</td>
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<tr>
<td>T7&lt;sub&gt;2&lt;/sub&gt;TW+P</td>
<td>531.7&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>527.7&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>529.7&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Variety Mean (V) 525.9<sup>a</sup> 493.1<sup>a</sup>

LSD (5%) for variety V
SE 10.72

LSD (5%) for priming P
SE 102.1

LSD (5%) for V × P
SE 96.49

CV% 19.76

Figures followed by the same letter(s) are not significantly different at P = 0.05 by DMRT.

ns = non significant (P>0.05).
Seed vigor has been used to distinguish seeds having the potential to produce strong, healthy seedlings and those with weakened performance potential. In the lab test the treatment $T_{424TW}$ had highest vigor index (637.2) in variety $V_{1NK}$ where as in variety $V_{2NF}$, $T_{724TW+P}$ had the highest (527.7) index which was followed by $T_{312WW}$ (511.8). This result of lab test was directly related with the result of field seedling emergence with respect to early and total field emergence. The days to 50% early emergence and total field emergence in both the varieties New Kuroda and Nantes Fancy were lead by the treatments $T_{424TW}$ and $T_{312WW}$.

From the laboratory study it can be concluded that the major benefits of priming were faster germination and higher germination percentage which encourage for further test in other vegetables too.

**CONCLUSION**

This study focused on simple and low cost technology to find out the effect of duration of water soaking on various parameters from carrot seed emergence to root yield. Water soaking for duration of 12 to 24 hrs has been found appropriate for two commercial varieties of carrot seed. The popular commercial variety New Kuroda ($V_{1NK}$) exhibited highest vigor index (637.2), faster early emergence (8.33 days), highest field emergence (56.33%) and plant stand (66.67%), thickest cortex diameter (1.70 cm) with highest economic yield of 22.13 t ha$^{-1}$ (50.65% more than control) in 24 hrs seed soaking in tap water than non primed seeds where as another commercial variety Nantes Fancy ($V_{2NF}$) showed faster emergence (8.66 days), highest field emergence (55.33%), higher plant stand (69.33%) and more economic yield (9.94% more than control) in 12 hrs seed soaking in 40$^0$C warm water.

From the study, it can be suggested to choose 24 hrs seed soaking in tap water for better yield of New Kuroda and 12 hrs seed soaking in 40$^0$C warm water for better yield with less green shouldered roots of Nantes Fancy. For confirmation, one more verification trial may be suggested.
LITERATURES CITED


Effect of Climate Change on Vegetable Seed Production in Some Selected Pockets of Nepal

Mohan B. Thapa\textsuperscript{1} and S. Dhungel\textsuperscript{2}

ABSTRACT

This study was conducted in seven vegetable seed production pocket districts representing high hills, mid hills and terai region of Nepal. This study was based on the primary information collected using semi-structured questionnaires, focus group discussions and key informants survey. Meteorological data of last 10 years from different metrological stations on or nearby the production pockets were collected and analyzed. The pattern of rainfall shows a slightly increasing trend in the mountainous areas receiving higher amount of annual precipitation. Amount of total precipitation in mid hills was found decreasing continuously with a slight increase in the year 2007. The pre-monsoon and winter rainfall was also in decreasing trend in terai whereas, rainfall pattern shows increasing trend in high hills which shows terai areas more vulnerable due to erratic rainfall pattern whereas high hills might benefit from the increasing rainfall pattern to some extent. A slightly increasing trend was noted in average annual temperature within the study area in a decade. The increasing trend of temperature was found higher in high hills and mid hills as compared to Terai. Furthermore, warming in the winter was higher as compared to other seasons. Eighty-six percent of respondents in high hills, 72% in mid hills, 78% in terai responded that they felt increase in temperature as compared to previous years. Similarly, the increase in winter temperature was felt more than that of summer experiencing warmer winters than previous years. The high hills received higher amount of precipitation in the recent years in terms of intensity and duration of monsoon. Almost all vegetable seed producers in high hill felt increased precipitation whereas trend of rainfall was in decreasing pattern in mid hills and Terai as experienced by 81% and 60% of the respondents respectively. Twenty percent in Mustang, 12% in mid-hills and 4% in Sarlahi reported that they felt some positive impacts due to climate changes. Forty-one percent of the respondents in Mustang expressed their view that cultivation of brinjal, chilly and cucurbits has been done successfully in Mustang these days. The flowering and ripening of broad leaf mustard, cabbage and carrot has sifted 10-15 days before. Most negative effects were felt in Sarlahi as responded by 89% of the farmers followed by mid hills (78%) and Mustang (40%). Sixty-six percent of the respondents in Mustang, 72% in mid-hills and 86% in Sarlahi felt that the planting time has pre-pond by about 15-20 days. The shift was found greater in Mustang (25 days) and lower in Sarlahi (13 days). However, planting time in case of rainy season crop had shifted some days after (22% in mid-hills and 8% in Sarlahi) generally due to delayed monsoon.

Key Words: climate change, adaptation, mitigation, resilience, coping strategies, vegetable seed production

INTRODUCTION

Climate change has been one of the emerging global challenges in the recent years. Accordingly, the United Nations General Assembly adopted a resolution to develop an international legal instrument to address this global problem. In accordance with this, the Intergovernmental Negotiation Committee met several times and the United Nations Framework Convention on Climate Change (UNFCCC) was adopted in May 1992. This Convention was opened for signature at the UN Conference on Environment and Development in Rio de Janeiro, Brazil in June 1992. Nepal signed this Convention on 12 June 1992 and ratified it on 2nd May 1994, making it effective three months later on 31st July 1994. Nepal has experienced

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an average maximum annual temperature increase of 0.06 degree Celsius. Despite having only 0.4 percent of the total global population and being responsible for only 0.025 percent of total GHG emissions in the world, Nepal will be affected disproportionately, especially from increasing atmospheric temperature. Changes in the annual rainfall pattern, intense rainfall and longer droughts have been observed. Similarly, both days and nights are presently warmer. The number of days with 100 mm of heavy rainfall is increasing. The timing and duration of rainfall is changing. The adverse impacts of climate change have been noticed in agriculture and food security, water resources, forests and biodiversity, health, tourism and infrastructures.

The agro-climatic diversity of Nepal also favors different kinds of vegetable seeds hence have both the comparative and competitive advantage for the local markets as well exports to International markets. Over the past decade, Nepal’s vegetable seed industry has grown considerably with respect to the number of farm families engaged in vegetable seed production and the quantity of seed produced and marketed within and outside country with support of various governmental and non-governmental organizations. They have targeted small, poor and disadvantaged farmers and have been able to demonstrate that vegetable seed production can be a viable option.

**METHODOLOGY**

The first hand data were collected by conducting face to face interview with the vegetable seed producing farmers of seven potential vegetable seed production districts of the country i.e. Dhankuta, Sarlahi, Dadeldhura, Ramechhap, Rukum, Surkhet and Mustang covering five development regions ranging from high hilly region to Terai. Similarly, Focus Group Discussion and Key Informant Survey were also conducted for the collection and triangulation of the data. Meteorological data of the study districts for the period of last 10 years (2001-2010 A.D) were collected from Department of Hydrology and Meteorology and analyzed by using different data analysis software as SPSS & MS Excel sheet.

**RESULT AND DISCUSSION**

**Annual rainfall trend**

The annual precipitation in the study area within a decade showed an erratic pattern of rainfall with an alternate increasing and decreasing pattern. In Terai areas maximum rainfall occurred in the year 2004 and 2007 and minimum in the year 2009. The pattern of rainfall shows a slightly increasing trend in the mountainous areas receiving higher amount of annual precipitation. Amount of total precipitation in mid hills was found decreasing continuously with a slight increase in the year 2007 only. Interestingly, the year 2004 received highest rainfall in Terai whereas just opposite to that the mountainous areas received the lowest precipitation in that year. This erratic pattern of rainfall with an alternate increasing and decreasing pattern within the country thus creating rain deficit in some areas moderate rainfall in other and alternate changing pattern of rainfall creating floods, landslides in one year and severe drought in other as well. The pre monsoon and winter rainfall was also in decreasing trend in terai whereas rainfall pattern shows increasing trend in case of high hills which shows terai areas more vulnerable due to erratic rainfall pattern whereas high hills might benefit from the increasing rainfall pattern to some extent.

**Change in temperature**

Figure 2 shows a slightly increasing trend in average annual temperature within the study area within a decade. Nepal’s temperature has increased by 1.8 degree Celsius during last 32 years. In Nepal average temperature increase was recorded as 0.06 degree Celsius per year and that
in Terai and Himalayas was 0.04 degree Celsius and 0.08 degree Celsius/year respectively (Shrestha et al., 1999). The increasing trend of temperature was found higher in high hills and mid hills as compared to Terai. Furthermore, warming in the winter was higher as compared to other seasons.

![Figure 2: Trend of change in temperature over a decade (2001-2010)](image)

Farmer perception on climate change within a decade

Most of the respondents in the study areas perceived the change in temperature (29.5%) and change in rainfall pattern (24.6%) as the most prominent and important indicators of climate change. Change in temperature and rainfall pattern is the most prominent indicators of climate change as perceived by farmers. Almost all the respondents (86% in high hills, 72% in mid hills and 78% in terai) responded that they felt increase in temperature as compared to previous years. None of the respondents reported the decrease in temperature concluding that days are getting hotter and felt more in high hills. Similarly, the increase in winter temperature was felt more than that of summer experiencing warmer winters than previous years. The high hills received higher amount of precipitation in the recent years in terms of intensity and duration of monsoon. Almost all vegetable seed producers in high hill felt increased precipitation

![Figure 1: Trend of annual precipitation in the study area (2001-2010)](image)
whereas trend of rainfall was in decreasing pattern in mid hills and Terai as experienced by 81% and 60% of the respondents respectively. Also, 34%, 94% and 60% of respondents in high hills, mid hills and terai felt the initiation of monsoon has delayed thus enforcing delayed plantation of major crops. Similarly, the decrease in snowfall is especially felt in the high hilly areas. During FGD, farmers reported that snowfall used to occur 8-9 times up to 4-5 feet few years before but had decreased to 4-5 times up to 4-5 inches only these years. Similarly, thunderstorms were felt sometimes which was unusual previously. Early flowering of forest plants i.e. Rhododendron and temperate fruits i.e. apple, pear, peach, plums etc were felt in mid and high hilly areas. Similarly the drying of natural water resources, more effort needed to take water from the wells due to decreasing water level, drying of ponds/lakes were felt in Terai regions. The increasing disease pest infestation was however felt by most of the respondents of the study area.

Effects of climate change in vegetable seed production

There was mixed response of the farmers when they were asked about the effect of climatic change on the vegetable seed production. Very few farmers (20% in Mustang, 12% in Mid Hills, 4% in Sarlahi) reported that they felt some positive impacts due to climate changes. Farmers of Mustang were able to grow cauliflower, cabbage, chili, tomato and cucumber, which used to require greenhouses in order to survive. Similarly some farmers of Dadeldhura reported that the shift in planting time of Lady’s Finger from June to August has prevented seed damage due to excessive rain. 41% of the respondents in Mustang expressed their view that cultivation of Brinjal, Chilly and cucurbits has been done successfully in Mustang these days due to favorable environment created due to changed climatic condition. The flowering and ripening of Broad leaf mustard, Cabbage, Carrot has sifted 10-15 days before. However higher proportion of respondent were in the view that they experienced negative impact of changed climate. Most negative effects were felt in Sarlahi as responded by 89% of the farmers followed by mid hills (78%) and Mustang (40%) was found. Comparatively less and untimely rainfall had affected the sowing and harvesting time especially in rain fed areas. Increased temperature especially in Terai had affected the flowering, seed setting and ripening of specially the cucurbits and tomato. Hybrid seeds are more sensitive to humidity and temperature, therefore, their germination and development is directly affected by such weather conditions. Dry spell directly affects the quality of vegetable
seed produced. There is higher pest incidence due to drought conditions. The increasing disease pest infestation, as indicated by 63% of respondents in Mustang, 21% in mid hills and 32% in Sarlahi was the major negative impact. Decreased in quantity and quality of seeds produced (22%) was another negative impact felt.

**Shift in planting time**

The impact of climate change as perceived by the vegetable seed producing farmers was the shift in planting time. Most of the respondents (66% in Mustang, 72% in mid hills and 86% in Sarlahi) felt that the planting time has pre-pond by about 15-20 days. The shift was found greater in Mustang (25 days) and lower in case of Sarlahi (13 days). However, planting time in case of rainy season crop had shifted some days after (22% in mid-hills and 8% in Sarlahi) generally due to delayed monsoon.

**Change in flowering and ripening time.**

Change in climate as perceived by the farmers of the study area had direct affect on flowering and ripening of vegetable crops. Majority of the respondents in mid-hills (80%) felt early flowering of vegetable crops especially the Cole crops and radish. Similarly, flowering in Tomato, brinjal was felt earlier in Terai region. Flowering of Broad leaf mustard, cabbage, Chilly and carrot have shifted some 15-20 days earlier in Mustang. Change in ripening time was found in line with that of flowering time of vegetable crops.

Eighty nine percent of farmers in mid hills, 73% in Mustang and 67% in Sarlahi experienced crops reaching early maturity. Farmers had their opinion that the increase in temperature lead to forced maturity of the seeds. During cold waves in Terai the ripening time of vegetable seeds were found delayed.

Both the early and late ripening had adverse affect in seed quality. Problem in seed shape, size and luster were experienced due to early maturity. Kumar et.al, 2009 in one of the study found rapid rise of temperature at the time of the pollination lead to pollen abortion in cabbage hence no viable seed was produced. Though no cases of complete failure to seed set in any of the vegetable seed produced in the study area, the increased temperature decreased setting of seeds especially in beans in mid hills (71%) and Tomato and cabbage in Sarlahi (54%). The production per unit area of seeds was found decreasing as responded by 74.1% of the respondents.

**Effect on quality of seed**

Much of the variation in seed quality among seed lots is the direct or indirect result of variation in weather before or at harvest, hot dry periods generally providing good quality seed (Austin, 1972). Majority of the respondents (94% in mid hills, 93% in Sarlahi and 66% in Mustang) felt decreased seed size as compared to previous year. Similarly, the shape of the seed was also found changed. The wrinkled seeds were found by 71% and 59% of the respondents in mid hills and Sarlahi respectively. The proportion was relatively less (7%) in case of Mustang. Farmers also found decrease in luster of the seed they produced. Almost 80% of the farmers accepted that seeds were dull looking and less attractive than previous. Sher Bahadur Roka of Surkhet worried that the quality of seed has decreased so rapidly that farmers/buyers might not accept for seed purpose. Some farmers in Ramechhap reported late harvesting and drying of bean seeds due to continuous rainfall at the harvesting season thus degrading the seed quality. Siddique and Goodwin, 1980 found reduced seed quality in bean (Phaseolus vulgaris L.) due to high temperatures after anthesis.
**Intensity of disease pest**

Results indicate that climate change could alter stages and rates of development of the pathogen, modify host resistance, and result in changes in the physiology of host-pathogen interactions. The most likely consequences are shifts in the geographical distribution of host and pathogen and altered crop losses, caused in part by changes in the efficacy of control strategies. Incidence of pest and diseases was found more severe in Terai. The incidence and damage caused range from medium in some crops to devastating loss in other. Ninety three percent of respondents in Sarlahi felt excessive incidence of disease in some major vegetables as beans, cucurbits, tomato and potato.

The increased infestation of aphids, fruit fly and borer had directly affected the production and increased cost of production whereas the yellow mosaic virus in lady’s finger and mosaic virus in tomato has decreased the quality of the produced seed. Cabbage butterfly and Diamond black moth infestation in cabbage, cauliflower and radish, neck rot in Tukinasi variety of radish was felt increased in Mustang. Gradual shift of pest and disease of Sarlahi have felt in hills and mountains. The infestation of aphids and powdery mildew were found increased in Mustang. Some pathogens of important crops from Terai zones has adapted in hills and mid-hills (e.g. rust and foliar blight) that adversely affects the quantity and quality of vegetable seeds. However during group discussion in Dadeldhura some positive impact of changed climate in disease pest infestation were also discussed. The decreased infestation of beetle in beans due to late plantation (Third week of August) in comparison to the early plantation in July was felt. This was due to the completion of the life cycle of the insect before planting time. Radish when planted in third week of August showed less or no infestation of aphids compared to late plantation in September.

**SUMMARY AND CONCLUSION**

Climate change is evident in the study areas. Communities are already experiencing unusual changes in temperature and rainfall patterns, which were supported by a number of indicators such as decreased rainfall over the last few years, increased rainfall intensity within short duration, increasing temperature, invasion of weeds and species, and outbreak of pests and diseases. These outcomes were linked to increased risks and hazards, increased magnitude of impacts and their severity and vulnerability posed by such factors in vegetable seed production and hence to the livelihoods of farmers residing in all the three ecological zones.

Current and future scenarios of climate change indicate that many of the study areas will face risks that include higher aridity, more variable water supply, melting of glaciers, erratic rainfall, and periods of water scarcity and drought. Drought may cause outbreak of pests and diseases. The shift in planting, flowering and ripening time of vegetable seeds, decrease in quantity and quality of seed produced, poor germination of seed, poor pod and seed setting along with the change in crop canopy were also experienced by the farmers of the study area. Impacts were observed contributing to loss of species and local landraces, declining productivity and yield, outbreak of diseases and pests.

**ACKNOWLEDGEMENT**
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Supply Situation of Vegetable Seeds in Nepal: An Analysis from Policy Perspective

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ABSTRACT

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The government of Nepal has approved different policies and legislation related to seed and emphasized the importance of quality improvement in the seed sector. However, the public and private sectors face problems to access quality assurance services, maintain the quality of seeds and supply based on the demand to the consumer. Considering the situation, this paper tries to analyze existing production, requirements and distribution scenario of selected vegetable seeds along with policy issue in the vegetable seeds sub-sectors in Nepal. Based on the analysis, policy options were recommended for seed quality improvement and income generation. Results indicated that over the four decades, the demand for vegetable seeds is increasing at a rapid rate compared to seed production. The national demand of vegetable seed could be met by adopting two strategies: first, the effort of varietal development, maintenance, testing and national listing of imported varieties that are suitable for different locations should be combined with the maintenance of the seed cycle based on the farmer’s preference, and second, the effort is needed to improve the quality of seeds by adopting proper postharvest operation such as appropriate drying and storage technology. It is necessary to manage the supply of farmer preferred varieties and quality seeds through government initiative by creating conducive environment to private sectors investment. For seed quality improvement, the identified role of the public sector, private sector and community-based organizations (CBOs) should be implemented in right time synchronized to meet the national demands of the vegetable seeds.

Key words: vegetable seeds, strategies, requirements, policy issues

INTRODUCTION

Government of Nepal (GoN) has launched the Seed Act in 1988 and the enabling Regulations in 1997 to make available high quality seed for increased production and to protect the seed user and seed seller from fraudulent practices (Shrestha et al., 2001). Consequently, the Ministry of Agriculture and Cooperatives (MOAC), with the advice of the National Seed Board (NSB), has formulated a National Seed Policy, 2056 (1999), in compliance with the Seed Act and Regulations and the ongoing seed program. Seed certification in Nepal is voluntary, but truthful labeling for containers of notified crops varieties offered for sale in market is compulsory, as per provision of Seed Act 1988 (Thapa et al., 2008).

National Seed Company Ltd. (NSC/L), government farms, research stations and private sectors are the formal seed supplying organizations, and they have good seed networks for seed replacement of cereals and vegetables. While International/National Non-Government Organizations (I/NGOs), different donor agencies and the government have been involved in seed production and seed supply system in the country, the informal seed supply system still plays a significant role in meeting the seed demand of the farmers (Thapa et al., 2008). Until the mid-1980s, more than 90 percent of Nepal’s vegetable seeds requirement was met by informal sources, i.e., own production and farmer-to-farmer exchange. But in the last thirty years the commercial seed sector has grown rapidly. From a mere 10 tonnes of commercial seeds produced in 1975/76 (9 tonnes from government farms and one tonne from private growers), it reached around 1335 tonnes in 2012. The total demand for vegetable seed in Nepal is around 2085 Mt (VDD, 2012). Above data indicate that the total production of seed in Nepal is not fulfilling the national demand (750 mt deficit). To meet the national demand, the remaining quantity of seed is being imported from abroad and farmers are using their saved seed. Now the formal sector supplies 70 percent of the total demand, which was only 10 percent in 1984/85. Currently, the vegetable seed production is mainly organized through contract production, with technical support mainly provided by the Vegetable Development Directorate (Department of Agriculture, GoN/ Nepal), Nepal Agricultural Research Council and different
NGOs (Thapliya, 2006 and NARC, 2012). Even though there is an increasing trend of seed supply from formal sectors, the farmers at the field level are facing problems regarding its quality aspects. Furthermore, Thapa (2007) reported that from samples collected in the years from 2000/01 to 2006/07 in Nepal, about 24% of the tested samples were found to be below standard, indicating that low quality seeds were being sold in the market. This indicates the need for an effective seed law enforcement program and active participation of the private sector in the quality assurance system in Nepal to meet prescribed seed standards. On this background, this paper analyzed the existing production and distribution scenario, policies, legislation and guidelines related to vegetable seeds sub-sector in Nepal. Based on the analysis, policy options were recommended for seed quality improvement and seed supply based on consumers demand to generate information for actors involved in vegetable seeds supply chain in Nepal.

METHODOLOGY

The majority of data used in this paper were from secondary sources (publication from Seed Quality Control Center (SQCC), Nepal Agricultural Research Council (NARC), Vegetable Development Directorate (VDD) etc) except some data related to seed production from seed companies and other seed stakeholders. The information collected from the different sources was coded, tabulated and analyzed using Microsoft excel for calculating present national production requirements and the supply situation of vegetable seeds. For the case study, five vegetable crops including onion (Allium cepa), tomato (Solanum lycopersicum), cucumber (Cucumis sativus), okra (Abelmoschus esculentus) and French beans (Phaseolus vulgaris) were selected after discussion with seed experts and related stakeholders based on their relative importance in Nepal. Compound growth rate (CGR) of vegetable production area, vegetable seed production and seed requirements were calculated over the past four decades. The future projection of required quantity seed for the above mentioned vegetables for the coming five years were also analyzed. The detail description of compound growth rate (CGR) and growth rate (GR) are given below.

Compound growth rate

Growth of any variable indicates its past performance. The analysis of growth is usually used in economic studies to determine the trend of a particular variable over a period of time. As it indicates the performance of the variable under consideration, it can be used to make interpretations and to evolve policy decisions. Compound growth rate (CGR) of vegetable production area, vegetable seed production and seed requirements were calculated over the past four decades.

\[ Y_t = a + b^t u_t \]  \hspace{1cm} (1)

Where,

- \( Y_t \) = dependent variable for which growth rate was estimated
- \( a \) = intercept
- \( b \) = regression coefficient \((1 + g)\), where \( g \) is the compound growth rate,
- \( t \) = years which takes values, 1, 2, ..., \( n \), and
- \( u_t \) = disturbance term for the year \( t \).

The equation was transformed into log-linear form and was estimated using the ordinary least square (OLS) technique. The compound growth rate \( g \) in percentage was then computed from the relationship:

\[ g = \left\{ \text{Antilog of (ln} \ b - 1) \right\} \times 100 \]  \hspace{1cm} (2)
The significance of the regression coefficient was tested using the student’s’ test (adapted from Gaire et al., 2011 and Gujarati, 1999).

**GR calculation for selected vegetable seeds for 5 years (2011/12 to 2016/17)**

The growth rate (GR) for the next 5 years was calculated from the following equation:

\[ P_1 = P_0 (1 + r)^n \]  

(3)

Where \( P_1 \) = future requirement of seed, \( P_0 \) = present production/utilization of seed, \( r \) = growth rate, \( n \) = number of years. In our case:

\[
\log (P_1) = \log (P_0) + 5 \log (1 + r) \\
\log (1 + r) = (\log P_1 - \log P_0)/5 \\
\log r = X \\
\]

Where value of \((\log P_1 - \log P_0)/5 = X\)

\[ r = e^X \]

**RESULTS**

**Vegetable seed production and requirements in Nepal**

The data for area used in fresh vegetable production and total vegetable seed production and requirements in Nepal are available since 1974/75. Area under the vegetable crops in 1974/75 was 82,000 ha, total physical production of vegetable seeds was 10 mt and requirements were 293 mt. These indicators increased substantially during 1974/75-2011/2012. Compared to 1974/75, the vegetable production area increased by about three-fold (244,102ha), seed production increased by 127-fold (1274.4 mt) and seed requirements increased by almost 7-fold (2085 mt) in the year 2011/12. The compound growth rate of fresh vegetable production, vegetable seeds production and seed requirements was 2.46%, 15.24% and 5.29%, respectively, over this period (VDD, 2012; SQCC, 2012). The private sector started entering in seed business in the early 1980s with enforcement of the Seed Act of 1989, which has boosted the critical role of private seed industry in Nepal. Since the early 1990s, the government of Nepal has been making some efforts at privatization of the seed industry and at present, the private sector accounts for more than 95% share in organized vegetable seed production and marketing (Bharati et al., 2008). Even though the percentage increment in seed production was much higher than seed requirements, average annual growth rate of production was lower (33.05 mt) compared to seed requirements (46.46 mt) in Nepal. The vertical line shows the shortfall between per annum seed production and seed requirements (Figure 1). Since the late 1990s, vegetable production area, the demand for vegetable seeds and seed production have increased in parallel, but with a gap of approximately 750 mt between them being met through either import or through informal channel (farmers to farmers exchange, illegal entry of seeds).
Figure 1. Area used for fresh vegetable production, total domestic seed production and seed requirements in Nepal over four decades.

To answer the question how much vegetable seeds is required to meet the national requirements, the needed growth rate of domestic seed production to meet the national requirements were calculated. Projection was performed until 2016/17 based on available data. During projection of area, average annual growth rate 1974/75-2011/12 was used and it was assumed that the annual growth rate will be constant. Of the total seed, 75% is accounted for by peas, beans, onion, radish, cowpea and okra. The size of the different vegetable seeds is different and its seed rate and multiplication ratio also varied based on crops. So, in case of vegetable seeds requirements, the source seed (breeder and foundation seed) and improved seed requirements of only five selected vegetable crops were calculated for precise results based on the seed rate and multiplication ratio required for each individual crops.

In case of onion, total breeder, foundation and improved seed production in the year 2011/12 was 0.011 mt, 0.366 mt and 10.06 mt, respectively (NARC, 2012; SQCC, 2012; Field Survey, 2012). To meet the national requirements from domestic production based on the available area for onion production in the year 2016/17, the projected amount of above mentioned seeds is about 0.105 mt, 5.28 mt and 264.40 mt. The growth rate of 1.57, 1.71 and 1.92 per year is needed for breeder, foundation and improved seed, respectively to meet the above requirements of onion seed production. The breeder, foundation and improved seed production for tomato in the year 2011/12 was 2.7 kg, 113 kg and 13051 kg, respectively (NARC, 2012; SQCC, 2012; Field Survey, 2012). Only 0.133 kg, 27.9 kg and 5858 kg of breeder, foundation and improved seed, respectively, is needed to fulfill requirements in the year 2016/17. The present production is enough to meet the national requirements. The growth rate of 0.55, 0.76 and 0.85 per year is sufficient for breeder, foundation and improved seed, respectively to meet the above requirements of tomato seed production. A similar situation was the case for breeder seed of cucumber. The breeder, foundation and improved seed production for cucumber in the year 2011/12 was 5.35 kg, 30 kg and 1650 kg, respectively (NARC, 2012; SQCC, 2012; Field Survey, 2012). The quantities of 1.44 kg, 144 kg and 14478 kg of breeder, foundation and improved seed, respectively, were needed to fulfill requirements in the year 2016/17. Thus, present production of breeder seed is enough to meet the national requirements. The growth rate of 0.77 for breeder seed is sufficient; however, a growth rate of 1.37 and 1.54 per year is
needed for foundation and improved seed, respectively, to meet the above requirements of cucumber seed production. In case of okra, total breeder, foundation and improved seed production in the year 2011/12 was 0.012 mt, 0.580 mt and 25.52 mt, respectively (NARC, 2012; SQCC, 2012; Field Survey, 2012). To meet the national requirements from domestic production based on the available area for okra production in the year 2016/17, the projected amount of above mentioned seeds is about 0.45 mt, 3.60 mt and 288 mt. The growth rates of 1.30, 1.44 and 1.62 per year are needed for breeder, foundation and improved seed, respectively to meet the above requirements of okra seed production. There are different types of French bean are available in Nepal. During calculation of seed production and requirements, all types (sword, pole and bush type) of French bean were included. Total breeder, foundation and improved seed production in the year 2011/12 was 0.081 mt, 1.17 mt and 25.91 mt, respectively (NARC, 2012; SQCC, 2012; Field Survey, 2012). To meet the national requirements from domestic production based on the available area for French beans production in the year 2016/17, the projected amount of above mentioned seeds is about 0.37 mt, 14.80 mt and 592.08 mt. The growth rates of 1.36, 1.66 and 1.87 per year are needed for breeder, foundation and improved seed, respectively to meet the above requirements of French bean seed production (Figure 2).

**Figure 2.** Details growth rates of breeder, foundation and improved seeds for different vegetable crops

<table>
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<tr>
<th>Seed laws, policies and guidelines</th>
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<td>Government of Nepal (GoN) has prepared the seed vision 2013-2025 as a seed sector development strategy in Nepal. It aims to increase crop productivity, enhance income and</td>
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<td>Year</td>
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<td>2004</td>
<td>National Agriculture Policy: 2004 (2061)</td>
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<td>2000</td>
<td>National Seed Policy: 2000 (2056)</td>
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<td>1997</td>
<td>Seed Regulation: 1997 (2054)</td>
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</table>
A seed act was passed by parliament in 1998 to regulate quality seed production functions (Thapa et al., 2008). It is a brief document, which allows regulations to be made to deal with its enforcement (Shrestha et al., 2001). The main features of Seed Act 1998 are: functions, duties and powers to NSB; power to constitute sub-committee under NSB; establishment/functions, duties and responsibilities of Central Seed Testing Laboratory (CSTL); power to notify the kind and varieties and prescribe the minimum level of purity and germination of notified kind varieties; truthful labeling of container of notified kind varieties is compulsory (voluntary seed certification); appointment/functions, duties and responsibility of seed analyst and seed inspector; permission from NSB for import and export of notified kind varieties from Nepal; power to hear the cases and provision to institute the cases and punishment; reorganization to national and international organization for seed testing and certification; and power to frame the rules for seed law enforcement.

Government of Nepal revised the Seed Act 1988 to redefine the certain terms and definitions and make it apposite in the line of international practices and context of the World Trade Organization (WTO). This was first amended in 24 Jan. 2008. The main provisions in amended Seed Act, 1988 include: redefining the terms and definition in line with international practices: mandatory participation of women in NSB; licensing system to establish private seed testing laboratory; establishment of Seed Quality Control Centre (SQCC) in place of Seed Certification organization; authority to private sector to involve in quality assurance system through licensing of seed analysts; seed sampling and crop inspection; appointment of chief of SQCC as member secretary of NSB; permission from NSB is required for seed business; restriction to sale un-notified kind and varieties of seeds; establish the fees and levied service charges for seed testing and certification; and increase fines and punishments (MoAC/GoN, 1998).

Agriculture Perspective Plan: 1995-2015
Among four important input priorities set by APP, technology is considering an important input which also includes seed production as a technology. It recommends seed production along with non-research activities to be diverted to competitive private sector operations, i.e., market based. Moreover, high value-crops are among commodity priorities – e.g., vegetable seeds are prescribed for hills & mountains (APP, 1995).

Community Seed Bank-Implementation guideline-2065 (2009)
It focuses on type of seed such as modern varieties (MV), farmers varieties; seed multiplication and storage through collective and individual approach; seed processing using farmers and modern methods and seed exchange through cash transaction, barter and seed loan (Shrestha et al., 2013).

DISCUSSION
In most of the policies, guidelines and legislation related to seeds, there is more focus on the quality seed production and assurance of its supply for increasing production and productivity of the crops. Even though the government of Nepal approved different policies and legislation, most of the public and private sectors face problems to get quality assurance services in time due to limited government resources and manpower (Thapa et al. 2008). In addition, most of the seed produced by public and private sectors is marketed without meeting prescribed minimum seed standards and proper labeling due to lack of their own internal quality assurance system and effective seed law enforcement program in Nepal (SQCC, 2003). Low quality seeds were being sold in the market, which demanded an effective seed law enforcement program and active participation of private sector in quality assurance system in Nepal to meet prescribe seed standards for proper drying, storage and truthful labeling of notified kind and varieties. National Seed Company Ltd. (NSC/L), government farms, research stations and private sectors are the formal seed supplying organizations. They have very good seed networks for seed replacement of cereals and vegetables. Even though, different donor agencies and government have been involved in seed production and seed supply system in the country, the informal seed supply system plays a significant role in supplying seed demand of the farmers (Thapa et al., 2008). It is estimated that 90% of the total production and distribution of cereal seed in
Nepal is still met through the informal sector (Thapa Chhetry, 2006 cited in Thapa et al., 2008). Less than 5% of the total requirements are met through the network of NSC/L and less than 1% is reported to be met through imports (Hada and Dawadi, 2001 cited in Thapa et al., 2008).

Seed certification in Nepal is voluntary, but truthful labeling for containers of notified crops varieties offered for sale in market is compulsory as per provision of the Seed Act 1988 (Thapa et al., 2008). In the field, it is observed that, most of the farmers are producing un-notified varieties of different crops and selling them to the market without truthful labeling (Field survey and personal communication with various stakeholders, 2012). The main reasons for doing that were due to more demand for those varieties, their easily availability and lower price. The formal seed sector may need to consider the notification and formalization of those varieties which are the farmers’ preference rather than focus on multiplication of only registered varieties. In the case of cereals, seed certification programs are in place, but in case of vegetable seed production, seed certification programs have not been initiated yet, which is one of the major factors for quality deterioration of vegetable seed. Illegal import, untrained sellers (agro-vets), unlabeled seeds and weak seed inspection are the major factors for poor policy implementation (Shrestha and Pandey, 2011). Effective implementation of seed policy and legislation, development and harmonization of seed policy with latest development, demand based source seed production and marketing and faster development, release and deployment of farmers preferred varieties in farmers field is required for efficient functioning of seed system in Nepal (Gauchan et al., 2014).

Available data showed that the open pollinated (OP) seeds that were sourced entirely from domestic production about a decade ago are being rapidly replaced by imports (Budhathoki et al., 2002). At the same time, hybrid seeds are becoming popular, especially among commercial growers. In Nepal, only one hybrid variety of tomato called Shrijana has been registered and K1F1 hybrid of cucumber is in the process of registration among different vegetables (NARC, 2012). Out of 244 vegetables varieties registered, 214 varieties are hybrid. The only registered varieties of okra and French bean were OP, but more than 80% of varieties of tomato, cucumber and onion registered for import were hybrid (Paudyal, 2012). All the registered varieties for import were F1 generation (hybrid). The reason for importing of those hybrids might be due to higher quality of seed, higher production and suitability for different climatic conditions and seasons as the domestically released varieties are not adapted to all ecological domains in all seasons. In one side of our result showed that the present production of tomatoes source seed (breeder, foundation) and improved seed is enough for the national requirements. Similarly, present production of cucumber seed is also enough for national requirements if proper seed chain is maintained after production of breeder seed. At the same time, 22 varieties of tomato and 32 varieties of cucumber were registered for import. These data reflect that production of only certain varieties for particular crops is not sufficient to meet the national requirements across all vegetables. To meet the national demand, varietal development, varietal maintenance, maintenance of the seed cycle, and improvement of seed quality must be improved based on the preference of the farmers by keeping them in center. It is necessary to manage the supply of farmer preferred varieties through government by creating conducive environment to private sector investment. Vegetable seed is a very international business, particularly for advanced varieties and hybrids, so it is not necessarily evident that Nepal can or should aim to produce all of its own vegetable seeds. Certainly some of the lower value seeds that can be produced locally (onion, okra, pea, bean, etc.), and there is also potential for Nepal to do hand-pollinated hybrids such as Shrijana tomato.

Budhathoki et al. (2002) reported that the quality of Nepalese seeds has been deteriorating, prompting farmers to switch to imported seeds. Low seed moisture content is pre-requisite for long-term storage and is the most important factor causing loss of seed viability and vigor during processing and storage. The demand for quality seed is increasing day by day, presenting
new challenges to meet the consumer’s demands by taking competitive advantage in the context of international practices and WTO. The present need is to identify the roles of public and private sectors in seed quality management for supply of good quality seeds at national and international levels in sustainable ways through which every actor in the seed chain benefits from the improvement in seed quality. For seed quality improvement, the possible role of the public sector, private sector and community-based organizations (CBOs) are described below.

**Roles of the Public Sector**

- Increase the involvement of the private sector in seed business through revising and developing the quality assurance fee to support seed testing, field inspection, and seed certification to sustain private seed business.
- Strengthen the monitoring and supervision system to control the quality of seed on the basis of national seed and field standards.
- Establish seed certification programs to improve seed production and quality control.
- Provide seed crop inspectors, seed samplers and seed analysts in government, non-government and private sector who are monitored through a regulatory framework.
- Issue seed licenses for quality seed production and distribution by district and regional offices.
- Raise awareness about improved seed among general farmers, emphasizing quality parameters and seed regulation.
- Reduce the postharvest loss and improve the germination and vigor of the produced seed by improved drying and packaging.
- Focus on providing soft loans to the private sector for the promotion of seed enterprises especially for source seed production and post-harvest operations.
- Support capacity building and harmonization of seed programs to maintain the seed quality and the seed propagation cycle in a sustainable way.
- Train the local level agro-vets for maintaining the quality of seed and provide some supports for maintaining good storage conditions in the marketing chain.
- Harmonize the seed act, rules, and regulations according to regional, national and international standards.
- Focus on continuous technology generation and dissemination in collaboration with private sectors.
- Coordinate and integrate seed programs guided by the seed vision, policy, act and regulation.
- It is suggested on the testing and national listing process that assures the imported varieties are suitable for different locations, rather than trying to do all of the breeding and seed production in Nepal.

**Roles of the Private sector**

- Work in close coordination with the public sector to improve seed quality and availability.
- Invest in research and development for quality improvement.
- Conduct comprehensive sensitizing programs for seed law enforcement (discussions, meetings, seminars and workshops).
- Backstopping the CBOs and farmers for quality seed production at the field level as well as for post-harvest operations.
- Strictly follow the seed certification and truthful labeling of seed.
- Encourage farmers to use high quality seeds.
- Be accountable for providing a high of standard seeds to end users.
- Use good drying, packaging and storage practices to maintain seed quality (good vigor and germination percentage).
• Continuously supply drying and storage materials at reasonable prices as and when required to CBO, dealers and farmers.
• Move toward selling seed based on seed count rather than seed weight basis for high priced seed.

Role of CBOs
• Be accountable for maintaining field standards during seed production.
• Use proper drying, handling and storage practices to maintain the quality of seed and minimize losses.
• Form seed quality control groups within the organization to monitor and enforce standards.

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Preliminary Screening of Advanced Potato Clones against Moisture Stress in Khumaltar, Lalitpur

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ABSTRACT
A preliminary study on potato cultivars was undertaken at Hattiban Research Farm Khumaltar, Lalitpur (1340 masl) during the years 2008/09 and 2009/10 to compare the responses of different advanced potato cultivars for their tolerance against moisture stresses. Completely rain-fed, rice-straw mulching and frequently irrigated conditions were considered as the moisture treatments in the trial. Among the assessed clones, CIP 394003.161, CIP 392243.17, CIP 391058.35 CIP 392242.25, Khumal Seto-1, CIP 378711.7, Ca x 27/40-7, CIP 396011.47, Primicia, CIP 391598.75, LBr 40, L 235.4, CIP 394007.55, Kufri Chipsona-2, NPI-106 and Ca x LBr 40.6 were found performing better than the check variety Kufri Jyoti in completely rain-fed conditions. In frequently irrigated treatment, clones CIP 391011.47, Ca x LBr 40.6, CIP 378711.7 and LBr 40 were superior, whereas in the mulching treatment, clone LBr 40 performed the best followed by 394003.161, Ca x LBr 40.6, CIP 391011.47, Kufri Jyoti, CIP 392250.56, Primicia, CIP 391598.75, CIP 392236.6, Khumal Seto -1, CIP 389746.2, 27/40, Des x LBr 43.18, CIP 800947 and 391058.35 respectively in assessed phenotypic, yield and its attributes compared to Kufri Jyoti and Desiree. This result clearly indicated that the overall performance of the clone was more under genetic control rather than the environment factors. Based on the preliminary results, the best performing clones will be further assessed in multi-locational varietal trials of National Potato Research programme in the future.

Keywords: Potato clones, variety section, moisture stress, rain-fed conditions.

INTRODUCTION
Potato (\textit{Solanum tuberosum} L) ranks 5\textsuperscript{th} in area, 2nd in production and first in productivity among the major food crops of Nepal (ABPSD, 2011). It produces nutritious food more quickly, even in harsher climates than most of other crops. It is well adapted in different climates, but it can be adversely affected by temperature extremes than other warm season crops. Thus, potato may be among the crops most-affected by climate warming (Bonierbale \textit{et al.}, 2008). Global warming has been expected to have profound effect on potato production worldwide including Nepal. One of the major effects of global warming is less availability and deterioration in quality of irrigation water.

Potato tuber itself consists of 80\% water and plant is herbaceous in nature. Due to this, all the developmental stages of potato plant are susceptible to moisture stress (Acharya, \textit{et al.}, 2008), which makes potato plant a highly sensitive crop to the stress which brings many physiological and bio-chemical changes in plants (Bansal and Nagarjan, 1987) and in the tubers as well.

Major focus of National Potato Research Programme (NCRP) in the past was on finding high yielding and disease resistant varieties which has resulted several commercial potato varieties suitable for different agro-climatic conditions (Khatri \textit{et al.}, 2010).

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Potato cultivar, named as NPI-106, one of the widely cultivated varieties in the hills, has been observed with moderate moisture stress tolerating trait in dry hills of Nepal (NPDP, 1988). Some of the mulching trials conducted in the past have significantly demonstrated very positive effect on moisture retention (NPRP, 1990). In some of the potato growing countries of the world including India drought tolerant varieties have been developed. International Potato Center (CIP) has identified a number of moisture stress resistance germplasm (CIP, 1992) which can be useful in Nepalese condition to develop climate smart varieties. Therefore, aiming to cope with low moisture stress through variety selection and moisture conservation present study was undertaken first time in the country.

MATERIALS AND METHODS

Total of 33 advanced potato clones available at National Potato Research Programme (NPRP) Khumaltar were assessed at Hattiban Research Farm of NPRP at Khumaltar in the years 2008/09 and 2009/10. The treatments applied were completely rain-fed, mulching and irrigated conditions. Rice straw was used as the mulching material. All other cultural practices were followed as per the NPRP recommendations. The crop was planted at first week of February both the years. To help tuber emergence, first irrigation was provided immediately after planting to all the treatments after then only irrigated plot was irrigated when needed and in other two treatments irrigation was completely stopped. In a plot, 12 tubers were planted per row in rod-row design with 60 x 25 row to row and plant to plant spacing. Fertilizer was applied at the rate of 100:100:60 kg NPK and 20 tons FYM per hectare. Plant growth parameters (% plant emergence, plant height, plant uniformity, plant vigor and number of main stems per plant) and tuber yield and its attributes such as the number of plants harvested, number and weight fraction of the tubers in three grades, total number and weight of tubers per plot, yield tons per hectare and color, shapes and eye depth of the tubers at harvest were the observations taken from experimental plots both the years.

RESULTS AND DISCUSSION

In the completely rainfed condition, LBr 40, CIP 391061.73, BR 63/65 and BSU PO3 were highest emerging clones, however, none of the clones had 100% emergence even at 45 days after planting (Table 1) which could be due to the moisture stress at emergence stage of the tubers. Single irrigation provided immediately after planting seems not sufficient to boost emergence in potato if soil is dry at planting. Probably due to the second irrigation in the irrigated treatment, emergence of clones ranged from 71 to 100%, whereas in mulching treatment, clones CIP 394007.55, CIP 393574.71B, LBr 40 and NPI 106 were the best performing clones in emergence. The average plant emergence was highest (94%) in irrigation treatment followed by mulching (90%) and lowest in rainfed treatment (77%). Percent ground cover of the clones was highest (75%) in CIP 393574.72B and lowest (20%) in Ca x 27/40 in rainfed treatment, whereas in irrigated conditions, highest (99%) ground cover was observed in the clone CIP 393385.39 followed by CIP 392242.25 (85%). Clone CIP 393574.72B had the highest percentage ground cover (83%). However, the percent ground cover of irrigated treatment was higher than the rainfed and mulching treatments.

Average plant vigour did not differ between irrigated and rainfed conditions, but slightly differed with mulching. Except Kufri Kanchan, none of the tested clones were superior in plant vigour, however, majority of the tested clones in irrigated treatment and some of the clones in rainfed conditions were scored 5 in 1-5 scales in plant vigour.

Average number of main stems was highest (4.7) in the clone CIP 393385.39 in rainfed treatment followed by CIP 389660.9 (4.5). Khumal Seto-1 had the highest number of main
Table 1. Treatment effects on vegetative characteristics of different clones, NPRP Khumaltar

Table 2 presents tuber yield and its attributes. Highest number of tubers per plot (1.5 m²) was harvested in the clone CIP 391598.75 (157) followed by NPI 106 (146) in the treatment rainfed, whereas in irrigated plots, clone L.235.4 was the highest tuber producing clone (194). In rainfed treatment, total tuber weight per plot was obtained highest (3.9 kg) from the clone CIP 391598.75 followed by NPI 106 (3.1), CIP 391011.47 (3.0 kg) and CIP 392242.25 (2.9 kg), respectively. In irrigated plot, clone CIP 391011.47 produced highest (4.7 kg) tuber yield. Clones CIP 391011.47, CIP 378711.7 and Ca x Lbr 4.06 were found superior to Kufri Jyoti. Almost all of the tested clones were superior to Desiree one of the check varieties in the study. CIP 391011.47 and Lbr 40 were highest yielding clones (Table 2) in mulching treatment. Clone CIP 391598.75 was found highest tuber yielder (25.7 t/ha) among all the clones tested in the trial in rainfed conditions followed by NPI 106 (22.6 t/ha) and CIP 391011.47 (20.7 t/ha), CIP 391058.35 (20.5 t/ha), respectively. In irrigated conditions, clone CIP 391011.47 produced highest yield (31.2 t/ha) and Kufri Kanchan produced lowest (9.7 t/ha). Kufri Jyoti, one of the check varieties also gave satisfactory yield (24.7 t/ha). In mulching treatment, clone CIP 391011.47 was found highest yielder (26.9 t/ha) followed by Lbr 40 (26.0 t/ha).
Table 2: Treatment effects on vegetative characteristics of different clones, 2067/68 and 2068/69 at NPRP Khumaltar

<table>
<thead>
<tr>
<th>Clones</th>
<th>Number</th>
<th>Wt. kg</th>
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<td>T1</td>
<td>T2</td>
<td>T3</td>
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<td>72</td>
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Mean Adjusted yield: 25.7 t/ha in irrigated treatment followed by mulching (24.5 t/ha) and lowest (14.3 t/ha) in rainfed treatment. The average yield of all 3 different treatments was highest (26.3 t/ha) in the clone CIP 391011.47 followed by CIP 391598.75 (24.5 t/ha), LBr 40 (22.8 t/ha), Ca × LBr 40.6 (22.6 t/ha) and NPI 106 (21.8 t/ha), respectively, whereas check varieties Desiree gave 16.0 and Kufri Jyoti 20.6 t/ha respectively in the trial.

In completely rain-fed conditions, clones CIP 394003.161, CIP 392243.17, CIP 391058.35 CIP 392242.25, Khumal Seto-1, CIP 378711.7, Ca × 27/40-7, CIP 396011.47, Primicia, CIP 391598.75, LBr 40, L 235.4, CIP 394007.55, Kufri Chipsona-2, NPI-106 and Ca × LBr 40.6 were found performing comparatively better than the check variety Kufri Jyoti. In the irrigated treatment, clones CIP 391011.47, Ca × LBr 40.6, CIP 378711.7 and LBr 40 were superior to Kufri Jyoti (Table 2). In the mulching treatment, clone LBr 40 performed the best followed by CIP 394003.161, Ca × LBr 40.6, CIP 391011.47, Kufri Jyoti, CIP 392250.56, Primicia, CIP 391598.75, CIP 392236.6, Khumal Seto -1, CIP 389746.2, 27/40, Des × LBr 43.18, CIP 800947 and 391058.35 respectively.

The average yields of all the tested clones were highest (17.7 t/ha) in irrigated treatment followed by mulching (16.6 t/ha) and lowest (14.3 t/ha) in rainfed treatment.
Some of the clones like CIP 391598.75, NPI 106 CIP 39242.25 and CIP 391011.47, CIP 394003.161 and LBr 40 were found the best performing in all of the three conditions. The highest yield in irrigated treatment was obtained 31.2 t/ha whereas in rainfed conditions it was 23.5 t/ha and in mulching treatment, highest yield was 26.9 t/ha indicating that the contribution of moisture in tuber yield increment is highly significant. Based on all the performance, some of best clones will be assessed next year in replicated way at Hattiban Research Farm Khumaltar, in Physiology lab at NPRP Khumaltar, Lalitpur and in major collaborating research stations of NARC.

LITERATURE CITED
**ABSTRACT**

Farmers’ Field Trial (FFT) on Potato was carried out for four consecutive years (2007/2008 to 2012/13) in order to identify suitable clones with good plant uniformity, tuber color, shape, drought, pest and diseases tolerant, high productivity and suitable for the Karnali region of Nepal. Based on the results and farmer’s preference, clone 392222.25 is identified as high yielding drought tolerant variety, thus selected and recommended for cultivation in the Karnali region of Nepal.

**Key words:** Clone, drought, Karnali region, RCBD, tuber yield,

**INTRODUCTION**

Potato (*Solanum tuberosum* L.) is one of the most important tuber crops of Nepal. It is utilized as a major vegetable in terai and mid hills and used as a vegetable and staple food in high hills. It occupies the 5th position in area coverage and 2nd in total production and 1st in productivity among the food crops such as rice, wheat, maize, millet and potato) grown in Nepal. Area under potato is 197234 ha and total production 2690421 mt with an average productivity of 13.64 t/ha (ABPSD, 2012/13). The area under potato in Jumla district is about 2,650 ha which is 1.3% of the total cultivated area, total production 26,000 Mt with average productivity of 9.81 mt/ha (DADO, Jumla, 2012/13) which is far below to national average (13/6 t/ha). Ministry of Agricultural Development considered potato as one of the important cash crop of Nepal. However, potato serves as staple food in the high hills and plays a vital role in the food security in the Himalayan regions of the country. Out of total area under potato, around 19% is in the high hills and mountains, 44% in the mid hills and 37% in terai (NPRP, 2012/13).

In the recent years food security has become one of the biggest challenges of Nepal especially by the hills. Similar to other developing countries, food security situation has been affected in the country by the increasing population, changes in food habits and impacts of climate changes (Bista et. al 2013). Low productivity of potatoes in the Karnali region has been identified as core problem resulting from several limiting factors such as inadequate disease free, drought tolerant basic seed of recommended varieties of potatoes to flush out the degenerated seed potatoes, inadequate knowledge regarding the new varieties and inadequate availability of quality seed potatoes of recommended varieties. To overcome these problems, farmer's field trial on different clones of potato was conducted at outreach sites of Agriculture Research Station (ARS) Jumla.

**MATERIALS AND METHODS**

Seven different clones of potato were evaluated and compared in RCBD with eleven replications during 2007/08 to 2008/09 and 7 replication during 2012/13 whereas 13 different varieties in three replication (farmer per replication) during 2011/12 at Patmara VDC of Jumla. The plot size was assigned 7.2 m² (3m x 2.4m). The plots were fertilized with 20 ton compost/ha. Well sprouted tubers of 25-50g size were planted with 60 cm x 25 cm spacing. Planting and harvesting was done on the last week of Chaitra and last week of Bhadra, respectively. All the management practices were followed as per the recommendations. The necessary data for growth, yield and yield parameters were recorded and statistically analyzed.
RESULTS AND DISCUSSIONS

During 2007/08 to 2008/09, seven different clones of potato were evaluated and compared with Khumal Seto -1 and Jumli Local. The tallest plants were measured in clone CIP 394037.103 and Jumli local (39 cm) where as lowest in Kufri Chipsona -2 (31 cm). The highest number of stem per plant was measured in CIP 392222.25 (5) where as lowest in L235-4. In respect to plant maturity, clone 392222.25, L235-4, Khumal seto 1 and TPS 7/67 (F1C1) were medium and others were late in maturity.

Regarding the shape of tested clones, Jumli local was found long tuber shaped whereas rest of the clones were found round shaped. Regarding color of tested clones, clone 394037.103 was found red skinned and rests were white. With respect to the yield and its attributes, Jumli local produced the highest number of tubers per plot (538) followed by L235-4 (351) and lowest in Khumal Seto -1 (290). Clone CIP 392222.25 produced the highest tuber yield (22.2 mt/ha) followed by HPS 7/67 (19.0 mt/ha) and lowest (14.3 mt/ha) in 394037.103 (Table 1 and 2).

Table 1: Characteristics of different potato clones tested at farmer’s field of Jumla during the summer season of 2007/08

<table>
<thead>
<tr>
<th>Clones</th>
<th>Plant ht (cm)</th>
<th>No. of main stem</th>
<th>No. of tubers/plot</th>
<th>Yield/plot (Kg)</th>
<th>Yield/ha (t/ha)</th>
<th>Maturity</th>
<th>Tuber characteristics</th>
<th>Color</th>
<th>Shape</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
</tr>
<tr>
<td>392222.25</td>
<td>41</td>
<td>5</td>
<td>349</td>
<td>16.06</td>
<td>22.33</td>
<td>M</td>
<td>W</td>
<td>R</td>
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<tr>
<td>L235-4</td>
<td>34</td>
<td>3</td>
<td>345</td>
<td>13.18</td>
<td>18.3</td>
<td>M</td>
<td>W</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>Khumal Seto 1</td>
<td>35</td>
<td>4</td>
<td>290</td>
<td>10.65</td>
<td>14.79</td>
<td>M</td>
<td>W</td>
<td>R</td>
<td></td>
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<tr>
<td>K. Chipsona 2</td>
<td>31</td>
<td>4</td>
<td>345</td>
<td>10.66</td>
<td>14.81</td>
<td>L</td>
<td>W</td>
<td>R</td>
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<tr>
<td>HPS 7/67</td>
<td>37</td>
<td>4</td>
<td>321</td>
<td>13.56</td>
<td>18.84</td>
<td>M</td>
<td>W</td>
<td>R</td>
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<tr>
<td>394037.103</td>
<td>39</td>
<td>4</td>
<td>299</td>
<td>10.25</td>
<td>14.24</td>
<td>L</td>
<td>R</td>
<td>R</td>
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<tr>
<td>Jumli local (ch)</td>
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<td>4</td>
<td>535</td>
<td>10.82</td>
<td>15.02</td>
<td>L</td>
<td>W</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CV (%)</td>
<td>16</td>
<td>20.5</td>
<td>25.5</td>
<td>23</td>
<td>23</td>
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<tr>
<td>LSD (0.05)</td>
<td>5.9</td>
<td>0.8</td>
<td>91.3</td>
<td>2.83</td>
<td>3.93</td>
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</table>

During 2011/12 thirteen different clones of potato were tested. Emergence was found non-significant among the tested clones. Highly uniform (5) plants were recorded in clones CIP 392222.25, PRP55861.7 and Khumal Seto 1 whereas, lowest (3) in CIP 395192.1.

The highest ground (88.3%) coverage was observed in Khumal Seto -1 and lowest (70%) in clone 395192.1. Clone 395192.1 showed the tallest (60.4 cm) plants and shortest (30.47 cm) plants in CIP 393574.61. Though number of main stems per plant were statistically non-significant, the highest number (4.7) were recorded in CIP 394050.11 followed by clone CIP 392222.25 (4.4) and lowest (2.8) in CIP 393574.61. The highest number of tubers per plot (338) was counted in PRP55861.7 followed by CIP 392222.25 (333.3) whereas the lowest (141.7) in PRP 55861.8. Highest tuber yield (20.95 t/ha) was recorded in clone CIP 392222.25 followed by CIP 394050.11(16.95 t/ha) and lowest (4.48 t/ha) in Jumli local (Table 3).

Table 2: Characteristics of different potato clones tested at farmer’s field of Jumla during the summer season of 2008/09
<table>
<thead>
<tr>
<th>Clones</th>
<th>Uniformity (1-5)</th>
<th>Ground coverage (%)</th>
<th>Plant height (cm)</th>
<th>Main stem (no.)</th>
<th>No. of tubers/plot</th>
<th>Yield/plot (Kg)</th>
<th>Yield/ha (t/ha)</th>
<th>Maturity</th>
<th>Tuber characteristics</th>
</tr>
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<tbody>
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<tr>
<td>392222.25</td>
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<td>85</td>
<td>54.33</td>
<td>4.4</td>
<td>333.3</td>
<td>15.07</td>
<td>20.94</td>
<td>M</td>
<td>W</td>
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<tr>
<td>L235-4</td>
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<td>80</td>
<td>43.93</td>
<td>3.5</td>
<td>338</td>
<td>5.07</td>
<td>7.04</td>
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<td>R</td>
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<tr>
<td>Khumal Seto 1</td>
<td>5</td>
<td>88.3</td>
<td>36.2</td>
<td>4.1</td>
<td>243.7</td>
<td>7.47</td>
<td>10.37</td>
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<td>W</td>
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<tr>
<td>Kufri Chipsona 2</td>
<td>4</td>
<td>80</td>
<td>41.1</td>
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<td>8.29</td>
<td>11.51</td>
<td>M</td>
<td>R</td>
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<td>85</td>
<td>48.2</td>
<td>4.7</td>
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<td>16.95</td>
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<td>394037.103</td>
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<td>60.4</td>
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<td>16.85</td>
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<td>R</td>
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<tr>
<td>Jumla local</td>
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<td>75</td>
<td>52.6</td>
<td>5.2</td>
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<td>11.18</td>
<td>15.53</td>
<td>L</td>
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<td>25.65</td>
<td>28.76</td>
<td>28.84</td>
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</tr>
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</table>

**Note:** Color: W-white, R-Red  Shape: R-Round, OL-Oblong, L-Long, O-Oval  Maturity: M-medium, L-Late

**Table 3:** Characteristics of different potato clones tested at farmer's field of Jumla during the summer season of 2011/12

<table>
<thead>
<tr>
<th>Clones</th>
<th>Uniformity (1-5)</th>
<th>Ground coverage (%)</th>
<th>Plant height (cm)</th>
<th>Main stem (no.)</th>
<th>No. of tuber/plot</th>
<th>Yield/plot (kg)</th>
<th>Yield/ha (ton)</th>
<th>Maturity</th>
<th>Tuber characteristics</th>
</tr>
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<tbody>
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<tr>
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<td>54.33</td>
<td>4.4</td>
<td>333.3</td>
<td>15.07</td>
<td>20.94</td>
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<td>W</td>
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<td>PRP55861.7</td>
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<td>80</td>
<td>43.93</td>
<td>3.5</td>
<td>338</td>
<td>5.07</td>
<td>7.04</td>
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<td>R</td>
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<tr>
<td>K Seto 1</td>
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<td>36.2</td>
<td>4.1</td>
<td>243.7</td>
<td>7.47</td>
<td>10.37</td>
<td>M</td>
<td>W</td>
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<td>41.1</td>
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<td>171.7</td>
<td>8.29</td>
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<td>R</td>
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<td>35861.18</td>
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<td>R</td>
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<td>12.19</td>
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<td>15.53</td>
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<td>W</td>
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<tr>
<td>Jumli local (ch)</td>
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<td>85</td>
<td>50.57</td>
<td>3.4</td>
<td>193.7</td>
<td>3.22</td>
<td>4.48</td>
<td>L</td>
<td>W</td>
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<tr>
<td>EMS</td>
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<td>23.71</td>
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<td>LSD</td>
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<td>28.84</td>
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</tr>
</tbody>
</table>

**Note:** Color: W-white, R-Red  Shape: R-Round, OL-Oblong, L-Long, O-Oval  Maturity: M-medium, L-Late

**Table 4:** Characteristics of different potato clones tested at farmer's field of Jumla during the summer season of 2012/13
During 2012/13 seven different clones of potato were evaluated. Emergence of potato clones was non-significant among them. Highly uniform plants were recorded in clone 392222.25, Desiree, K Seto 1 whereas the lowest in Jumla local. Ground coverage was found highest (90%) in clone K Seto 1 and lowest (75.71%) in Desiree. Tallest plants (84.14 cm) were recorded from HPS II/67 followed by HPS 7/67 (80.43 cm) whereas the dwarfest (57.43 cm) plants were recorded from Desiree. Though number of main stem among the clones was non-significant, clone 392222.25 produced the highest (5.37) number of the main stem followed by Desiree (5), Khumal seto 1 (4.89) and lowest in NPI 106 (4.14). Highest number (317.86) of tubers per plot was produced from 392222.25 followed by NPI 106 (316.43) and Khumal seto 1 (311.71) whereas lowest (162.71) number of tubers were produced from HPS II/67. Tuber yield was recorded highest (21.01 t/ha) in clone 392222.25 followed by Khumal seto 1 (19.41 t/ha) and NPI 106 (19.40 t/ha) whereas the lowest (6.33 t/ha) in HPS 7/67 (Table 4).

In all the years of on-farm studies from 2007/08 to 2012/13, farmers’ preferences on tested clones along with the check varieties was scored as good (G), fairly good (FG) and very good (VG) in the parameters such as plant appearance, tuber appearance and taste at the harvest. In addition, the response of tested clones against drought was also assessed as tolerant (T) and susceptible (S) at the time of vegetative stage. The results are presented in Table 5 below.

Results showed that plants of clones CIP 392222.25, HPS 7/67 and Khumal seto-1 were ranked as very good by the participants in all the three years of assessment, whereas remaining 2 clones as good (G) (Table 5). Tuber appearances of clones 392222.25 and Khumal seto-1 also ranked as very good. Taste of clone 392222.25, Khumal seto-1 and Jumli local ranked as very good. Clone CIP 392222.25 was observed as drought tolerant and all other as susceptible in all the three years.

### Table 5: Farmer’s rating on potato clones tested during 2007/08-2008/09

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Emergence (%)</th>
<th>Uniformity (1-5)</th>
<th>Ground coverage (%)</th>
<th>Plant height (cm)</th>
<th>Main stem (no.)</th>
<th>No. of tuber/plot</th>
<th>Yield/plot (kg)</th>
<th>Yield/ha (ton)</th>
<th>Maturity</th>
<th>Color</th>
<th>Shape</th>
<th>Note</th>
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<td>392222.25</td>
<td>92.2</td>
<td>5</td>
<td>80</td>
<td>71.1</td>
<td>5.3</td>
<td>317.86</td>
<td>15.13</td>
<td>21.01</td>
<td>M</td>
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<td>4.57</td>
<td>76</td>
<td>78.5</td>
<td>4.1</td>
<td>316.43</td>
<td>13.97</td>
<td>19.41</td>
<td>L</td>
<td>W</td>
<td>R</td>
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<tr>
<td>Desiree</td>
<td>89.9</td>
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<td>75</td>
<td>57.4</td>
<td>5.0</td>
<td>182.14</td>
<td>9.8</td>
<td>13.63</td>
<td>E</td>
<td>R</td>
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<tr>
<td>K Seto 1</td>
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<td>69.1</td>
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<td>293.86</td>
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<td>4.43</td>
<td>81</td>
<td>80.2</td>
<td>4.7</td>
<td>164.71</td>
<td>4.56</td>
<td>6.34</td>
<td>L</td>
<td>W</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>EMS</td>
<td>34.7</td>
<td>0.167</td>
<td>22.2</td>
<td>125</td>
<td>1.1</td>
<td>4198.5</td>
<td>10.117</td>
<td>9</td>
<td></td>
<td></td>
<td></td>
<td>19.51</td>
</tr>
<tr>
<td>P</td>
<td>ns</td>
<td>***</td>
<td>***</td>
<td>ns</td>
<td>***</td>
<td>6.188</td>
<td>0.067</td>
<td>0.167</td>
<td>ns</td>
<td>***</td>
<td>***</td>
<td>19.51</td>
</tr>
<tr>
<td>LSD</td>
<td>0.676</td>
<td>5.1</td>
<td>12.1</td>
<td>70.24</td>
<td>3.448</td>
<td>4.789</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>CV%</td>
<td>6.5</td>
<td>8.93</td>
<td>5.8</td>
<td>15.0</td>
<td>15.0</td>
<td>25.93</td>
<td>29.11</td>
<td>29.12</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Color: W-white, R-Red Shape: R-Round, OL-Oblong, L-Long, O-Oval Maturity: M-medium, L-Late
CONCLUSIONS AND RECOMMENDATIONS

Based on the results of four consecutive years and farmer’s preference, clone 39222.25 is identified as uniform, high yielding and drought tolerant variety, thus selected and recommended for cultivation in the Karnali region of Nepal.

LITERATURES CITED


**Efficacy of *Metarhizium anisopliae* (Metsch.) Sorokin against the Potato Tuber Moth, *Phthorimaea operculella* (Zeller) in Consumable Potato, under Laboratory Conditions**

Sunita Pandey¹, Marc Sporleder², Yubak Dhoj Gharty Chhetry¹, Yagya Prasad Giri³ and Jürgen Kroschel²

**ABSTRACT**

The potato tuber moth *Phthorimaea operculella* (Zeller) (Lepidoptera: Gelechiidae) is major pest of potato (*Solanum tuberosum* L.) in tropical and subtropical regions of the world causing serious economic damage especially in non-refrigerated potato storerooms. Chemical pesticide use for post-harvest pest management in farmers’ rustic storerooms causes health risks to farmers and consumers, triggered a search for safer pest management alternatives, such as use of entomopathogens. *Metarhizium anisopliae* (Metsch.) Sorokin culture originally isolated from white grub larvae native from Nepal was grown on artificial media and its biological activity assessed against the potato tuber moth in the laboratory, using potato tuber surface contamination bioassay. A total of 5 bioassays were conducted. In four bioassays fresh fungus stock suspensions were tested while in one bioassay the fungus stock suspension of the first bioassay was reused after 8-month storage period at ambient temperature. All probit lines revealed a common slope of 0.57. The first stock suspension revealed an LC50-value of 6.9×10⁶ conidia/ml while after 8-month storage a significant activity loss of about 90% (7.2×10⁶ conidia/ml) was observed. The other three bioassays revealed LC50-values of mean 4.2×10⁵ (2.9 to 6.1×10⁵) conidia/ml without significant differences in their potencies. According to the probit lines (3-5) > 7.5x10⁷ conidia/ml would be required to kill >90% PTM. Hence it can be concluded that the *M. anisopliae* strain showed high biological activity against PTM larvae and has potential as bio-control agent for controlling the pest; however, activity can be significantly reduced if stored inappropriately or for longer periods.

**Key words:** biological control, entomopathogens, potato pests, probit analysis

**INTRODUCTION**

The potato tuber moth *Phthorimaea operculella* (Zeller) (Lepidoptera: Gelechiidae), which is cosmopolitan pest of potato (*Solanum tuberosum* L.) and other solanaceous crops, was reported for the first time in 1966 from the Kathmandu valley, Nepal (NARC, 1967). Today, it is distributed along mid-hills where it produces economic losses especially in the summer crop starting from late May or early June to October-November (Pradhan, 1984) and after harvest in traditional, non-refrigerated storages. The damaging life stage of the pest is the larva, which feeds on potato foliage as well as tubers in the field and tubers in storage (Haines, 1977; Raman, 1980; Sileshi, 2001; Povolny, 2004). In Nepal, among 40 phytophagous species associated with potato, the potato tuber moth is the most important pest (NPRP, 2004/05). Post harvest losses might reach 30-85% (Joshi, 1989) and in some cases 100% (NPRP, 2004/05) in rustic potato

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storages. Such losses are similar to the losses reported from other tropical-subtropical regions (CIP, 1988; Palacios and Cisneros, 1996; Chandel and Chandla, 2005; Lagnaoui and El-Bedewy, 1997) as infested tubers are subject to secondary infestation.

Tiwari et al. (2006) reported that 80% of the farmers in Kathmandu valley rely on chemical pesticides to manage potato tuber moth in storage. Such kind of control is not only environmentally hazardous; it also jeopardizes farmers and consumers health, and helps to induce resistance in potato tuber moth against diverse insecticides (Saour, 2004; Dogramaci and Tingey, 2008) and outbreaks of secondary pests (Lagnaoui and El-Bedewy, 1997). These facts trigger a search for safer alternatives, such as the use of entomopathogens that can be included as a component in integrated pest management (IPM) strategies.

The ubiquitous fungi, *Metarhizium anisopliae* (Metsch.) Sorokin (Ascomycota: Hypocreales) is an important agent for biological control of several insect pests (Ekesi et al, 2003; Marannino et al, 2006). It produces mycotoxins and destruxins, i.e. a group of secondary metabolites, which are considered as an important new generation of insecticides (Tanada and Kaya, 1993). It is a recognized pathogen of more than 200 insect species, including several major pests (Roberts and Hajek, 1992). The pathogen penetrates its hosts directly through the insect exoskeleton and proliferates throughout the insect’s body, producing toxins and draining the insect nutrients, eventually killing it. Once the fungus has killed its host, it grows through the softer portions of the cuticle, covering the insect with a layer of green mold. Sabbour (2002) assayed *M. anisopliae* against *P. operculella* neonate larvae by dipping potato tubers in suspensions of the fungus prior moth attack and determined a LC$_{50}$ of 8.61×10$^7$ conidia/ml seven days after inoculation of moths.

The objective of the study was to determine the biological activity (LC$_{50}$) of *Metarhizium anisopliae* through laboratory bioassays for evaluating the entomopathogen’s potential use as an IPM component targeting the potato tuber moth in rustic farmers’ potato storerooms.

**MATERIALS AND METHODS**

**Mass rearing of potato tuber moths**

Potato tuber moth was mass reared at the laboratory of the Entomology Division Khumaltar, Lalitpur, of the Nepal Agriculture Research Council (NARC). The rearing was initiated with potato tuber moth-infested potato tubers collected from different farmers’ storerooms in Sankhu, Nepal. The tubers were placed in a plastic box (30×23×14.5 cm), which were partially filled with fine sterilized sand, and incubated at ambient temperature until pupae developed. Dry sand helped to absorb the moisture from infested potato and served as pupation medium. When the larvae had completed its larval stage, the pupae (with their cocoons) were harvested through sieving (2.5 mm mesh width). Cocoons were removed and pupae were surface-sterilized by washing them in a sodium hypochlorite solution (0.3%). The collected pupae were air-dried and placed in a cylindrical plastic container (Ø 13 cm, 12 cm depth), which was covered with mesh cloth (15 cm). After adult emergence, a filter paper was placed on the mesh cloth providing oviposition site. Adults were fed with a diluted honey solution (1:5 honey: water) which was dropped on the edges beside the filter paper. The filter papers were changed daily and the papers containing the eggs collected in a box stored at 10 ºC until use in bioassays or for further rearing. For rearing, the papers containing the eggs were placed into a plastic container with potato tubers as food source. For bioassays, filter papers with eggs were placed individually in petri dishes (Ø 15 cm × 3 cm depth), the dishes sealed with parafilm and incubated at room temperature (between 25 to 27 ºC) until larvae emergence. Fresh eggs generally hatched after 4 days of incubation and neonates were used immediately in bioassays.
Preparation of \textit{M. anisopliae} culture

The fungus \textit{M. anisopliae} was grown on artificial media in insect pathology laboratory Department of Entomology, Institute of Agriculture and Animal Science (IAAS), Rampur, Chitwan. The materials used for preparing selective medium were composed of 20 g dextrose, 10 g peptone, 18 g agar-agar and 1000 ml of distilled water. These components were mixed thoroughly and dissolved in the water in a conical flask. The prepared medium was sterilized in autoclave at 121 °C with a pressure of 15 lb for 15 min. When the medium was cooled down to 60 °C, 0.6 g streptomycin, 0.05 g tetracycline, and 0.05 g cyclohexamide dissolved in 20 ml sterilized distilled water was poured in conical flask that contained the medium and thoroughly mixed. Sterilized liquid medium was then poured into sterilized petri plates (116 ºC for 4 hours in oven) and kept to solidify for streaking fungus culture. The culture was incubated at 24 °C and 75% RH to induce growth and sporulation of fungus in an aseptic condition in the laboratory. After 16 days, the conidia were harvested by scrapping off the contents of each Petri dish using a sterile metal spatula. The culture was stored in cool temperature at 4 ºC.

Preparation of \textit{M. anisopliae} concentrations

For the preparation of \textit{M. anisopliae} concentrations, the conidia scrapped off from the Petri dish were mixed homogenously in water together with 2 drops of Tween 20 (0.1%, dispersing agent). Conidia in the stock solution were quantified by counting under microscope using the hemocytometer (Thoma) and the stock solution was adjusted to $\approx2 \times 10^7$ conidia/ml by adding water. Five bioassays were conducted. For each bioassay a new stock solution (No I, III-V) was prepared with the exception of bioassay II, for which purpose the stock solution No I was stored over an 8-month period at ambient temperature. Since exact adjustment to $2 \times 10^7$ conidia/ml was not always possible, the quantity (titer) assessed through counting (average of three counts) of conidia was taken as the most exact estimate of the highest concentration used in each bioassay. The stock suspension “Ma-stock” was further diluted using different dilution factors to obtain different concentration levels (see Table 1).

Bioassay procedure

In bioassays, neonate larvae were exposed to surface contaminated potato tubers. Each suspension of different \textit{M. anisopliae} concentrations (see Table A 1 for concentration level used in each bioassay) was filled in a plastic container (0.5 liter) and 12 washed and air-dried potato tubers per suspension (3 tubers with a total weight of about 100 g were used in each replication) were posed in a net and dipped into its respective suspension for a period of five seconds to obtain an even coating of the pathogen on the tuber surface.

Table A 5. \textit{Metarhizium anisopliae} concentrations used in five bioassays for assessing the concentration–mortality regression lines of the fungus-host system.

<table>
<thead>
<tr>
<th>Date</th>
<th>Concentration levels (conidia/ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1\textsuperscript{st}</td>
</tr>
<tr>
<td>2008/9/7</td>
<td>$1.9 \times 10^7$</td>
</tr>
<tr>
<td>2009/5/13</td>
<td>$1.6 \times 10^7$</td>
</tr>
<tr>
<td>2009/6/24</td>
<td>$2.9 \times 10^7$</td>
</tr>
<tr>
<td>2009/7/7</td>
<td>$2 \times 10^7$</td>
</tr>
<tr>
<td>2009/8/7</td>
<td>$2 \times 10^6$</td>
</tr>
</tbody>
</table>

Each bioassay included one control (water with Tween-20 only).

Each bioassay included a control without the fungus; i.e. tubers were dipped into water with Tween only. After surface contamination of the tuber (tuber dipping), treated tubers were air-dried for few minutes and placed in bioassay containers (12 cm depth and 13 cm in diameter).
Fifty neonate larvae, not older then 4-h after hatching, were inoculated on the treated potatoes per container using a camel hair paint brush. Containers were closed with a lid, which contained a mesh window for ventilation, and incubated at ambient room temperature (25-28 °C). Larval survival was recorded after sixteen and twenty-one days (second evaluation) of incubation. During evaluation, developed pupae and adults were considered as survivors. After the second evaluation no further development to pupae of test insects was expected.

Statistical analysis

Probit regression lines for each bioassay replication were calculated according to Finney (1971). The mortality responses (scored as failure to pupate, repetitions were pooled) were adjusted for the bioassay-specific natural mortality by using Abbott’s formula (Abbott, 1925).

\[
\text{Adjusted mortality rate} = \frac{\text{mortality rate observed} - \text{control mortality rate}}{1 - \text{control mortality rate}}
\]

Natural mortalities were estimated as a parameter in the probit models using the control responses (background mortality) observed in each assay as the provisional estimate. The data were analyzed in a parallel line assay. A variance ratio test (G-test; \( \chi^2_{\text{total}} - \chi^2_{\text{heterogeneity}} \)) was applied to test the parallelism of all five probit regression lines. If heterogeneity was significant in the data a heterogeneity factor (= \( \chi^2_{\text{df}} \)) was included in the calculation of variances, co-variances and confidence limits. The obtained Probit regression lines were compared by their \( \text{LC}_{50} \)-values and relative potencies. 95% confidence limits for \( \text{LC}_{50} \)-values and potencies. The Likelihood-Chi\(^2\) test confirmed parallelism between all five regression lines (\( \chi^2 = 9.488, df = 4, P = 0.73 \)) and the common slope for all concentration-response lines was found to be 0.57 (SE ± 0.00087). The \( \text{LC}_{50} \) values ranged from \( 2.94 \times 10^5 \) (bioassay 3) to \( 7.16 \times 10^7 \) (bioassay 2) conidia per ml (Table A 2).

RESULTS

Control mortality varied between the five assays ranging from 21.1% (±1.46%) (bioassay 2) and 52.3% (±1.19%) (bioassay1); however, the background mortality was almost similar (around 35%) in bioassays 3 to 5 (Figure A 1). Mortalities in the total set of data revealed significant heterogeneity (\( \chi^2 = 28.9, df = 18, P = 0.042 \)), and therefore a heterogeneity factor was included for calculating variances and 95% confidence limits for \( \text{LC}_{50} \)-values and potencies. The Likelihood-Chi\(^2\) test confirmed parallelism between all five regression lines (\( \chi^2 = 9.488, df = 4, P = 0.73 \)) and the common slope for all concentration-response lines was found to be 0.57 (SE ± 0.00087). The \( \text{LC}_{50} \) values ranged from \( 2.94 \times 10^5 \) (bioassay 3) to \( 7.16 \times 10^7 \) (bioassay 2) conidia per ml (Table A 2).

Potencies of the \( \text{LC}_{50} \)-values revealed significant differences between some of the 5 bioassays. Lowest activity was observed in bioassay 1 and 2 (i.e. from the first Ma-stock suspension); bioassay 2 revealed a significantly reduced activity (about 10-times) compared to bioassay 1, which can be attributed to loss of viability during the 8-month storage period of the fungus. Bioassays 3-5 showed no significant variability in their potencies but revealed significantly increased potencies compared to bioassay 1 (Table A 2). This might indicate that the Ma-culture used in the first stock suspension was of lower viability, while the bioassays 3-5 showed the full potential of the fungus against neonate \( P. \text{operculella} \) larvae.
**Figure A 1.** Probit regression lines retransformed into percentage mortalities plotted against log concentration of *M. anisopliae* (conidia/ml) treated to neonate larvae of *P. operculella* during a series of 5 assays. Dots are observed mortalities, open dots are control mortalities observed, lines are model predictions, x-bars are 95% confidence.

**Table A 6.** Probit statistics for *M. anisopliae* in *P. operculella* larvae

<table>
<thead>
<tr>
<th>Date</th>
<th>Equation</th>
<th>Chi^2</th>
<th>P</th>
<th>LC_{50} (conidia/ml)</th>
<th>Relative potencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008/9/7</td>
<td>-3.9 + 0.57</td>
<td>13.</td>
<td>0.0</td>
<td>6.92×10^6 (2.36×10^6)</td>
<td>- 1</td>
</tr>
<tr>
<td>2009/5/1</td>
<td>-4.5 + 0.57</td>
<td>11.</td>
<td>0.0</td>
<td>7.16×10^7 (1.12×10^7)</td>
<td>- 0.09</td>
</tr>
<tr>
<td>2009/6/2</td>
<td>-3.1 + 0.57</td>
<td>3.4</td>
<td>0.6</td>
<td>2.94×10^5 (1.56×10^5)</td>
<td>- 23.9</td>
</tr>
<tr>
<td>2009/7/7</td>
<td>-3.3 + 0.57</td>
<td>2.8</td>
<td>0.7</td>
<td>6.14×10^5 (3.24×10^5)</td>
<td>- 11.4</td>
</tr>
</tbody>
</table>
DISCUSSION

The slope of the concentration–mortality regression line for the fungi *M. anisopliae* and the host *P. operculella* larvae was constant throughout the series of assays; however the value observed in this study of 0.57 is much smaller than the slope of 1.9 reported by Sabbour (2002) who used almost the same treatment procedure as used in this study for the same pathogen-host system but mortality was evaluated after seven days of treatment. The difference between the slopes obtained in this and Sabbour’s study might be due to different experimental conditions like variation of isolates used, environmental condition, insect culture, and differences in experimental procedures (differences in pathogen concentrations, incubation periods). Sabbour evaluated mortality after 7 days while this study determined mortality after >14 days. This study revealed LC\textsubscript{50}-values ranging from 2.94×10\textsuperscript{5} to 7.16×10\textsuperscript{7} conidia per ml also according to the probit lines (3-5) > 7.5x10\textsuperscript{4}7 conidia/ml would be required to kill >90% PTM, which was still lower then the LC\textsubscript{50}-value of 8.61×10\textsuperscript{7} conidia/ml obtained by Sabbour (2002). The maximum value 7.16×10\textsuperscript{7} was obtained from *M. anisopliae* after storing the stock solution I for an 8-month period.

This study revealed significant differences in potencies between different *M. anisopliae* preparations, with lowest activities of the pathogen during the first two bioassays. The reason for lower fungal activity in the first bioassay might be partly due to experimental differences like a reduced fitness of test insects (assay revealed an natural background mortality of >50% while in other assays background mortality was around 30%), whereas in the second assay the reduction in fungal activity can be attributed to a loss of activity during an 8-month storage period of the *M. anisopliae* preparation at ambient temperature (varied between 15 and 24 ºC). Clerk and Madelin (1965) reported that the viability of the conidia of *M. anisopliae* decreased as the storage temperature increased from 8 to 25 ºC. In this experiment the preparation had lost about 90% of its activity within 8 month of storage. Therefore, the fungus should be stored best at about 4 ºC, in dark and at very low humidity. The longevity of conidia is generally more stable at cool and dry condition (Hong et al., 1997). The last three bioassays, which were conducted within a short period of time and hence at more or less similar temperatures using always fresh fungus culture, resulted in quite similar LC\textsubscript{50}-values. This shows that the results on low LC\textsubscript{50}-values are repeatable if the fungi preparations are fresh (viable) and experimental conditions are held constant. The latter three bioassays reveal probably the full potential of the fungus against neonate *P. operculella* larvae.

CONCLUSIONS

The *M. anisopliae* strain showed high biological activity against potato tuber moth neonate larvae and hence has potential as biocontrol agent for controlling the pest in potato storerooms; however, activity can be significantly reduced if stored inappropriately or for longer periods. Optimal storage conditions and the products shelf life need to be assessed before the fungus can be used as a biopesticide. In addition, further experiments needs to be carried out under farmers’ or simulated storage conditions before final recommendations can be made.
ACKNOWLEDGEMENTS
This study was part of a collaborative project between the National Agriculture Research Council (NARC), Lalitpur, Nepal, and the International Potato Center (CIP), Lima, Peru, funded by the German Federal Ministry for Economic Cooperation and Development (BMZ), Germany. We thank Mr. Tika Ram Bagale for lab assistance.

LITERATURES CITED


Effect of Pinching and Levels of Gibberellic Acid on Growth, Flowering and Yield of African Marigold (Tagetes erecta L.)

H. P. Pandey¹, K. Mishra¹, S. S. Pant¹ and U. Pun²

ABSTRACT

A field experiment was conducted to evaluate the plant growth and yield of African marigold cv. Calcutta Local through pinching practice and using different level of GA₃ in the Abloom Flora Farm of Gunjanagar, Chitwan from March to August, 2013. The experiment was conducted in two factorial randomized complete block design with two pinching levels (pinching and non-pinching practices) and five GA₃ levels (0, 50, 100, 150 and 200 ppm). Result showed a significant effect of pinching and levels of gibberellic acid on plant growth and flower yield. Pinching also significantly increased the number of branches, plant spread, number of flower per plant, yield per plant (299.33 g) and yield per hectare (12.04 t/ha). Earlier days to flower initiation was observed in non-pinching. Gibberellic acid at 50,100,150 and 200 ppm significantly increased the plant height, number of branches, plant spread and number of flower per plant, flower yield per plant and yield per hectare over control. Earlier days to flower initiation was found with increase in GA₃ level. Among all levels, GA₃ at 200 ppm was significantly superior due to its maximum flower yield (14.64 t/ha).

Key words: Gibberellic acid, pinching, growth, flower yield and African marigold.

INTRODUCTION

Marigold is one of the commercially exploited flower crops that belong to the family Compositae and genus Tagetes. The two main popularly grown species in marigold are Tagetes erecta L. and Tagetes patula L. which have their origin in Mexico and South Africa respectively. Tagetes erecta L. is popularly known as “African marigold” while Tagetes patula L. as “French marigold.” Marigold as compared to other flowering annuals is easily adaptable to various conditions of growing and has fairly good keeping quality. It is propagated by seeds and comes up well in all types of soil. It is a hardy annual plant and attains more than 100 cm height within its life span. The flowers of these species are generally large in size with bright shades, ranging from yellow to orange and are the best for combination in any flower arrangement. Nepalese have traditionally been using flowers or bunch of flowers to offer god and goddess or as a garland to the deities or fellow human being or as floral decoration during festivals (Pun, 2004). Small and marginal farmers can get good economic benefit from marigold cultivation during normal and off season (Adhikari and Pun, 2011). Marigold is grown for cut flowers, making garlands, decoration during several social and religious functions, besides its use in landscape gardening.

Apart from its significance in ornamental horticulture, it has been valued for other purposes too. The aromatic oil extracted from marigold, is called as “tagetes oil”. It is used in preparation of high grade perfumes and also used as an insect repellant. It is also being grown as a trap crop in agriculture against nematodes. Recently dried flower petals of marigold are important source of carotenoids and which is used as poultry feed in order to improve the colour of egg yolk as well as broiler’s skin. There are two common methods of propagation of marigold i.e.

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by seeds and by cuttings. Plants raised from seeds are tall, vigorous and heavy yielder and hence, seed propagation is preferred to cuttings.

Cultivation of marigold is attracting flower growers due to its easy culture and short duration to produce marketable flowers and gaining popularity amongst flowers dealers due to its wide spectrum of attractive color, shape, size and good keeping quality (Arora, 1998). Pinching in marigold, during its vegetative stage, is supposed to increase number of branches which ensures the higher production of flower along with uniform size and excellent quality flower. While gibberellic acid (GA$_3$) is supposed to increase flower quality and maintains uniformity in flower size and number. It is also supposed to promote plant growth and increased number of primary and secondary branches which eventually ensures higher production of flower. Doddagoudar et al. (2002) observed that exogenous foliar application of growth regulators stimulate flowering, pollination, fertilization and seed setting to get maximum yield.

**MATERIALS AND METHODS**

The experiment was conducted in silty loam soil (pH 6.26, 0.18% Total N, 73 kg ha$^{-1}$ P$_2$O$_5$, 262 kg ha$^{-1}$ K$_2$O and 1.74% organic matter) in Abloom Flora Farm, Gunjanagar-5, Chanauli, Chitwan, Nepal during March to August, 2013. The experiment was laid out in a two factorial randomized complete block design with two pinching level (pinching and non-pinching practices) and five GA$_3$ levels (0, 50, 100, 150 and 200 ppm). Thus, there were all together 10 treatments and replicated thrice. The treatments were randomly allocated by using random number table (Gomez and Gomez, 1984). Total experimental area was 329 m$^2$ (23.5 m $\times$ 14 m). Space between replication and plot was 1 m and 0.5 m respectively. The individual plot size was 3 m $\times$ 2 m i.e. 6 m$^2$. The row to row distance was 60 cm and plant to plant distance was 40 cm. There were 5 rows in each plot and 5 plants in each row. There were all together 25 plants in each plot and inner 5 plants were selected for observation.

The land was brought to a good tilth by two deep ploughing. Before leveling of experimental plot, weeds and left over crop residues were removed. Weeding and removing of left over residues was followed by digging and leveling. The raised bed of 5.00 m length $\times$ 1.00 m breadth and 15 cm height was prepared for raising the seedlings. Nursery bed was applied with 50 Kg of well decomposed FYM, 170 gram of DAP, 100 gram of urea and 130 gram of MOP was mixed thoroughly in the soil before sowing of seed in the nursery. The seeds of African marigold cv. Calcutta Local obtained from the Abloom Flora Farm were sown in 7 cm apart lines after treating with Captan at 2 g per kg of seed and covered with straw still the completion of seed germination. The water was given regularly in the evening still the seedlings were ready for transplanting. Seedlings were allowed to grow in the nursery for 30 days and transplanting was done in the experimental plot in evening time. Well decomposed FYM was applied in the plots @ 20 mt/ha two weeks before planting. Half dose of nitrogen and full dose of phosphorus and potash @ 160: 60: 60 kg NPK/ha were applied as basal dose. The remaining half dose of nitrogen was top dressed one month after seedlings transplanting. Nitrogen was applied through urea (46% N) and potash through murate of potash (60% K$_2$O) respectively. Recommended doses of phosphorus were applied through diammonium phosphate (46% P$_2$O$_5$ and 18% N).

GA$_3$ was weighed with the help of digital balance. Four different concentrations viz., 50, 100, 150 and 200 ppm of gibberellic acid (GA$_3$) were prepared manually with distilled water just before their use. In a few ml of 95 per cent absolute alcohol 0.05 g of GA$_3$ was dissolved and diluted with distilled water to make 1 liter of GA$_3$ solution of 50 ppm. The concentrations of 100, 150 and 200 ppm solution were prepared with same procedure. Pinching was done one month after seedlings transplanting and gibberellic acid was sprayed at the same day by using knapsack sprayer. In control treatment distilled water was sprayed at the same time. Pinching
was done to remove the apical portion of plant. 3-4cm apical portion was cut with the help of scissor.

The recorded data were entered, tabulated and processed in Excel. The recorded data on different parameters were analyzed by using MSTAT-C software and the means were separated using Duncan’s Multiple Range Test (DMRT). The marigold flower were harvested when 75% petal were unfolded. Plant height, plant spread, number of branches, days to flower initiation, days to 50% flowering, fresh weight flower, dry weight of flower, number of flower per plant, yield per plant and yield per hectare were recorded.

RESULTS AND DISCUSSION

Plant growth

Effect of pinching and levels of gibberellic acid on growth of marigold showed a significant influence on plant height, plant spread and number of branches (Table 1). Plant height of marigold was recorded significantly higher in non-pinching treatment (115.8 cm) in comparison with pinching treatment (111.4 cm) at harvest stage. The higher plant height noticed with non pinching treatment was mainly due to the fact that plants were not pinched and grew to their original height without reduction. Decrease in plant height with increased number of leaves and branches due to pinching was reported in marigold (Sehrawat et al., 2003 and Tomar et al., 2004), in coriander (Iyyangouda, 2003), in fenugreek (Sudarshan, 2004), in chrysanthemum (Singh and Baboo, 2003 and Grawal et al., 2004) and in carnation (Pathania et al., 2000 and Kumar and Singh, 2003). Significantly higher plant height was recorded in GA3 sprayed treatment as compared to control at various days after transplanting. At harvest stage significantly higher plant height was recorded in GA3 200 ppm sprayed treatment (119.8 cm) in comparison with GA3 50ppm (111.2 cm) and control treatment (106.4 cm) but was at par with GA3 150 ppm (117.3 cm) and GA3 100 ppm sprayed treatment (113.3 cm). The increase in plant height and number of branches per plant with application of GA3 seems to be due to enhanced cell division and cell enlargement, promotion of proteins synthesis coupled with higher dry matter accumulation in the plant. Stimulation of branching may be attributed to the breakage of apical dominance. Similar results were reported by Lal and Mishra (1986) in aster and marigold, Shetty (1995) and Doddagoudar (2002) in China aster and Lone et al. (2005) in chilli.

The effect of pinching and levels of gibberellic acid on plant spread was significant at full bloom stage. Significantly higher plant spread (71.68 cm) was noticed in pinching treatment at full bloom stage in comparison with non-pinching treatment (67.38). Similarly plant spread was significantly higher in GA3 200 ppm (72.83 cm), GA3 150 ppm (71.92 cm) and GA3 100 ppm (69.17 cm) whereas significantly lower plant spread was noticed in control treatment (66.28 cm) and GA3 50 ppm (67.45 cm). Similar result was obtained by Ramdevputra et al. (2009). Significantly higher number of primary branches was recorded in pinching treatment (15.18) in comparison with non-pinching treatment (12.94). Similarly, significantly higher number of primary branches was recorded in GA3 200 ppm sprayed treatment (15.63) in comparison with GA3 100 ppm (13.93), GA3 50 ppm (13.13) and control (13.03) but was at par with GA3 150 ppm sprayed treatment (14.57). Pinching resulted in increased number of branches per plant which might be attributed to the breaking of apical dominance and sprouting of auxiliary buds. Similar findings were reported by Singh and Arora (1980) in African marigold, Pathania (2000) and Kumar and Singh (2003) in Carnation and Sen and Naik (1977) in chrysanthemum.
Table 1. Effect of pinching and levels of gibberellic acid on vegetative characteristics of marigold in Gunjanagar-5, Chitwan, Nepal (2013)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Vegetative characteristics</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Plant height (cm)</td>
<td>Plant spread (cm)</td>
<td>No of primary branches</td>
<td></td>
</tr>
<tr>
<td>Pinching</td>
<td>111.40&lt;sup&gt;b&lt;/sup&gt;</td>
<td>71.68&lt;sup&gt;a&lt;/sup&gt;</td>
<td>15.18&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Non-Pinching</td>
<td>115.80&lt;sup&gt;a&lt;/sup&gt;</td>
<td>67.38&lt;sup&gt;b&lt;/sup&gt;</td>
<td>12.94&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>LSD&lt;sub&gt;0.05&lt;/sub&gt;</td>
<td>4.16&lt;sup&gt;*&lt;/sup&gt;</td>
<td>2.24&lt;sup&gt;*&lt;/sup&gt;</td>
<td>0.87**</td>
<td></td>
</tr>
<tr>
<td>SEM±</td>
<td>1.40</td>
<td>0.76</td>
<td>0.29</td>
<td></td>
</tr>
<tr>
<td>GA3 levels</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 ppm</td>
<td>106.4&lt;sup&gt;c&lt;/sup&gt;</td>
<td>66.28&lt;sup&gt;b&lt;/sup&gt;</td>
<td>13.03&lt;sup&gt;c&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>50 ppm</td>
<td>111.20&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>67.45&lt;sup&gt;b&lt;/sup&gt;</td>
<td>13.13&lt;sup&gt;bc&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>100 ppm</td>
<td>113.30&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>69.17&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>13.93&lt;sup&gt;bc&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>150 ppm</td>
<td>117.30&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>71.92&lt;sup&gt;a&lt;/sup&gt;</td>
<td>14.57&lt;sup&gt;ab&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>200 ppm</td>
<td>119.80&lt;sup&gt;a&lt;/sup&gt;</td>
<td>72.83&lt;sup&gt;a&lt;/sup&gt;</td>
<td>15.63&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>LSD&lt;sub&gt;0.05&lt;/sub&gt;</td>
<td>5.564**</td>
<td>3.55*</td>
<td>1.37**</td>
<td></td>
</tr>
<tr>
<td>SEM±</td>
<td>1.873</td>
<td>1.19</td>
<td>0.46</td>
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</tr>
<tr>
<td>CV%</td>
<td>4.78</td>
<td>4.21</td>
<td>8.06</td>
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</tr>
<tr>
<td>Mean</td>
<td>113.60</td>
<td>69.53</td>
<td>14.06</td>
<td></td>
</tr>
</tbody>
</table>

Treatments means followed by the common letter (s) within column are non-significantly different among each other based on DMRT at 5% level of significance. * denotes significant at 5% level and ** denotes significant at 1% level of significance.

Days to flowering

Pinching and levels of gibberellic acid on days to flowering of marigold was found significant. Earlier days to flower initiation was observed in non-pinching treatment (42.80 days) in comparison with pinching treatment (46.27 days). Similarly significantly early flowering was recorded in GA<sub>3</sub> 200 ppm sprayed treatment(40.83 days) in comparison with control (48.17 days) but was at par with GA<sub>3</sub> 150 ppm sprayed treatment (43.83 days), GA<sub>3</sub> 100ppm (44.17 days) and GA<sub>3</sub> 50ppm (45.67 days). days to 50 percent flowering was recorded earlier in non-pinning treatment (50.47 days) in comparison with pinching treatment (55.20 days). Similarly, days to 50 percent flowering was recorded earlier in GA<sub>3</sub> 200 ppm sprayed treatment (49.17 days) in comparison with control treatment (57.00 days) but was at par with GA<sub>3</sub> 150 ppm (51.83 days), GA<sub>3</sub> 100 ppm (52.67 days) and GA<sub>3</sub> 50 ppm (53.50 days).

Pinched plants took more (56.12) number of days to 50 per cent flowering compared to non pinched plants (51.70 days). The delayed flowering due to pinching was also observed by Malleshappa (1984) in China aster, Grewal <i>et al.</i> (2004) in chrysanthemum and Naik (2003) in marigold, which might be due to removal of apical portion of the plants. The newly emerged shoot took longer time to become physiologically mature and thus resulted in delayed to 50% flowering.
Flower characteristics and yield

Pinching significantly influenced the fresh weight, diameter, depth and number of flower per plant, yield per plant and yield per hectare. Similarly levels of gibberellic acid also significantly influenced number of flower per plant, yield per plant and yield per hectare. Highest fresh weight of flower was recorded in non-pinched treatment (5.207 g) in comparison with pinched treatment (4.673 g).

Diameter of flower was recorded higher in non-pinching treatment (4.8 cm) in comparison to pinching treatment (4.352 cm). Similarly, depth of flower was also recorded higher in non-pinching treatment (2.653 cm) in comparison with pinching treatment (2.480 cm). Higher number of flower per plant was recorded in pinching treatment (63.87) in comparison with non-pinching treatment (49.60). Similarly, highest number of flower per plant was recorded in GA$_3$ 200 ppm sprayed treatment (67.7) in comparison to GA$_3$ 150 ppm (59.8), GA$_3$ 100 ppm (57.3), GA$_3$ 50 ppm (52.5) and control (46.3). Similar results were obtained by Kumar et al. (2010) in African marigold.

Maximum number of flower per plant was recorded in pinching treatment (63.9) in comparison to non-pinching treatment (49.6). Similarly, maximum number of flower per plant was
recorded in GA$_3$ 200 ppm sprayed treatment (67.7) in comparison to GA$_3$ 150 ppm (59.8), GA$_3$ 100 ppm (57.3), GA$_3$ 50 ppm (52.5) and control treatment (46.3). Similar results were obtained by Kumar et al. (2010) in African marigold. The increase in number of flower in pinched plant might be due to the fact that it checked apical dominance and diverted extra energy in to the production of more number of branches and flowers. Similar results were observed by Jhon and Paul (1995) in chrysanthemum, Srivastava et al. (2002) in marigold, Khandelwal et al. (2003), Tomar et al. (2004) and Naresh and Singh (2012) in marigold.

Yield per plant was recorded highest in pinching treatment (299.3 g) in comparison with non-pinching treatment (253.9 g). Similarly, higher yield per hectare was recorded in pinching treatment (12.0 t/ha) in comparison with non-pinching treatment (10.1 t/ha). Yield per plant was recorded higher in GA$_3$ 200 ppm sprayed treatment (350.20 g) in comparison with GA$_3$ 150 ppm (306.4 g), GA$_3$ 100 ppm (274.6 g), GA$_3$ 50 ppm (247.7 g) and control (204.2 g). Similarly, significantly higher yield per hectare was recorded in GA$_3$ 200 ppm sprayed treatment (14.6 t/ha) in comparison with GA$_3$ 150 ppm (12.5 t/ha), GA$_3$ 100 ppm (10.9 t/ha), GA$_3$ 50 ppm (9.4 t/ha) and control (7.8 t/ha) respectively. Similar results were obtained by Kumar et al. (2011) in African marigold.

Table 1. Effect of pinching and levels of gibberellic acid on flower characteristics and yield of marigold in Gunjanagar-5, Chitwan, Nepal (2013)

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Fresh weight of flower (g)</th>
<th>Diameter of flower (cm)</th>
<th>Depth of flower (cm)</th>
<th>Number of flower per plant</th>
<th>Flower yield per plant (g)</th>
<th>Yield per hectare(t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pinching</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pinching</td>
<td>4.67$_b$</td>
<td>4.35$_b$</td>
<td>2.48$_b$</td>
<td>63.87$_a$</td>
<td>299.33$_a$</td>
<td>12.04$_a$</td>
</tr>
<tr>
<td>Non-Pinching</td>
<td>5.21$_a$</td>
<td>4.80$_a$</td>
<td>2.65$_a$</td>
<td>49.60$_b$</td>
<td>253.95$_b$</td>
<td>10.10$_b$</td>
</tr>
<tr>
<td>LSD$_{0.05}$</td>
<td>0.53$_*$</td>
<td>0.25$_{**}$</td>
<td>0.15$_*$</td>
<td>4.19$_{**}$</td>
<td>17.59$_{**}$</td>
<td>0.73$_{**}$</td>
</tr>
<tr>
<td>SEM$_{±}$</td>
<td>0.18</td>
<td>0.08</td>
<td>0.05</td>
<td>1.41</td>
<td>5.92</td>
<td>0.25</td>
</tr>
<tr>
<td>GA$_3$ levels</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>0 ppm</td>
<td>4.38</td>
<td>4.46</td>
<td>2.45</td>
<td>46.33$_d$</td>
<td>204.20$_d$</td>
<td>7.80$_d$</td>
</tr>
<tr>
<td>50 ppm</td>
<td>5.18</td>
<td>4.51</td>
<td>2.53</td>
<td>52.50$_{cd}$</td>
<td>247.70$_c$</td>
<td>9.41$_d$</td>
</tr>
<tr>
<td>100 ppm</td>
<td>4.88</td>
<td>4.55</td>
<td>2.70</td>
<td>57.33$_{bc}$</td>
<td>274.60$_c$</td>
<td>10.96$_c$</td>
</tr>
<tr>
<td>150 ppm</td>
<td>5.02</td>
<td>4.74</td>
<td>2.57</td>
<td>59.83$_{b}$</td>
<td>306.40$_b$</td>
<td>12.55$_b$</td>
</tr>
<tr>
<td>200 ppm</td>
<td>5.23</td>
<td>4.62</td>
<td>2.57</td>
<td>67.67$_a$</td>
<td>350.20$_a$</td>
<td>14.64$_a$</td>
</tr>
<tr>
<td>LSD$_{0.05}$</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>6.63$_{**}$</td>
<td>27.81$_{**}$</td>
<td>1.15$_{**}$</td>
</tr>
<tr>
<td>SEM$_{±}$</td>
<td>0.28</td>
<td>0.13</td>
<td>0.08</td>
<td>2.23</td>
<td>9.36</td>
<td>0.39</td>
</tr>
<tr>
<td>CV%</td>
<td>13.99</td>
<td>7.19</td>
<td>7.77</td>
<td>9.63</td>
<td>8.29</td>
<td>8.59</td>
</tr>
<tr>
<td>Mean</td>
<td>4.94</td>
<td>4.58</td>
<td>2.57</td>
<td>56.73</td>
<td>276.64</td>
<td>11.07</td>
</tr>
</tbody>
</table>

Treatments means followed by the common letter (s) within column are non-significantly different among each other based on DMRT at 5% level of significance. * denotes significant at 5% level and ** denotes significant at 1% level of significance.

CONCLUSION

The result showed that marigold cultivation in Chitwan is feasible. It can be concluded that, pinching of marigold showed marked influenced on the growth, phenology and yield parameters. Similarly levels of gibberellic acid also showed marked influenced on the plant growth, flowering and yield parameters of marigold. GA$_3$ 200 ppm showed the better performance in all parameters of marigold which were recorded in this experiment. Pinching along with GA$_3$ 200 ppm showed the maximum yield of marigold.
ACKNOWLEDGEMENT

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126.
Residual Effect of Partial Girdling on Quality of Satsuma Mandarin Fruit
A.K. Shrestha¹ and W. Kibet²

ABSTRACT
An experiment was carried out to evaluate 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 10 cm and 20 cm width to compare the effect with ungirdled (control) branch. After three years, the bark recovery was found to be significantly higher in the branches that received girdling of 10 cm width than 20 cm girdling treatment. The fruit size, total soluble solid content and the titratable acidity were not significantly different among the three treatments. However, the largest fruits (98.4±3.52 g) were obtained from the ungirdled branch while the highest brix (10.5 ± 0.25 %) was recorded in the fruits harvested from the 10 cm 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. 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 the TSS 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 higher 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 fruits with higher TSS (Iwagaki 1997). Candido et al. (2000) found higher t soluble solids in unirrigated fruits of tomato than in irrigated plots. Kriedemann and Ian (2003), reported that Brix in over watered ‘Okitsu’ Satsuma mandarins were lowest (7.7 %) while water stressed trees produced fruits with the highest Brix (13.2 %), the fruit size however reduced with water stress.

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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 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. It involves the removal of a ring of bark from a trunk or major limbs of a fruit tree hence blocking the downward transport of photosynthates and metabolites through the phloem to the roots, resulting in more carbohydrates being available for the fruits and young leaves/shoots (Wright, 1996; Li et al., 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 20 cm 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 peach, rambutan, ‘Ponkan’ mandarin and sour orange girdling increased carbohydrates above the girdled portion and reduced it below the girdle (Poerwanto and Irdiastuti, 2005; Onguso et al., 2005) which benefits the sinks above the girdle - the fruits and the shoots.

In ‘on’ trees, Li et al. (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 higher than in control. This indicates that in ‘on’ year the fruits use the photosynthates that increase above the girdle. Wiliams 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 ‘Fairchild’ mandarin observed a reduction in titratable acidity due to girdling in first year but no effect was observed in second and third year. Peng and Rabe (1996) also noted improved fruit colour and TSS ‘Mihowase’ SatsumaNotwithstanding, girdling has the potential to injure the trees to some extent and these girdles take considerable duration of time to heal the wound completely. Since residual effect of this girdling on quality of Satsuma mandarin have not been studied 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 mandarin trees 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 of 5.7, a bulk density of a 1.08 g cm$^{-3}$ and horizon A thickness of 0.15 m. The mandarin fruits trees used for this study had received 10 cm girdling and 20 cm girdling in 2003 and the girdled wound had not been fully recovered by the third year when they were evaluated. Five Satsuma mandarin trees (replications) were used for the experiment. Each tree had 3 treatment units, 10 cm partially girdled branch, 20 cm partially girdled branch and ungirdled branch as control. The experiment was laid out in Randomized Complete Block Design.
For the evaluation of fruit quality, 20 fruits from each treatment branch were picked from all the replication. The fruits were weighed using the physical balance. Juice was extracted and 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 NaOH.

The data were analyzed using ANOVA test and separated by multiple range tests. Bark recovery was determined by measuring regenerated bark at girdled branches and presented as percentage of the total branch circumference.

RESULTS

Bark recovery

There was continuous and gradual recovery of the bark on the girdled portion of the branches of Satsuma mandarin tree. The healing was faster in the branches that received 10 cm girdling than in the branches receiving 20 cm girdling (Figure 1). After three years of girdling operation, 10 cm girdled branches had recovered 31% of the bark while 20 cm-girdled branches had recovered 23% of the bark. Onguso et al. (2004) also reported recovery of bark on girdled peach stem.

Figure 1: Influence of girdle width on bark recovery in Satsuma mandarin.

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, acidity of fruit juice and TSS were not significant among the treatments (Table 1). 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 10 cm and 20 cm partial girdling on quality of Satsuma mandarin fruit

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Fruit weight (g)</th>
<th>Acidity (%)</th>
<th>TSS (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>98.4±3.52</td>
<td>1.1±0.05</td>
<td>10.0 ± 0.12</td>
</tr>
<tr>
<td>10 cm girdle</td>
<td>97.4±2.33</td>
<td>1.1±0.04</td>
<td>10.5 ± 0.25</td>
</tr>
</tbody>
</table>
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

There was no difference in total soluble solid content of fruit between 10 cm and 20 cm 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 10 cm and 20 cm 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 is not significant in the third year even though the bark has not fully regenerated. Brix and acidity of 10 cm girdling were not different from those of 20 cm girdle indicating that there is no advantage of 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 20 cm girdle reducing the size more than 10 cm girdle. This may be due to increased fruit set in the ungirdled and 10 cm girdled branches than in the 20 cm 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 Rabe and Peng (1996) have also made similar observations in their experiment related to girdling.

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Contribution of Mandarin on Livelihood Improvement of its Growers in Parbat District of Western Nepal

Padma Nath Atreya

ABSTRACT
The study was undertaken to explore the technology adoption and contribution of mandarin in different nine citrus pockets of Parbat district. Forty-five respondents were selected randomly from the study sites for interviews, group discussion, PRA, RRA and used a semi structured questionnaire for information and data collection. Data was also collected from traders. Average density of mandarin planting was found slightly higher (415 trees/ha) than national recommendation (300 trees/ha) and majority of the farmers (86%) were still using seedling trees as planting materials. The average productivity of mandarin orange was found 14.84 mt/ha which is higher than the national average and highest was 17.3 mt/ha in Banskharkha. Farmers were using bamboo baskets (Dokos), bags (Bora) and the card board boxes for packaging. It was found that 33% respondent earned more than one million NRs per year, while 22% and 33% respondents earned NRs half to one million and one hundred thousand to half million respectively. Mandarin farming increased the income level of farmers. Farmers were using increased income on children's education, family health care, drinking water, and housing facility improvement. Farmers have realized their improved nutritional condition because of more fruit consumption. It was found that mandarin cultivation decreased the work load of women in study area.

Key Words: Mandarin, orchard management, marketing, economic impact

INTRODUCTION
Citrus are important fruit crops of Nepal considered as a priority cash-generating commodity for mid-hill farmers (APP, 1995). It is estimated that about 25 percent of total fruit area in the country is covered by citrus in which mandarin (Citrus reticulata Blanco) shares the highest percentage (Shrestha and Verma, 1999). Mandarin contributes about 0.97 % to the agriculture gross domestic product (MoAD, 2012). Mandarin cultivation is one of the major economic activities in the mid-hills (550-1300 masl) of the western development region (Lohar, 1995). Mandarin is grown in 47 districts out of 75 and the area and production is increasing over the years in the western development region (NCDP, 1989). Mandarin cultivation provides nutrition, employment to the people, and source of household income and maintains environmental harmony (Shah, 1992; Gurung, 1993; Tomiyashu et al., 1998; Shrestha and Verma, 1999). The total area under mandarin in Nepal is 24,284 ha with the productive area of 15,304 ha and production of 166,120 mt. and productivity 10.89 mt/ha. Parbat, the mid-hill district of western development region is the one of the important mandarin growing area of Nepal. The total area, productive area, production and productivity in Parbat district was 583 ha 272 ha, 3522 mt and 12.95 mt/ha respectively in 2011/12 (ABPSD, 2012).

Despite the fact that mandarin is a viable option to increase farm income and hence alleviate widespread poverty considerable attention has not been given for its production as well as marketing aspects. It is necessary to evaluate strength and weakness of mandarin growing in mid hill. This study aims to explore major production practice and problem faced by mandarin

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growers of Parbat district so as to suggest appropriate strategies to boost up production and productivity of this crop.

**Materials and methods**

Five mandarin growers from each of the production pockets (Banskharka, Majhphat, Deupur/Deurali, Tilahar, Kurgha, Limithana, Thanamaula, Pangrag and Tribeni) were randomly selected. Altogether, 45 samples (farmers) from the whole district were selected. Three types of citrus traders; pre-harvest contactors, retailers and wholesalers were identified and selected for the interview. Two pre harvest contactors and two retailers were selected purposively from each pocket area and two wholesalers from each area were selected and were also interviewed by using the checklist. One farmers group representing to District Citrus Producers Association (DCIPA, Parbat) was selected for Focus Group Discussion (FGD). In order to assess required production parameters one Participatory Rural Appraisal (PRA) from each area was carried out. Likewise, to collect market related information Rural Market Appraisal (RMA) was conducted. The study being of the exploratory type, various sources and techniques of gathering information were used, both primary and secondary data were collected and analyzed. The primary information were collected mainly through; field survey, PRA, RMA and FGD while secondary information were collected by reviewing of various published as well as unpublished documents, reports, testimonials and related research paper available in Ministry of Agriculture Development, Fruit Development Directorate, Nepal Agricultural Research Council , National Citrus Development Program, District Agriculture Development Office (Parbat), Farmers Groups Records, Agriculture Service Center, Village Development Committee, private traders/dealers and growers.

Semi structure questionnaire was designed for collecting the information from farmers, and checklist were administered for traders, entrepreneurs, transporters and farmers groups. Likewise, necessary sets of checklists were prepared for collecting information from DADOs staffs and also other key stakeholders. Collected data were manually tabulated and analyzed by using MS-Excel software package then presented in tables and grapes.

**Result and Discussion**

**Land holding and production history**

The average land holding size of the surveyed farmers was 30.55 ropani (1 ropani = 500 m²) in which 5.17 ropani was irrigated land (Khet), and 10.06 ropani rainfed upland (Bari) and 12.48 ropani other type of land.. On an average mandarin cultivation in the study area was started 26 years ago. However, in Banskharkha mandarin cultivation was started 38 years before. More commercial cultivation of mandarin was started in Parbat in the year 1980 (DADO, 2068).
Existing mandarin growing situation

The average area per household used for cultivating mandarin was 2.38 ropanies. Household mandarin cultivation area was found highest in Banskharkha (6.1 ropani) followed by Pangrang (4.8 ropani), Deupur/Deurali (2.4 ropani), Tribeni (1.80 ropani) and Limithana (1.70 ropani), and least was in Majhphat (0.80 ropani). The average number of trees of mandarin/ha was found slightly higher than national recommended density (300 trees/ha i.e. 15 plants/ropani) and this was because of highly terraced land that gives farmers an opportunity to maintain the plant to plant distance as per the recommendation but they couldn’t manage the row to row spacing between the trees that made possible to adjust higher density of trees.

The average number of mandarin trees was recorded 20.8 trees per ropani. The highest was 25 trees in Banskharkha.

**Table 1:** Area, planting density, yield parameters and farm gate price of mandarin

<table>
<thead>
<tr>
<th>Pocket Area</th>
<th>Per household area under mandarin (ropani)</th>
<th>Plant density (No. of trees/ropani)</th>
<th>Fruit bearing %</th>
<th>Average Fruits /Tree</th>
<th>Productivity (mt/ha)</th>
<th>Stage of maturity at harvest (%)</th>
<th>Average farm gate price (NRs/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Banskharka</td>
<td>6.1</td>
<td>25</td>
<td>73.7</td>
<td>821</td>
<td>17.3</td>
<td>75</td>
<td>32.5</td>
</tr>
<tr>
<td>Majhphat</td>
<td>0.8</td>
<td>18</td>
<td>68.7</td>
<td>467</td>
<td>12.2</td>
<td>77</td>
<td>30.0</td>
</tr>
<tr>
<td>Deupur/Deurali</td>
<td>2.4</td>
<td>21</td>
<td>67.3</td>
<td>678</td>
<td>13.2</td>
<td>78</td>
<td>30.0</td>
</tr>
<tr>
<td>Tilahar</td>
<td>1.1</td>
<td>19</td>
<td>63.6</td>
<td>490</td>
<td>13.9</td>
<td>75</td>
<td>30.0</td>
</tr>
<tr>
<td>Kurgha</td>
<td>1.3</td>
<td>20</td>
<td>67.8</td>
<td>637</td>
<td>15.9</td>
<td>78</td>
<td>27.0</td>
</tr>
<tr>
<td>Limithana</td>
<td>1.7</td>
<td>21</td>
<td>71.8</td>
<td>568</td>
<td>14.9</td>
<td>75</td>
<td>29.0</td>
</tr>
<tr>
<td>Thanamaula</td>
<td>1.5</td>
<td>20</td>
<td>63.3</td>
<td>510</td>
<td>14.2</td>
<td>75</td>
<td>26.5</td>
</tr>
<tr>
<td>Pangrang</td>
<td>4.8</td>
<td>23</td>
<td>58.0</td>
<td>735</td>
<td>16.7</td>
<td>79</td>
<td>30.0</td>
</tr>
<tr>
<td>Tribeni</td>
<td>1.8</td>
<td>20</td>
<td>73.7</td>
<td>579</td>
<td>15.32</td>
<td>76</td>
<td>27.5</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>2.4</strong></td>
<td><strong>20.8</strong></td>
<td><strong>67.6</strong></td>
<td><strong>609.4</strong></td>
<td><strong>14.8</strong></td>
<td><strong>76.4</strong></td>
<td><strong>29.2</strong></td>
</tr>
</tbody>
</table>

The result showed that about 67.55 percent of mandarin trees were at bearing stage. The average productivity of mandarin at surveyed areas was 14.84 mt/ha which is higher than national average productivity (11.18 mt/ha). It could be due to the reason that all the study areas were special pockets for citrus production where commercial growers are involved in production and management.

Mandarin fruit was found marketed mainly through the pre-harvest contractors in Banskharkha and Deupur/Deurali. The contractors come to the orchard and contract the farmer by price bargaining on the basis of estimated number of fruits per tree. The contractors that come to the field are mainly from Pokhara, Kathmandu and Butwal. Once the negotiation is done, they harvest as per the market demand. The fruits can be found till Magh and Falgun months in those areas. In Pangrang, farmers market their produce through the cooperatives and every farm orchard is involved in whole process of marketing and thus they are able to achieve good price. But in other pockets the farmers themselves take their produce to the market and occasionally it is done by the pre-harvest contractors and post-harvest traders and collection agents. It was also noted that fruits are harvested at 75% maturity stage based on yellow color development.

**Planting Material:** Farmers are not yet aware of benefit of grafted saplings for higher productivity and stress management. More than 85% of farmers reported that they are using seedlings (seed propagated) planting materials and rest are using grafted sapling as a planting material obtained from DADO.
Cropping System: Mandarin was found grown mostly in rainfed upland (Bari) in the study area while rice is particularly grown in the irrigated land (Khet). In the Khetland, maize, rice, followed by wheat and rice, fallow and maize cropping system is common. Similarly, maize relay by millet and fallow, and maize followed by vegetable and fallow cropping system is common in upland. For the soil management and to retain nutrients, farmers adopt terracing in citrus. Although mulching is a very effective technique to conserve the moisture particularly in citrus but farmers are not adopting the technology. Maize is the main intercrop in mandarin orchard, however some farmers are also intercropping millet and maize. Now a days, ginger, turmeric, pulses as well as vegetables are also cultivated in orchards as intercrops. Intercropped orchards are generally manured and compost applied. Farmers hoe their orchard for intercropping which can damage the roots of the mandarin trees. Similarly, in Deupur and some parts of the Kurgha area, farmers practiced coffee and mandarin in the same orchard that leads to competition for the nutrients and water as they uptake the nutrients from the same surface level leading to low productivity of both the crops.

Application of Manure and Fertilizers: One Doko (ca. 25 kg), compost was used particularly during plantation and most of the farmers of Deupur and Pangrang areas used a Doko of compost/tree/year. Use of chemical fertilizer in mandarin was found very rare.

Land Preparation: Pit digging prior to one month of sapling plantation and were filled with compost/FYM. Pit size 1m × 1m and the distance between two pits was 5 meter. Mandarin plantation is usually done in rainy season.

Training and Pruning: Training and pruning are most important in orchard management operations for quality production of fruits. In case of training and pruning, farmers were found usually doing it after finishing the harvest removing dead branches from the trees. Apart from that no pruning was done in some areas like Tribeni. Dried and diseased branches are removed generally in Poush-Magh (Jan-Feb) of year.

Weeding: Weed free orchard is the key factor for tree healthy production and productivity. The most commonly found weeds in mandarin orchard were Siru, Gandhe, Bambara, Boke, and Dubo. It was observed that, the farmers were not much serious to control weeds in fruit orchards. Few farmers were also found growing climber summer vegetables like pumpkins, sponge gourd, bitter gourd, cucumber on mandarin orchards.

Marketing

Major markets of mandarin produced in Parbat district are Kushma, Beni, Baglung, Pokhara, Narayanghat, Butwal, Kathamandu. Fruit from the orchards are collected at collection centers and from there fruit are sold to retailer, bicycle vendor, brokers, school/hostels, hotels/restaurants, and distant wholesaler and also to exporter. Various marketing agencies or middlemen are involved in marketing process.

The average seasonal market price of the mandarin in Kushma bazar as reported by DADO publication was Rs. 30.25 per kg in 2011. However, the farmers from Banskhakha reported that they were able to get Rs. 60 per kg in Falgun and Chaitra after storing the product and taking out the product when the market is lean. So we can infer that the market price of the mandarin in each pocket area fluctuates from Rs. 15 to Rs 45 depending on season and average market price of the produce in each pocket area was Rs. 29.16/kg and shown in table 1.
Problems

Production problem: Despite the potential economic benefits of citrus, a number of socioeconomic and agronomic constraints were responsible to prevent farm households to adopt, integrate and expand mandarin into the present farming system. Insect pests and diseases were the major problems in citrus cultivation. The major insects causing problems in citrus cultivation in the district were leaf minor, sting bug, lemon butterfly, leaf eating caterpillar, shoot borer, aphids, leaf hopper, citrus psylla and fruit fly. Powdery mildew, root rot and foot rot were the major diseases. PRA discussion at field level have identified various issues and constraints such as scattered production centers, high cost of production, lack of appropriate production technology, poor distribution system due to agricultural road and transport to the production pocket and insufficient storage facilities.

Marketing problem: The result showed that among the different marketing problems on an average 96.44 percentage mandarin growers reported that there is a problem of training followed by organized market requirement (96.16%), transportation (91.94%), market price (84.97%), price behavior (83.86%), marketing information (81.44%), and packaging / grading (62.88%), respectively (Table 2). Thus the study strongly needs to organize market related training activities and to construct organized market facilities. However this has been started in Parbat District in last fiscal year with 11 members of the mandarin growing farmers from each of the region forming an association called District Citrus Producer Association (DCIPA) and they are operating in the concerned area but yet its impact on production and marketing has yet to be determined in the following years.

Table 2: Marketing Problems (% of farmers responding as problem).

<table>
<thead>
<tr>
<th>Pocket Area</th>
<th>Market Price</th>
<th>Price Behavior</th>
<th>Marketing Information</th>
<th>Organized Market</th>
<th>Transport Facility</th>
<th>Packaging Grading</th>
<th>Training</th>
</tr>
</thead>
<tbody>
<tr>
<td>Banskharka</td>
<td>70.00</td>
<td>90.00</td>
<td>85.00</td>
<td>100.00</td>
<td>90.00</td>
<td>70.00</td>
<td>100.00</td>
</tr>
<tr>
<td>Majhphat</td>
<td>82.00</td>
<td>82.00</td>
<td>70.00</td>
<td>92.00</td>
<td>97.00</td>
<td>52.00</td>
<td>99.00</td>
</tr>
<tr>
<td>Deupur/Deurali</td>
<td>88.00</td>
<td>78.25</td>
<td>86.00</td>
<td>94.00</td>
<td>86.00</td>
<td>65.00</td>
<td>97.00</td>
</tr>
<tr>
<td>Tilahar</td>
<td>92.00</td>
<td>83.00</td>
<td>82.00</td>
<td>96.00</td>
<td>85.00</td>
<td>63.00</td>
<td>92.00</td>
</tr>
<tr>
<td>Kurgha</td>
<td>75.25</td>
<td>89.00</td>
<td>75.00</td>
<td>91.00</td>
<td>87.00</td>
<td>61.00</td>
<td>95.00</td>
</tr>
<tr>
<td>Limithana</td>
<td>97.50</td>
<td>87.50</td>
<td>87.50</td>
<td>100.00</td>
<td>100.00</td>
<td>62.50</td>
<td>100.00</td>
</tr>
<tr>
<td>Thanamaula</td>
<td>70.00</td>
<td>70.00</td>
<td>82.50</td>
<td>95.00</td>
<td>90.00</td>
<td>75.00</td>
<td>87.50</td>
</tr>
<tr>
<td>Pangrang</td>
<td>92.50</td>
<td>82.50</td>
<td>85.00</td>
<td>100.00</td>
<td>95.00</td>
<td>55.00</td>
<td>100.00</td>
</tr>
<tr>
<td>Tribeni</td>
<td>97.50</td>
<td>92.50</td>
<td>80.00</td>
<td>97.50</td>
<td>97.50</td>
<td>62.50</td>
<td>97.50</td>
</tr>
<tr>
<td>Average</td>
<td>84.97</td>
<td>83.86</td>
<td>81.44</td>
<td>96.16</td>
<td>91.94</td>
<td>62.88</td>
<td>96.44</td>
</tr>
</tbody>
</table>

| Rank | IV | V  | VI | II | III | VII | I  |

Impact

Impact on livelihood: Because of the low education level and income of poor rural farmers, they are unable to invest for drinking water, toilet construction and for better housing. Survey shows that, the drinking water facilities in the study areas are improved after increased income generated by mandarin growing.
Similarly housing condition of farmers is directly related with economic status. It was found that 32 (71%) farmers had temporary type of house and 13 (29%) had permanent type of house before mandarin growing. After they started getting income from mandarin cultivation pattern of housing changed. At present 40 (89%) households have permanent type of house with stone and tin roofing. Before, most farmers had thatch (Khar) roofing.

**Change in workload of women:** Mostly in rural area women are main contributors in agricultural sector. It was found that mandarin cultivation decreased the work load of women in study area. Seasonal work has to be done for mandarin orange cultivation. Before mandarin cultivation farmers used to grow millet, maize, upland rice and other cereal crops which requires regular management such as tillage, weeding, and other intercultural operations but fruit farming does not require such. Out of 45 respondents only 2% mentioned that mandarin farming increased the work load of women and rest 9% indicated there is no change in workload while 89% said incorporation of mandarin cultivation decreased the workload of women (Fig. 2).
**Fruit consumption:** Trends of fruit consumption are directly related with fruit availability and level of awareness. Mandarin farming increased the awareness in society, increased the level of education which caused increasing trends of fruit consumption.

As high as 96% respondents mentioned that household fruit consumption increased after mandarin farming while rest respondent has said that there was no effect of mandarin farming in fruit consumption.

**Socioeconomic:** At present they can easily manage money for their child education compared to earlier. Similarly fig. 8 shows that mandarin farming increases the social and health status of farmers. It was found that out of 45 mandarin growers interviewed 33% mentioned that mandarin cultivation provided full time employment for them partial employment for 56% farmers while 11% farmers were found hiring external people during peak period of time.

![Fig 3: Positive change experienced in different sector](image)

Fig 3: Positive change experienced in different sector

Fig. 4 shows that 33% of the respondent earned more than 10 lakhs/year, while 22% and 33% respondents earned Rs 5-10 lakhs and 1-5 lakhs/ year respectively. Before mandarin cultivation it was very hard to them to even Rs 50 thousand per annum.

![Fig 4: Annual income of respondents before and after mandarin orange farming in percentage.](image)

Fig 4: Annual income of respondents before and after mandarin orange farming in percentage.
It was found that farmers utilized their income primarily in food, child education, clothes, medicine and daily required goods as they earn more than they utilize in other sectors. Some farmers use to purchase cultivable land, improving the housing condition, livestock purchase and social functions. Fig 5 shows that how farmer utilized their income earned from mandarin farming.

![Fig 5: Utilization of income generated from mandarin orange farming](image)

**CONCLUSION**

The average density of mandarin was found slightly higher (415 trees/ha) than national recommended density (300 trees/ha) and the farmer of study area was found to using sapling and seedlings both for planting materials. The majority of the mandarin trees under study were found bearing and the productivity of citrus (14.84 mt/ha) was found higher than national average (11.18 mt/ha). The gross margin analysis showed that most of the farmers realized profit from the mandarin cultivation. Traditional packaging materials like bamboo baskets (*Dokos*) are used for packing. The modes of transportation are porters, mules, horses, tractors, local buses and so on. Many a time these packages filled with fruits are dropped or thrown while loading and unloading. Roads are rough and bumpy. Citrus fruit are damaged to great extent during transportation. Unsuitable storage conditions damage fruits further.

Mandarin cultivation has positive economic implication to the Nepalese farmers. It shares major portion of their household economy of the commercially growing farmers. It is empirical that mandarin based farming systems is more profitable land use approach in the hills of Nepal as compared to annual crop based systems could bring substantial improvement in income of farm households in the hill regions where farm size is very small and barely enough to sustain farm family from annual crops. Improvements in harvesting techniques, storage conditions, handling techniques during transportation, packaging, modes of transport and marketing conditions are needed improvement to reduce post-harvest losses in mandarin fruit. Although government has emphasized to produce/cultivate mandarin in mid hills of Nepal, this research results reveal that more efforts need to be given to solve growers’ problem.
LITERATURES CITED


Effect of Plant Population on Bulb Size and Yield of Marketable Bulbs of Onion Varieties during Off Season

S. Shakya¹, S.M. Shakya¹, S.K. Sah¹ and A. Srivastava ¹

ABSTRACT

An experiment was conducted in Sunwal, Nawalparasi district of Nepal to assess the effect of plant population on bulb size and marketable yield of two onion varieties during rainy season of 2008. Two off season varieties of onion as main plot factor viz. Agrifound Dark Red (AFDR) and N-53 and six different plant populations (125, 100, 83.34, 66.67, 50 and 33.34 plants per m²) obtained by using different spacings of 10×8, 10×10, 12×10, 15×10, 20×10 and 20×15 cm as sub plot factors were used as treatments and laid out in a split plot design with three replications. Marketable bulb yield of AFDR (25.55 mt ha⁻¹) was higher than that of N-53 (19.78 mt ha⁻¹). Marketable bulb yield was highest at closer spacing of 10×10 cm for both the varieties which was 26.97 mt ha⁻¹ in AFDR and 22.48 mt ha⁻¹ in N-53. The size of the bulbs increased with increase in spacing. The most preferred size of bulb was found to be of diameter between 3.5 to 5 cm whose yield was found highest (2.19 kg/plot) at the closest spacing of 10×8 cm which was not statistically different from that (2.17 kg/plot) at the spacing of 10×10 cm. The most preferred sized bulb yield showed a similar trend of increase as total marketable bulb yield with decrease in spacing. The spacings of 12×10, 10×10 and 10×8 cm produced total marketable bulb yields which were not significantly different from each other. The highest net return of Rs. 5,68,977 per hectare was found at the spacing of 12×10 cm for the variety AFDR.

Keywords: Off season, onion, spacing, varieties

INTRODUCTION

Onion (Allium cepa L.) is one of the world’s most important vegetables and is cultivated in both temperate and tropical regions (Brewester, 1994). It ranks third in production among the vegetable crops in the world after tomato and cabbage (FAO, 1996) while Thapa and Paudyal (2000) reported it to rank 4th in position in terms of its volume and value of the production in Nepal. There is steady demand of onion bulb throughout the year which is increasing every year in Nepal. Severe scarcity of onion bulbs is seen from August to March in the vegetable markets of Nepal which is fulfilled by import from India in the period (Budathoki, 2006) and the condition is aggravated by the storage losses of up to 88% (Srivastava and Sharma, 1994). About 30,781 mt of onions were imported from India during the year 2007/08 (Republica, 2009).

In the context of the steady demand of onion and the import status of the onion bulbs, the production of onion bulbs has been emphasized by the government and the Mission Onion is in action in this line which aims to substitute imports by increasing the land devoted to onion

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farms from 15,062 ha to 27,292 ha across the country by fiscal year 2011/12 (Republica, 2009). This increase in bulb production could further be increased by increasing the productivity of onion bulbs which seems to be very low in Nepal.

Budhathoki et al. (2004) reported that Agrifound Dark Red and N-53 are established as promising off season varieties. Currah and Proctor (1990) reported that N-53 and Agrifound Dark Red were suitable for Kharif season (July to November). From the four varieties tested during off season during late rainy season of 2007 under Inner Terai condition, AFDR and N-53 were found to be suitable varieties with higher yields (Dahal, 2008).

Plant population density is one of the important factor that governs bulb size and yield of bulb in onion crop (Brewster, 1990) and the increase in yield is achieved through increased production per unit area. Besides, planting distance can be vital for contributing to better marketable bulb yield in onion (Acharya, 2007).

Thus, there is need of identifying optimum bulb size demanded by the market of a specific locality and appropriate plant population density to achieve maximum yield of bulbs of desired size. Therefore, the present study aims at comparing the two varieties of onion viz., Agrifound Dark Red and N-53 at different population densities so that the effect of plant population on bulb size could be assessed and the appropriate plant population for achieving the higher total yields as well as marketable sized bulb yield could be identified under Terai condition of Nawalparasi district of Nepal.

MATERIALS AND METHODS

The experiment was conducted at Sunawal VDC-1 of Nawalparasi district from July, 2008 to January, 2009. The onion varieties namely N-53 and Agrifound Dark Red (AFDR) were selected for the study. The seedlings were transplanted at the age of 57 days after seed sowing (DAS). Transplanting was done at six different spacings of 10×8 cm, 10×10 cm, 12×10 cm, 15×10 cm, 20×15 cm and 20×15 cm as designated treatments, the gross plot size for the six subplots taking single border row around each subplot according to the spacings were 1.904 m², 1.96 m², 2.016 m², 2.1 m², 2.24 m² and 2.4 m² respectively with 238, 196, 168, 140, 112 and 80 plants respectively and the net plot area contained a plant population of 180, 144, 120, 96, 72 and 48 plants respectively.

The experiment was laid out in split plot design with three replications. There were 12 treatment combinations in a replication consisting of two varieties viz. AFDR and N-53 as the main plot factors and six plant population viz. 125, 100, 83.34, 66.67, 50 and 33.34 plants per m² as the subplot factor. The following were the treatment combinations:

Treatment 1 (T1) = 125 plants per m² of variety AFDR (10×8 cm)
Treatment 2 (T2) = 100 plants per m² of variety AFDR (10×10 cm)
Treatment 3 (T3) = 83.34 plants per m² of variety AFDR (12×10 cm)
Treatment 4 (T4) = 66.67 plants per m² of variety AFDR (15×10 cm)
Treatment 5 (T5) = 50 plants per m² of variety AFDR (20×10 cm)
Treatment 6 (T6) = 33.34 plants per m² of variety AFDR (20×15 cm)
Treatment 7 (T7) = 125 plants per m² of variety N-53 (10×8 cm)
Treatment 8 (T8) = 100 plants per m$^2$ of variety N-53 (10×10 cm)
Treatment 9 (T9) = 83.34 plants per m$^2$ of variety N-53 (12×10 cm)
Treatment 10 (T10) = 66.67 plants per m$^2$ of variety N-53 (15×10 cm)
Treatment 11 (T11) = 50 plants per m$^2$ of variety N-53 (20×10 cm)
Treatment 12 (T12) = 33.34 plants per m$^2$ of variety N-53 (20×15 cm)

A survey was conducted in the district to assess the marketable size of the onion bulbs. For this purpose, four major market areas of the district namely Gaindakot, Kawasoti, Sunwal and Parasi were selected. Five vegetable traders of each market and five onion growing farmers cum traders of the Sunwal and Swanthi VDCs were asked to separate the bulbs on the basis of size in categories like large, medium and small (five in each category) according to their perception. The diameter of five bulbs in each category was measured with the help of a Vernier Calliper. On the basis of the results of the survey as well as support from literature, a grading of the bulbs on the basis of the diameter was done.

The data recorded were entered into the Microsoft Excel spread sheet and were then analyzed by using MSTAT-C for deriving ANOVA. Means were compared by using Duncan’s Multiple Range Test (DMRT) at 0.05 level of significance (Gomez and Gomez, 1984).

RESULTS AND DISCUSSIONS

Vegetative characters

The plant height of Agrifound Dark Red (33.40 cm) was significantly higher than the plant height of N-53 (30.69 cm) at 30 days after transplanting (DAT) while the plant height of Agrifound Dark Red and N-53 were not significantly different at 45, 60 and 75 DAT. Spacing and interaction effect of spacing and varieties didn’t significantly affect the plant height at 30, 45, 60 and 75 DAT. The number of leaves of variety AFDR was at par with the number of leaves of the variety N-53 at different spacing at 30, 45, 60 and 75 DAT. The interaction effect was also statistically non significant at 45, 60 and 75 DAT while at 30 DAT the interaction effect was found highly significant with the highest number of leaves (5.05) at 20×15 cm and the lowest number of leaves (4.15) in the variety N-53 at the spacing of 10×10 cm.

Quality characteristics

Average polar length of onion bulbs was not significantly different between the varieties. Spacing significantly affected average polar length with the lowest polar length at the spacing of 10×10 cm (i.e., 3.31 cm) which was not significantly different from that of 3.34 cm at the spacing of 10×8 cm. The interaction between varieties and spacings on average polar length was not significant. There was no significant difference between the varieties with respect to the neck thickness and the effect of spacing and interaction effect between varieties and spacings on average neck thickness was also not significant.

AFDR showed the mean bulb diameter of 4.43 cm which was comparatively greater than that of N-53 (4.31 cm) but not different statistically. There was significant difference in the mean diameter of the harvested bulbs due to spacing treatments which also showed similar pattern as the polar length and the neck thickness. The highest mean diameter was 5.09 cm at the widest spacing of 20×15 cm and the lowest (3.91 cm) at the closest spacing of 10×8 cm. The bulb diameter increased with increase in the spacing. Similar results were obtained in case of bulb
diameter in Kharif season in Bangladesh (BARI, 2006 and 2007). With respect to the average mean diameter, the interaction effect between the varieties and spacings was not significant.

With respect to the mean bulb weight, the varieties were significantly different. AFDR with 46.64 g had higher mean bulb weight as compared to N-53 which was 45.03 g (Table 3). Sharma and Neupane (1995) found the average bulb weight to be 32.70 g AFDR which was contradictory to the present results. While Rokaya et al. (2004) reported the bulb weight of 27 to 47 g for the variety Nasik Red-53. There was also significant effect of spacing on the mean bulb weight with lowest mean bulb weight of 34.76 g at the closest spacing of 10×8 cm and the highest mean bulb weight of 61.07 g at the widest spacing of 20×15 cm. The mean bulb weight decreasing with the decrease in the spacing seems in conformity to the findings of the result obtained from experiments in Bangladesh during Kharif season (BARI, 2002, 2006 and 2007). The interaction between varieties and spacings was not significant with respect to the mean bulb weight.

The varieties did not differ significantly in respect of number of single marketable bulbs per plot and percent single marketable bulbs while spacing had significant effect on them while variety and spacing had significant effect on doubled marketable bulbs and percent doubled marketable bulbs with no significant interaction effect.

The number of total marketable and unmarketable bulbs per plot was not significantly different between the two varieties. Spacing had significant effect on marketable bulbs and unmarketable bulbs per plot while the interaction effect was not significant.

Table 1. Number of marketable and unmarketable bulbs per plot of onion varieties at different spacings at Sunwal, Nawalparasi, 2008/09

<table>
<thead>
<tr>
<th>Treatments (Main plot)</th>
<th>Marketable bulbs per plot</th>
<th>Unmarketable bulbs per plot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agrifound Dark Red</td>
<td>75.50</td>
<td>12.73</td>
</tr>
<tr>
<td>N-53</td>
<td>72.17</td>
<td>10.45</td>
</tr>
<tr>
<td>S E&lt;sub&gt;m&lt;/sub&gt;</td>
<td>1.21</td>
<td>1.03</td>
</tr>
<tr>
<td>CD (P=0.05)</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Spacing (Sub plot)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S&lt;sub&gt;1&lt;/sub&gt; (10×8 cm)</td>
<td>95.50&lt;sup&gt;a&lt;/sup&gt;</td>
<td>28.34&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>S&lt;sub&gt;2&lt;/sub&gt; (10×10 cm)</td>
<td>95.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>21.17&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>S&lt;sub&gt;3&lt;/sub&gt; (12×10 cm)</td>
<td>83.00&lt;sup&gt;b&lt;/sup&gt;</td>
<td>10.34&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>S&lt;sub&gt;4&lt;/sub&gt; (15×10 cm)</td>
<td>69.34&lt;sup&gt;c&lt;/sup&gt;</td>
<td>4.34&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>S&lt;sub&gt;5&lt;/sub&gt; (20×10 cm)</td>
<td>58.34&lt;sup&gt;d&lt;/sup&gt;</td>
<td>3.17&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>S&lt;sub&gt;6&lt;/sub&gt; (20×15 cm)</td>
<td>41.84&lt;sup&gt;e&lt;/sup&gt;</td>
<td>2.17&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Mean</td>
<td>73.83</td>
<td>11.58</td>
</tr>
<tr>
<td>S E&lt;sub&gt;m&lt;/sub&gt;</td>
<td>2.38</td>
<td>1.03</td>
</tr>
<tr>
<td>CD (P=0.05)</td>
<td>7.02</td>
<td>3.02</td>
</tr>
<tr>
<td>CV%</td>
<td>7.89%</td>
<td>21.65%</td>
</tr>
</tbody>
</table>

Treatments means followed by common letter (s) within column are not significantly different among each other based on DMRT at 5% level of significance.
Only the varieties differed significantly with respect to TSS content of the bulbs with AFDR showing comparatively higher (10.36 °Brix) TSS content as compared to N-53 (7.42 °Brix). Similarly, in case of dry matter percentage, the bulbs of AFDR had significantly higher dry matter percentage (10.98%) as compared to N-53 (10.30%). Spacings and interaction effect were also observed to be non-significant with respect to TSS and dry matter percentage. Shukla and Prabhakar (1989) also reported that there was no effect of spacing on TSS and dry matter percentage of the onion bulbs.

**Number and yield of single marketable bulbs in different grades**

On the basis of the literature review and survey of the traders and farmers of the district, the bulbs for vegetable or fresh purpose has been classified as given below.

Table 2: Different grades of onion bulbs according to the diameter

<table>
<thead>
<tr>
<th>Grades</th>
<th>Diameter (cm)</th>
<th>Grade designation</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;2</td>
<td></td>
<td>Unmarketable</td>
</tr>
<tr>
<td>Grade I</td>
<td>2-3.5</td>
<td>Small</td>
</tr>
<tr>
<td>Grade II</td>
<td>3.5-5</td>
<td>Optimum</td>
</tr>
<tr>
<td>Grade III</td>
<td>5-6</td>
<td>Large</td>
</tr>
<tr>
<td>Grade IV</td>
<td>&gt;6</td>
<td>Very large</td>
</tr>
</tbody>
</table>

From the market survey, no distinct price variation according to grades or size of bulbs was seen. So, here these grades have only been used to assess the effect of plant population on bulb size.

There was no significant difference in the number of bulbs in grade I and grade II between two varieties and the interaction effect between variety and spacing while spacing had significant effect on them.

Table 3. Number of single marketable bulbs of onion varieties in different grades at different spacings at Sunwal, Nawalparasi, 2008/09

<table>
<thead>
<tr>
<th>Treatments Varieties(Main plot)</th>
<th>Grade I (2-3.5 cm)</th>
<th>Grade II (3.5-5 cm)</th>
<th>Grade III (5-6 cm)</th>
<th>Grade IV (&gt; 6 cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agrifound Dark Red</td>
<td>17.78</td>
<td>34.73</td>
<td>12.12</td>
<td>4.39</td>
</tr>
<tr>
<td>N-53</td>
<td>17.62</td>
<td>33.28</td>
<td>9.50</td>
<td>3.12</td>
</tr>
<tr>
<td>S E&lt;sub&gt;m&lt;/sub&gt;</td>
<td>0.48</td>
<td>0.75</td>
<td>0.39</td>
<td>0.20</td>
</tr>
<tr>
<td>CD (P=0.05)</td>
<td>NS</td>
<td>NS</td>
<td>2.36</td>
<td>1.20</td>
</tr>
</tbody>
</table>

Spacing (Sub plot)

<table>
<thead>
<tr>
<th>Spacing (Sub plot)</th>
<th>Grade I (2-3.5 cm)</th>
<th>Grade II (3.5-5 cm)</th>
<th>Grade III (5-6 cm)</th>
<th>Grade IV (&gt; 6 cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S&lt;sub&gt;1&lt;/sub&gt; (10x8 cm)</td>
<td>32.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>52.50&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.17&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.00&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
<tr>
<td>S&lt;sub&gt;2&lt;/sub&gt; (10x10 cm)</td>
<td>28.17&lt;sup&gt;b&lt;/sup&gt;</td>
<td>51.67&lt;sup&gt;a&lt;/sup&gt;</td>
<td>10.17&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.00&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
<tr>
<td>S&lt;sub&gt;3&lt;/sub&gt; (12x10 cm)</td>
<td>20.67&lt;sup&gt;c&lt;/sup&gt;</td>
<td>41.67&lt;sup&gt;b&lt;/sup&gt;</td>
<td>10.84&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.67&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>S&lt;sub&gt;4&lt;/sub&gt; (15x10 cm)</td>
<td>12.50&lt;sup&gt;d&lt;/sup&gt;</td>
<td>29.67&lt;sup&gt;c&lt;/sup&gt;</td>
<td>12.34&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>4.34&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
<tr>
<td>S&lt;sub&gt;5&lt;/sub&gt; (20x10 cm)</td>
<td>8.67&lt;sup&gt;e&lt;/sup&gt;</td>
<td>17.84&lt;sup&gt;d&lt;/sup&gt;</td>
<td>13.84&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.67&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>S&lt;sub&gt;6&lt;/sub&gt; (20x15 cm)</td>
<td>4.17&lt;sup&gt;f&lt;/sup&gt;</td>
<td>10.67&lt;sup&gt;e&lt;/sup&gt;</td>
<td>10.50&lt;sup&gt;b&lt;/sup&gt;</td>
<td>8.84&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Mean</td>
<td>17.69</td>
<td>33.99</td>
<td>10.80</td>
<td>3.75</td>
</tr>
<tr>
<td>S E&lt;sub&gt;m&lt;/sub&gt;</td>
<td>0.72</td>
<td>1.84</td>
<td>0.85</td>
<td>0.46</td>
</tr>
<tr>
<td>CD (P=0.05)</td>
<td>2.12</td>
<td>5.41</td>
<td>2.51</td>
<td>1.34</td>
</tr>
<tr>
<td>CV%</td>
<td>9.93%</td>
<td>13.20%</td>
<td>19.22%</td>
<td>29.48%</td>
</tr>
</tbody>
</table>
The two varieties differed significantly with respect to the number of single marketable bulbs in grade III and grade IV. Similarly, the effect of spacing was significant in these aspects while the interaction effect was found to be non significant.

There was no significant effect of the varieties and interaction with respect to the weight of single marketable bulbs in grade I, II and III while the effect on yield of grade I, II, III and IV bulbs were significant with spacing. AFDR had significantly higher yield of single marketable bulbs in grade II, III and IV than N-53. The interaction effect of varieties and spacings on yield of grade IV bulbs was significant which showed the highest (1.28 kg) weight of bulbs at the widest spacing of 20×15 cm in AFDR and lowest or no bulbs at the spacing of 10×8 and 10×10 cm for both the varieties.

**Yield and yield components**

The effect of variety and spacing on final plant stand, biological yield and single marketable bulb yield was significant while the interaction effect was not significant. The highest single marketable yield was recorded at the spacing of 10×10 cm to be 3.44 kg which was not significantly different from those at the spacings of 10×8 and 12×10 cm i.e., 3.32 and 3.24 kg per plot respectively. The effect of spacing was only statistically significant in case of doubled marketable bulb yield.

AFDR had the highest total (single + doubled) marketable bulb yield (3.54 kg per plot) which was significantly higher than that of N-53 (2.85 kg). The marketable bulb yield per plot was highest (3.56 kg) at the spacing of 10×10 cm which was not significantly different from 3.42 and 3.41 kg at the spacings of 12×10 cm and 10×8 cm respectively (Table 4). The widest spacing of 20×15 cm produced the lowest (2.69 kg) marketable yield per plot. The interaction effect was not significant. Thus, the average marketable bulb yield per ha was significantly higher in AFDR (24.55 mt ha⁻¹) as compared to N-53 which was calculated to be 19.78 mt ha⁻¹. The highest marketable bulb yield per ha (24.72 mt ha⁻¹) was recorded at the spacing of 10×10 cm which was not significantly different from 23.73 and 23.66 mt ha⁻¹ at the spacings of 12×10 and 10×8 cm respectively. The lowest marketable yield per ha of 18.64 mt ha⁻¹ was exhibited by the widest spacing of 20×15 cm.

Significantly maximum bulb productivity and also the marketable bulb productivity at harvest were recorded at 10×10 cm spacing, which decreased linearly with an increase in plant spacing (Shrivastava et al., 1996). These results are in conformity. Similar results were also reported by Randhawa and Singh (1974), Brewster and Salter (1980) and Khare (1985) who observed that the total economic productivity of onion increased with increased plant density until an optimum was reached and then declined sharply.

Table 4. Single, doubled and total marketable bulb yield of onion varieties at different spacings at Sunwal, Nawalparasi, 2008/09

<table>
<thead>
<tr>
<th>Treatments Varieties(Main plot)</th>
<th>SMBY (kg/plot)</th>
<th>DMBY (kg/plot)</th>
<th>TMBY (kg/plot)</th>
<th>TMBY (mt ha⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agrifound Dark Red</td>
<td>3.32ᵃ</td>
<td>0.22</td>
<td>3.54ᵃ</td>
<td>24.55ᵃ</td>
</tr>
<tr>
<td>N-53</td>
<td>2.61ᵇ</td>
<td>0.24</td>
<td>2.85ᵇ</td>
<td>19.78ᵇ</td>
</tr>
<tr>
<td>S Eₘ</td>
<td>0.05</td>
<td>0.01</td>
<td>0.05</td>
<td>0.32</td>
</tr>
<tr>
<td>CD (P=0.05)</td>
<td>0.26</td>
<td>NS</td>
<td>0.28</td>
<td>1.90</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spacing (Sub plot)</th>
<th>SMBY (kg/plot)</th>
<th>DMBY (kg/plot)</th>
<th>TMBY (kg/plot)</th>
<th>TMBY (mt ha⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S₁ (10×8 cm)</td>
<td>3.32ᵃ</td>
<td>0.10ᵇ</td>
<td>3.41ᵃ</td>
<td>23.66ᵃ</td>
</tr>
<tr>
<td>S₂ (10×10 cm)</td>
<td>3.44ᵃ</td>
<td>0.13ᵈ</td>
<td>3.56ᵃ</td>
<td>24.72ᵃ</td>
</tr>
<tr>
<td>S₃ (12×10 cm)</td>
<td>3.24ᵃ</td>
<td>0.19ᵉ</td>
<td>3.42ᵃ</td>
<td>23.73ᵃ</td>
</tr>
<tr>
<td>S₄ (15×10 cm)</td>
<td>2.87ᵇ</td>
<td>0.22ᶜ</td>
<td>3.09ᵇ</td>
<td>21.42ᵇ</td>
</tr>
</tbody>
</table>
Higher yields from closer spacings or higher plant density had also been reported by several authors like Rashid and Rashid (1978), Shanthi and Balakrishnan (1989), Rumpel and Felczynski (1996), Karim et al. (1999), Kanton et al. (2002), Khan et al. (2003) and different experiments conducted in Bangladesh (BARI, 1992, 1998 and 2007). While marketable yield increased with plant density and depending on year was highest at 80 or 100 plants m\(^{-2}\) (Rumpel and Felczynski, 1996) and increase in marketable bulb yield at densities above 76.92 plants m\(^{-2}\) was reported by Kanton et al. (2002). The interaction effect of varieties and spacings was not found to be statistically significant in case of total marketable bulb yield per ha.

**Economic analysis of off season onion production**

Higher number of seedlings required for closer spacing increased the cost of seedling production progressively as the spacing decreased. The cost of production of onion bulb in main field varied with the levels of spacing, the cost of planting and harvesting being the major determinant factors affecting the cost of bulb production. The cost of production was highest (Rs. 2,93,754.60/ha) at the closest spacing (10×8 cm) and the lowest at the widest spacing (20×15 cm) i.e. Rs. 1,65,382.70/ha for AFDR while for N-53 spacing of 10×8 cm incurred the highest cost of Rs. 2,73,504.60/ha and the lowest cost of Rs. 1,59,982.70/ha was observed at the spacing of 20×15 cm.

Total return varied with the yield. Higher yield level gave the higher income. The total return of Agrifound Dark Red and N-53 at the spacing of 10×10 cm while benefit cost (B:C) ratio of Agrifound Dark Red and N-53 was highest at the widest spacing of 20×15 cm and lowest at the closest spacing of 10×8 cm. The lowest B:C ratio at the closest spacing was due to the higher cost of seedling production as well as main plot production which progressively increased with the increase in spacing due to the lowered cost of production as the seedling production cost and main plot production cost considerably decreased as the spacing increased.

Gross income (Net returns) was also higher in Agrifound Dark Red as compared to N-53. Gross income of Agrifound Dark Red at the spacing of 12×10 cm was highest (Rs. 5,68,977.40/ha) and at the widest spacing of 20×15 cm it was observed to be the lowest (Rs. 4,63,798.40/ha). For N-53, the highest gross income was found to be Rs. 4,33,883.90/ha at the spacing of 10×10 cm as compared to the lowest gross income of Rs. 3,31,417.40/ha at the widest spacing of 20×15 cm. For AFDR, the gross income increased up to the spacing of 12×10 cm after which it declined progressively at closer spacings of 10×10 cm and 10×8 cm while for N-53, the gross income increased up to the spacing of 10×10 cm after which it declined at the spacing of 10×8 cm.
CONCLUSION

Though not significant, the number and percentage of the single marketable bulbs per plot was higher in AFDR while the number and percentage of doubled marketable bulbs per plot was significantly higher in N-53. The highest number of single marketable bulbs and total marketable bulbs per plot were produced at the spacing of 10×8 cm (91.67 and 95.50 respectively) which were not significantly different from those of 10×10 cm i.e., 90 and 95 respectively. Significantly higher number of bulbs in grade III (12.12) and grade IV (4.39) were seen in variety AFDR while significantly higher weight of bulbs in grade II, III and IV in variety AFDR as compared to N-53. Highest number, percentage by number, weight and percentage by weight of single marketable bulbs in grade I was found at the closest spacing of 10×8 cm while the highest numbers of bulbs in grade II were seen at the spacing of 10×8 (52.50) and 10×10 cm (51.67) which were at par. Highest weight (2.19 kg) and percentage weight (65.866%) of the single marketable bulbs in grade II was seen at the spacing of 10×8 cm which were not significantly different from 2.17 kg and 63.01% respectively at the spacing of 10×10 cm. Highest number, percentage by number, weight and percentage by weight of single marketable bulbs in grade IV were seen at the spacing of 20×15 cm. The final plant stand, biological yield, TSS and dry matter percentage were significantly higher in the variety AFDR as compared to N-53. The final plant stand was significantly higher (122) at the spacing of 10×8 cm and lowest (42.84) at the spacing of 20×15 cm. Biological yield per plot was highest (6.24 kg) at the spacing of 10×10 cm which was not significantly different from 6.18 and 5.80 kg at the spacings of 10×8 and 12×10 cm respectively. Spacing had no significant effect on the TSS and dry matter percentage of the onion bulbs. Doubled marketable yield per plot was highest at the spacing of 20×15 cm while the single marketable yield per plot and total marketable yield per plot as well as marketable yield per ha was highest at the spacing of 10×10 cm which were not significantly different from those of 10×8 and 12×10 cm. Closer spacings produced significantly higher yield than wider spacings. The Grade II bulb yield showed similar pattern with the total marketable bulb yield per hectare with respect to spacing which increased with the decrease in spacing.

On the basis of economic analysis, variety AFDR performed better than N-53. Total cost of production was higher in AFDR because of the higher seed cost as compared to N-53. The cost of production was highest (Rs. 2,93,754.60/ha) in AFDR at the spacing of 10×8 cm and lowest (Rs. 1,65,382.70/ha) at the spacing of 20×15 cm. Similarly, for variety N-53, highest cost of production (Rs. 2,73,504.60/ha) was observed at the spacing of 10×8 cm and lowest (Rs. 1,59,982.70/ha) at the spacing of 20×15 cm. The highest net return per hectare for AFDR was observed (Rs. 5,68,977.40) at the spacing of 12×10 cm and for N-53 the highest net return of Rs. 4,33,883.90 was observed at the spacing of 10×10 cm.

From the present study, variety AFDR was found better than N-53 in different yield and yield attributes for off season onion bulb production. For both the varieties, the bulb size showed a general increase with increase in spacing. On the basis of single marketable bulb yield and total marketable bulb yield, planting density of around 84 to 125 plants m$^{-2}$ is found suitable. Plant
population of 100 to 125 plants m\(^{-2}\) is found suitable for maximum yield of medium sized or highly marketable sized bulbs.

**LITERATURES CITED**


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Effect of Spring Pruning on Bud Characteristics, Floral Stem Length and Quality Cut Flower Production of Hybrid Tea Rose Cultivars in Chitwan, Nepal

T.P. Sharma¹, S.S. Pant¹, K. Mishra¹ and R.B. Thapa¹

ABSTRACT
An experiment was conducted in the Abloom flora of Gunjanagar-5, Chitwan, Nepal during March, 2013 to August, 2013 to study the effect of Spring Pruning on Growth and Production of Quality Cut Flower of HT Rose Cultivars. The experiment was laid out in three factorial split- split plot design with three replications. There were 12 treatments consisting of three popular Italian HT Rose varieties (High Magic, Lenopa and Confetti of three different color viz white, red and yellow respectively), two dates (1st on 8th March, 2013 and 2nd on 18th March, 2013) and Pruning (Pruned and non-pruned). High Magic pruned on 8th March 2013 produced flower having longest floral bud (3.554cm) and flower stem (41.008cm). Maximum flower diameter (2.863cm) was also recorded in High Magic pruned on 8th March, 2013. High Magic also produced larger mean number of cut rose flowers (23.833) followed by Confetti (14.250) and Lenopa (10.333). Plants pruned on 1st date produced maximum mean number of flowers (20.889). Maximum (22.611) flowers per plot was counted in pruned plants. Among all cultivars, High Magic produced longer stem length in all dates of pruned and un-pruned condition followed by Lenopa and shorter stem length was produced by variety Confette in all conditions. Variety High Magic pruned on 18th March 2013 produced longer flower stem (44.750cm) whereas variety Confetti produced flowers having shorter stem length (24.333cm) in plants that were un-pruned on 8th March, 2013.

Key words: Pruning, variety, floral bud, floral stem, flower production.

INTRODUCTION
Rose (Rosa spp.) belongs to the family Rosaceae and is one of the most important woody perennials including shrubs, bushes of various sized ramblers and climbers as well as very small plants known as miniatures (Encyclopedia Americana, 1984; Gibson, 1984) and is one of the most economically important genus of ornamental, aromatic and medicinal plants with about 200 species and 20,000 cultivars widely distributed all over the world (Cuizhi and Robertson, 2003; Ritz et al, 2005). Rose is the most popular of all the flowers because of its beauty and fragrance and is called the “Queen of Flowers” (Schneider and Dewolf, 1995). The demand of rose cut flower is 7000-9000 sticks per day in Kathmandu and about 172 ropanies of land is covered under rose cultivation in Nepal (FAN, 2013). Roses respond well to pruning and are believed strictly to be pruned every year regularly. Pruning is the management of plant structure and fruiting wood and involves removal of plant’s top and root system to facilitate and increase its usefulness (Hessayon, 1988). Pruning is a very important and necessary step which is beneficial for growth and increases the aesthetic values like profuse and larger blooms with inspiring colour and quality of the flowers (Gibson, 1984, Anderson, 1991). Chimonidou et al. (2000) observed that when flower stem was removed by pruning, flower initiated shortly after the start of axillary bud growth. However, Terada et al.(1997) reported that after the cut flower and pruning, growth rate decreased immediately. On the other hand, Uma and Gowda (1987) reported hard pruning delayed flowering while influenced other flower characters such as increased length, bud length and diameter. Roses need different types and timing of pruning depending on their variety (Hessayon, 1988). Repeated blooming roses such as floribunda and hybrid tea roses need a heavy annual pruning that is done in December-January (Schneider and

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¹ Institute of Agriculture and Animal Sciences, Rampur, Chitwan, Nepal
Dewolf, 1995). Pruning also increases the percentage of high quality cut flowers (Han et al., 1997). Pruning can also be used for the size control of rose plants (Horan et al., 1995).

Availability of cut flowers in market is low in quality as well as in quantity. There is no standard time and intensity of pruning for the market oriented 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 the farmer's field in Gunjanagar-5, Chitwan, Nepal from March, 2013 to August, 2013.

MATERIALS AND METHODS

One year old rose plants of common Italian rose cultivars viz. High Magic, Lenopa and Confetti having white, red and yellow color respectively were taken as test crops for the experiment. The combinations of varieties, date and pruning of rose were used as treatments in the experiment. There were 8 plants in each experimental plot. Observations were taken from middle four plants. Only those rose plants which have pruning treatments were pruned. Pruning was done in two different dates i.e., 8th March, 2013 and 18th March, 2013. While pruning, medium pruning was done with secateurs removing all dry, diseased, damaged, weak and criss-crossed branches. After pruning, cut ends were painted with fungicides paste (Bordeaux paint) in order to protect against the attack of pests like fungus. The experiment was laid out in three factorial split-split plot design having three factors with twelve treatment combinations replicated thrice.

All the intercultural operations like hoeing, weeding, side dressing, irrigation, earthing up; mulching and plant protection measures were done regularly. The rose cut flowers were harvested at bud stage. Flowers were harvested from April 2013. Harvesting was carried out manually during evening with secateur retaining 5 cm stem from the branch attachment. Harvested flower of each plot were recorded in data sheet. Observations were recorded for several vegetative characters viz. plant height, cane characteristics, days to stem bud initiation, leaf characteristics and yield attributing parameters such as days to floral initiation, flower stem characteristics, flower bud characteristics and number of flowers harvested.

RESULTS AND DISCUSSION

Floral bud characteristic

Length of floral bud

The effect of variety on flower bud length was found to be significantly different with mean value 3.428cm (Table 1). The rose variety High Magic produced the flower having longest floral bud (3.554cm) which was at par with rose variety Lenopa (3.232cm) and shortest bud (3.499cm) was produced from rose variety Confetti. Plant pruned in 1st date i.e. 8th March 2013 produced flower with higher bud length (3.58cm) than flower pruned in 2nd date i.e., 18th March 2013(3.276cm). It might be due to increase in temperature during April that the plant pruned later produced small bud length. Flower bud length showed significantly no differences with the pruning.

Diameter of floral bud

Cultivars showed highly significant difference on the bud diameter of cut rose flowers (Table 2). Cultivar High Magic produced the highest flower bud diameter (2.714cm) and the smallest flower bud diameter (2.217cm) was produced from rose cultivar confetti where as cultivar Lenopa produced similar bud diameter (2.662 cm) as High Magic. Hessayon (1988) also reported varying flower diameters in different rose cultivars. Higher carbohydrate available for
the individual flower stem in pruned rose plants helps in better vigor of plant having higher flower bud diameter. Mukhopadhyay et al., (1987) have also found the similar result. The effect of time of pruning on floral bud diameter was found to be non-significant. The statistical analysis showed that flower bud diameter was found to be significantly influenced by pruning (Table 2). The rose plant which was pruned produced flower bud having the highest bud diameter (2.661cm) whereas the lowest flower bud diameter (2.401cm) was produced by rose plants that were not pruned. Mukhopadhyay et al., (1987) have also found similar result. According to him, higher carbohydrate available for the individual flower stem in pruned rose plants helps in better vigor of plant having higher flower bud diameter. Physiologically, fresh buds after pruning grow vigorously compared to older branches. Pruning mainly encourages the new growth with higher amount of plant reserved food materials, which are coincided with diameter.

**Floral Stem Characteristics**

**Length of flower stick**

The effect of variety on flower stem length was found to be significantly different with mean value 36.696 cm (Table 1). The rose variety High Magic produced the flower having longest stem (41.008cm) after harvest which was at par with rose variety Lenopa (38.983cm) and the shortest stem (30.097cm) was produced from rose variety Confetti. The effect of time of pruning on floral stem length was not significant. This may be due to short time difference between two pruning dates. Deepauw (1985) also reported that length of rose was only slightly affected by time of pruning. Stem length was not significantly different. This may be due to exhaustion of carbohydrate in stem due to heavy flowering in winter season. Mortenson and Gislerod (1999) also observed that heavy pruning during July decreased the stem length of rose plants.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Length of flower stick and length of flower bud harvested</th>
<th>Length of flower stick(cm)</th>
<th>Length of flower bud(cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Variety</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Magic</td>
<td>41.008&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
<td>3.554&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Lenopa</td>
<td>38.983&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
<td>3.232&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Confetti</td>
<td>30.097&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
<td>3.499&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>SEM±</td>
<td>0.9179</td>
<td></td>
<td>0.0648</td>
</tr>
<tr>
<td>LSD&lt;sub&gt;0.05&lt;/sub&gt;</td>
<td>3.604*</td>
<td></td>
<td>0.2535*</td>
</tr>
<tr>
<td>B. Time of pruning</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt;</td>
<td>36.256</td>
<td></td>
<td>3.581&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt;</td>
<td>37.136</td>
<td></td>
<td>3.276&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>SEM±</td>
<td>1.0737</td>
<td></td>
<td>0.0403</td>
</tr>
<tr>
<td>LSD&lt;sub&gt;0.05&lt;/sub&gt;</td>
<td>Ns</td>
<td></td>
<td>0.1389**</td>
</tr>
<tr>
<td>C. Pruning</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pruned</td>
<td>37.453</td>
<td></td>
<td>3.466</td>
</tr>
<tr>
<td>Non-pruned</td>
<td>35.939</td>
<td></td>
<td>3.391</td>
</tr>
<tr>
<td>SEM±</td>
<td>0.9515</td>
<td></td>
<td>0.0426</td>
</tr>
<tr>
<td>LSD&lt;sub&gt;0.05&lt;/sub&gt;</td>
<td>Ns</td>
<td></td>
<td>NS</td>
</tr>
<tr>
<td>Mean</td>
<td>36.696</td>
<td></td>
<td>3.428</td>
</tr>
<tr>
<td>CV%</td>
<td>11.00</td>
<td></td>
<td>5.27</td>
</tr>
</tbody>
</table>
Treatments means followed by the common letter (s) within column are non-significantly different among each other based on DMRT at 5% level of significance. DAP = Days after Pruning, LSD = Least significant difference, SEm = Standard error of mean and CV = Coefficient of variation.

**Diameter of flower stem**

The difference in Flower stem diameter was non-significant with all three treatment factors. This might be due to very small differences in diameter of stem with in cultivars. Flower stem diameter is larger only during the heavily pruned condition. It is because there are small numbers of branch in heavily pruned plant and all nutrient coming to the share of each stem. Similar results have been reported by Bajawa and Sarowa, (1977).

**Table 2. Effect of spring pruning on diameter of flower stick and floral bud of HT Rose cultivars in Chitwan District of Nepal (2013)**

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Diameter of flower stick and flower bud harvested</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Diameter of flower stick (cm)</td>
<td>Diameter of flower bud (cm)</td>
<td></td>
</tr>
<tr>
<td>A. Variety</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High magic</td>
<td>1.013</td>
<td>2.714^a</td>
<td></td>
</tr>
<tr>
<td>Lenopa</td>
<td>0.989</td>
<td>2.217^b</td>
<td></td>
</tr>
<tr>
<td>Confetti</td>
<td>0.788</td>
<td>2.662^a</td>
<td></td>
</tr>
<tr>
<td>Sem</td>
<td>0.0825</td>
<td>0.0188</td>
<td></td>
</tr>
<tr>
<td>LSD_0.05</td>
<td>Ns</td>
<td>0.07169**</td>
<td></td>
</tr>
<tr>
<td>B. Time of pruning</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1^st (8^th March 2013)</td>
<td>0.958</td>
<td>2.496</td>
<td></td>
</tr>
<tr>
<td>2^nd (18^th March, 2013)</td>
<td>0.902</td>
<td>2.566</td>
<td></td>
</tr>
<tr>
<td>Sem</td>
<td>0.0580</td>
<td>0.0385</td>
<td></td>
</tr>
<tr>
<td>LSD_0.05</td>
<td>Ns</td>
<td>Ns</td>
<td></td>
</tr>
<tr>
<td>Pruning</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pruned</td>
<td>0.867</td>
<td>2.661</td>
<td></td>
</tr>
<tr>
<td>Non-pruned</td>
<td>0.994</td>
<td>2.401</td>
<td></td>
</tr>
<tr>
<td>Sem</td>
<td>0.0739</td>
<td>0.0660</td>
<td></td>
</tr>
<tr>
<td>LSD_0.05</td>
<td>Ns</td>
<td>0.2028**</td>
<td></td>
</tr>
<tr>
<td>CV, %</td>
<td>33.68</td>
<td>11.06</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>0.957</td>
<td>2.531</td>
<td></td>
</tr>
</tbody>
</table>

Treatments means followed by the common letter (s) within column are non-significantly different among each other based on DMRT at 5% level of significance. DAP = Days after Pruning, LSD = Least significant difference, SEm = Standard error of mean and CV = Coefficient of variation.

**Interaction effect of cultivars and date of pruning on floral bud diameter**

Statistical analysis revealed that the flower bud diameter was significantly different for both the cultivars and pruning time. Maximum flower diameter (2.863cm) was recorded in variety High Magic pruned on 8^th March 2013. The lowest flower diameter (2.150cm) was obtained from variety confetti pruned on 8th March, 2013. Hessayon (1988) also reported varying flower diameters in different rose cultivars.
Interaction effect of varieties, dates and pruning in length of floral stick of HT rose cultivars in Chitwan (2013)

The interaction effect between varieties and date of pruning on length of flower stem seems to be significant statistically (Fig. 2). Among all cultivars, High Magic produced longer stem length in all dates of pruned and un-pruned condition followed by Lenopa and shorter stem length was produced by variety Confetti in all condition. Variety High Magic pruned on 18th March, 2013 produced longer flower stem (44.750cm) whereas variety Confette produced shorter stem length flower (24.333cm) in plants that were un-pruned on 8th March, 2013.

Number of flowers

Effect of varieties, date and pruning on Number of flowers harvested

Significant variation was seen among different varieties on total number of flower production (Table 3). High Magic produced larger number of cut rose flowers (23.833) followed by Confette (14.250) and Lenopa (10.333) respectively. The maximum number of flowers produced in cv. High Magic was perhaps produced due to its better adaptability in the environment compared to others. Similar results were observed by Khattak and Khattak (2001) who showed that the number of flowers in rose cultivars was affected differently. The effect of pruning date was seen significant with producing flower. Plant pruned in 1st date produced maximum number of flower (20.889) followed by 2nd date pruned (11.389). This might be due to heavy infestation of insect pest and increase in temperature that the plants pruned in later date failed to produce quality flower.
Pruning also had a significant effect on flower production (Table 3). Maximum (22.611) flowers per plot were counted in treatments with pruned plants, whereas minimum flowers (9.667) were observed in un-pruned plants. Here, it is worth mentioning that the pruned plants were cut back to about 22 cm, and while they were sprouting and producing branches, the un-pruned plants were still flowering. The pruned plants were not flowering for around a month time and during this time the un-pruned ones were flowering and those flowers were counted. That is one of the reasons why the un-pruned produced more flowers. When we took the flower production after pruned plant start flowering, number of flowers produced were maximum in the pruned plants. Mortensen and Gislerod (1994) also observed that hard pruning in July decreased the yield and stem length of flowers.

Table 3. Effect of Spring Pruning on Number of flowers harvested in HT Rose Cultivars in Chitwan district, Nepal (2013)

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Number of flowers</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Variety</td>
<td></td>
</tr>
<tr>
<td>High Magic</td>
<td>23.833&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Lenopa</td>
<td>10.333&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Confetti</td>
<td>14.250&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Sem</td>
<td>2.3122</td>
</tr>
<tr>
<td>LSD&lt;sub&gt;0.05&lt;/sub&gt;</td>
<td>7.389&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>B. Time of pruning</td>
<td></td>
</tr>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt; Date</td>
<td>20.889&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt; Date</td>
<td>11.389&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Sem</td>
<td>2.4429</td>
</tr>
<tr>
<td>LSD&lt;sub&gt;0.05&lt;/sub&gt;</td>
<td>5.317&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>C. Pruning</td>
<td></td>
</tr>
<tr>
<td>Pruned</td>
<td>22.611&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Non-pruned</td>
<td>9.667&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Sem</td>
<td>1.5366</td>
</tr>
<tr>
<td>LSD&lt;sub&gt;0.05&lt;/sub&gt;</td>
<td>4.735&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Mean</td>
<td>16.139</td>
</tr>
<tr>
<td>CV, %</td>
<td>40.39</td>
</tr>
</tbody>
</table>

Treatments means followed by the common letter (s) within column are non-significantly different among each other based on DMRT at 5% level of significance. DAP = Days after Pruning, LSD = Least significant difference, SEm = Standard error of mean and CV = Coefficient of variation.

**CONCLUSION**

Varieties and pruning affect all the vegetative and yield attributing parameters of rose. Early pruning on High Magic and Lenopa performed significantly better as compared to later pruning on Confetti and plants remained as un-pruned. Similarly the performance of rose flowers was also found significantly different with date. Among all varieties, High Magic pruned on 8<sup>th</sup> March, 2013 performed better in all vegetative growth and yield attributing characteristics but plant height was found the highest in un-pruned rose plants.
LITERATURE CITED


Constraints and Farmer’s Perception on Off Season Green Onion Production in Chitwan - A Survey

M. Dhital¹ and S.M. Shakya¹

ABSTRACT

The survey assessed the constraints and farmer’s perceptions on off season green onion production in Shukranagar, Jagatpur and Gunjanagar VDCs in Chitwan, Nepal. The primary data used for the investigation were obtained through the use of questionnaire, focus group discussion and key informant survey. Thirty commercial farmers and ten traders were randomly sampled for the study. Major constraints and influencing factors for green onion production, and marketing system were looked into. The study revealed that seedling raising was the most important problems faced by the off season growers followed by weed problem, lack of crop insurance facility, and diseases and pests. Lack of storage facility was the most important marketing problems due to highly perishable nature of green onion followed by lack of appropriate marketing facilities and fluctuation in the market price. Higher market price was the major influencing factors for green onion cultivation followed by its short duration as compared to bulb production which takes longer duration.

Key words: Constraints, off season, green onion, farmers perception

INTRODUCTION

The diverse agro-climatic conditions of Nepal both among the different ecological regions and within ecological region have provided nearly unlimited scope for growing several types of vegetables and spice crops throughout the year. Nepal has adopted a long term Agriculture Perspective Plan (APP) which gives vegetables high priority. Since twice as many women as men participate in the vegetable and spice crop production, they provide women an opportunity to increase their income. Further, increase in population and general awareness of the nutritional values of vegetables among the people have increased scope very much for promoting fresh vegetable production in Nepal.

Onion (Allium cepa L.) is one of the important vegetable crops in Nepal, ranking 4th position in terms of its volume and value of the production (Thapa & Paudyal, 2000). The per capita consumption of fresh onion in Nepal is 7.7 kg where as the recommended quantity is 18 kg per annum (Koirala et al., 1995). In 1998, the total area of onion production in Nepal was 8000 ha with average yield of 12.4 t ha⁻¹ (Ghimire et al., 1998) while during 2005 it reached to 8644.5 ha with an average productivity of 15 t ha⁻¹ (VDD, 2005). According to FAO, it is estimated that onion is grown in 2.71 million hectares in the world, producing 47.67 million tones of bulb onions each year. Approximately, 8 percent of this global onion production is traded internationally.

The term green onion describes an immature onion. Generally, green onions are harvested before the maturation of the bulbs. Even the large bulbed onions such as Agrifound Dark Red, Nasik-53, Grano or Granex, Red Creole can be harvested immature and used as salads and other culinary purpose. They have a small, not fully developed white bulb end with long green leaves. Farmers preferred selling onions green rather than keeping the plants for bulb production. Jaiswal and Suvedi (1996) suggested green onion production in the off season because of pre bolting, non bulbing, bulb splitting, and greater losses of bulb onions during storage and high demand of green onion in the market during off season (i.e. October-

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November). Farmers can get immediate income from selling of green top from off-season onion (Rokaya & Bhandari, 2004; Gautam, 2006). This profitable business gives cost benefit ratio of 3.7:1 (Singh & Singh, 2002).

In Nepal, onion is cultivated from November to early June as a normal or main season crop. The bulbs are harvested from mid May to early June and then stored under the prevailing ambient conditions. In recent years, the Vegetable Development Directorate (VDD) under the Department of Agriculture, Nepal has been making efforts to introduce off-season production of onion during October to December by planting small onion bulb known as ‘sets’. It is produced by planting the sets during July to August. But it takes long effort to produce sets, store them and then replant them. These operations require more time and space compared to direct seedling transplanting. Off-season onion can be produced by transplanting of onion seedlings which are raised by sowing the seed during June to July (Budathoki, 2006). Off season onion is one of the major sources of income for Nepalese farmers, but little research and development work have been done especially in the aspect of green top production. Thus, this research was undertaken with the objectives to assess the farmers perception regarding the off season green onion production and to identify the major constraints for off season green onion production in Chitwan.

Methodology

A survey was carried out using semi-structured questionnaire in off season vegetable growing areas of three VDCs viz. Shukranagar, Jagatpur and Gunjanagar in Chitwan district. There were altogether 30 households, constituting 10 households from each VDC engaged in commercial off season vegetable production. They were selected randomly. Similarly, 10 traders from the retail market of Bharatpur were selected randomly for the study purpose. PRA tools such as semi-structured questionnaire and key informant interview were used to acquire information. In addition, related literatures, statistical reports and web sites were visited, thoroughly reviewed and consulted and acquired information for this study. The survey was done in February, 2008. Data collected were coded and processed using SPSS and Excel programmes.

RESULT AND DISCUSSION

Production problems

Responses regarding various problems in production were recorded and analyzed during the field study. The respondents were asked to identify, choose and prioritize various categories of problems they had been facing on off season onion cultivation. Problem analysis was done by conducting focus group discussion with key informants at community level. The severity of problems was identified by ranking with appropriate score. The intensity of problems related to production problems of off season green onion in western Chitwan with their ranks has been presented in the table 1.

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Problems</th>
<th>Index</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Unavailability of seed on time</td>
<td>0.52</td>
<td>V</td>
</tr>
<tr>
<td>2</td>
<td>Weed problem</td>
<td>0.83</td>
<td>II</td>
</tr>
<tr>
<td>3</td>
<td>Nursery problem</td>
<td>0.88</td>
<td>I</td>
</tr>
<tr>
<td>4</td>
<td>Lack of irrigation facility</td>
<td>0.32</td>
<td>VI</td>
</tr>
</tbody>
</table>
Diseases and pest problem  0.59  IV
Non availability of credits  0.27  VII
Lack of crop insurance facility  0.62  III

Note: Scale value ranges from 1 to 0, where 1= most serious, 0.75 = serious, 0.5 = moderate, 0.25 = little bit and 0 = no problem at all.

This study showed that nursery or seedlings raising was the major problem perceived by the off season onion growers in the study area. The second most important problem as indicated by the farmers was weed problem followed by lack of crop insurance facility, unavailability of quality seed on time, diseases and pest, and non availability of credits from the government. This may be due to poor technical knowledge on management aspect.

Marketing system
In general, marketing of any product means a process through which the product is transferred from the producer to the ultimate consumers. Agriculture marketing is a key factor for the development of agriculture sector. So, marketing management and assured market facility for producer is instrumental for increased production and productivity of any agriculture commodities. In marketing system, producer farmers, traders, whole sellers and consumers are the main actors involved in the production and consumptions chain. The producer farmers were found to be involved in selling activity at the farm and markets. All together, four marketing channels were identified that had been operating for off season onion marketing throughout the study sites. Those marketing channels have been presented here under.

1. Producers → Consumers
2. Producers → Local Retailers → Consumer
3. Producers → Wholesalers → Retailers → Consumers
4. Producer → Middle man → Wholesalers → Retailers → Consumers

Trends of market price
The farm gate price of green onion was higher in the festive season in October-November in the Nepalese market. The highest farm gate price of greens was found to be NRs. 30 kg\(^{-1}\) during the month of October. Then, the price declined and reached to NRs.15 kg\(^{-1}\) during the month of February, 2008 in the whole sale market of Bharatpur, Chitwan.

![Price vs. Month Graph](image)

Figure 1. Farm gate price of green onion at Bharatpur, Chitwan (2008)

Marketing problems
Marketing is as important as the production techniques in case of agricultural commodity. Unless and until marketing systems are improved, no incentives to increase the production will benefit the growers. In the current poor marketing system of Nepal, producers and traders have been facing several marketing problems. The study showed that lack of storage facility was the major constraints for green onion marketing as it was highly perishable in nature. Lack of appropriate marketing facility was the second major problem followed by frequent strike, fluctuation in price and lack of transportation facility from the zone of production to the zone of consumption. The details of the marketing problems with their index values have been presented in table 2.

Table 2. Intensity of marketing problems of off season green onion in Chitwan (2008)

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Problems</th>
<th>Index</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lack of appropriate marketing facility</td>
<td>0.69</td>
<td>II</td>
</tr>
<tr>
<td>2</td>
<td>Fluctuation in price</td>
<td>0.45</td>
<td>IV</td>
</tr>
<tr>
<td>3</td>
<td>Frequent strike</td>
<td>0.58</td>
<td>III</td>
</tr>
<tr>
<td>4</td>
<td>Lack of storage facility</td>
<td>0.86</td>
<td>I</td>
</tr>
<tr>
<td>5</td>
<td>Lack of transportation facility</td>
<td>0.34</td>
<td>V</td>
</tr>
</tbody>
</table>

Note: Scale value ranged from 1 to 0, where 1 = most serious, 0.75 = serious, 0.5 = moderate, 0.25 = little bit and 0 = no problem, at all.

Farmers' perception
Higher market price was the major influencing factor for cultivating off season green onion in western Chitwan. The other factors which encouraged farmers for green production was because of its short duration period as compared to bulb production, which takes longer time to produce bulbs. Furthermore, in bulb production, there are problems of bulb sprouting in the storage, bulb doubling and splitting of the bulbs. These factors also encouraged farmers to go for green production rather than bulb production.

Table 3: Farmer's perception on factors influencing off season green onion cultivation in western Chitwan (2008)

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Factors</th>
<th>Index</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Short duration crop</td>
<td>0.71</td>
<td>II</td>
</tr>
<tr>
<td>2</td>
<td>High market price</td>
<td>0.85</td>
<td>I</td>
</tr>
<tr>
<td>3</td>
<td>Sprouting problems in bulbs</td>
<td>0.66</td>
<td>III</td>
</tr>
<tr>
<td>4</td>
<td>Doubling and splitting problems in bulbs</td>
<td>0.55</td>
<td>IV</td>
</tr>
<tr>
<td>5</td>
<td>Accessibility of market</td>
<td>0.27</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Nutritive value</td>
<td>0.13</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Land suitability</td>
<td>0.46</td>
<td>V</td>
</tr>
</tbody>
</table>

Note: Scale value ranged from 1 to 0, where 1 = highest preference, 0.75 = more preference, 0.5 = moderate preference, 0.25 = little bit and 0 = no preference, at all.

Conclusion
The nursery or seedlings production was the major production problems perceived by the off season onion growers in the study area. The second most important problem as indicated by the farmers was weed infestation followed by lack of crop insurance facility, unavailability of quality seed on time, diseases and pest, and non availability of credits from the government. This may be due to poor technical knowledge on management aspect. Higher market price was the major influencing factor for cultivating off season green onion followed by short duration, post harvest (sprouting) problems in bulbs, doubling and splitting problems in bulbs and land suitability for off season green onion cultivation. Lack of storage facility of green mass was the major constraints for green onion marketing because of its perishable nature. Lack of appropriate marketing facility was the second major problem followed by frequent strike, fluctuation in price and lack of transportation facility from the zone of production to the zone of consumption.

**LITERATURES CITED**


Arun Khanal¹ and Manoj Basnet²

ABSTRACT
Vegetables are the main source of food and nutrition for the increasing population that should be minimally taken at amount of 75-125 gram of green leafy vegetables, 85 gram of others vegetables and 85 gram of roots and tubers vegetables every day. The total vegetable production of Nepal is 3301648 metric tons from total cultivated area of 246392 hectares. To fulfill the demand of nation and utilize the export potentiality of seasonal and off season vegetables, there is a need to increase production and productivity. To increase production farmers are utilizing chemical fertilizer, improved technology and hybrid varieties a lot. Excessive and haphazard use of chemical fertilizer brings hazardous effect on health of people, soil, animals and environment we live. The unnoticed human waste urine that causes environmental pollution if unutilized could be used safely by the farmers as the alternative to chemical fertilizer as it is very rich in nutrient content that are essential for plant growth in available form. Human urine is locally available organic fertilizer that could be used as alternative source of chemical fertilizer for the production of vegetables with better product and lessen environmental hazard.

Keywords: Ammonia, human urine, organic fertilizer, urea, vegetable, yield

INTRODUCTION
Nepal is naturally a beautiful country with agriculture as mainstay of economy where 66.7% of people are involved in agriculture which contributes 31% of national gross domestic production (MoAD, 2013). Horticultural sector serves as the main component for commercialization and industrialization of agriculture to raise country economy and contributes 16.75% of Agricultural GDP and vegetable sector alone contributes 9.70% of AGDP (MoAD, 2013). The total vegetable production of Nepal is estimated at 33,01,648 metric ton from total cultivated area of 246392 hectare (VDD, 2013).

Vegetable production is important to feed the world, to supply essential nutrients for health, to create employment opportunities and to generate income. Demand of vegetable is increasing but the supply is in highly deficit condition. Great variation in physiographic locations and agroclimatic conditions of Nepal are boon for growing various vegetables at different seasons of the year (Pandey, 1995). Despite it, Nepal imports various vegetables every year with the expenditure of 2.756 billion Nepalese rupees (MoAC, 2012).

People are attracted towards commercial vegetable farming but they do not have enough organic manure and have to rely on high cost chemical fertilizers which is sourced totally from import. Nepal has been spending billions of rupees every year to import chemical fertilizers (Joshi and Singh, 2004).

Although the rate of application of chemical fertilizer in Nepal is not higher as compared to other countries, but unbalanced and hazardous use is becoming a great threat to the Nepalese

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agriculture. Use of chemical fertilizer deteriorates soil quality, water, plants, human and animal health. The use of chemical fertilizers has now proved to be very hazardous to human health and environment (Shomasundaran et al., 2004). Application of organic fertilizer and manures in the field is the best option to get high quality products and sustainable healthy production from field through eco-friendly way, as organic agriculture have environmental benefits, health benefits and also benefits for maintenance of soil fertility, lower economic burden to the farmers, social cohesion, better taste and long life (Ranabhat, 2008).

There are so many organic alternatives for chemical fertilizers like manures, FYM, compost, human and cattle urines, bone meals, poultry manures, vermin-compost etc., among which human urine is considered the best substitute for inorganic fertilizers. Human urine if discharged haphazardly leads to situations such as surface and ground water pollution, eutrophication, accumulation of salts with harmful impacts on soil health and crop yields, leaving serious impacts on aquatic life due to over loading of organic matter among others (Hussain et al., 2002). Human urine is a natural resource produced by every household which contains mostly nitrogen (N), phosphorus (P), and potassium (K). Urine has a fertilizer value of 18:2:5 NPK (Linden 1997) in easily available form. Nutrient contained in urine are in the ionic form and compares well with that of inorganic fertilizer (Kirchmann and Pettersson, 1995).

According to Vinneras et al., (2006) one adult human excretes 550 kg urine on wet mass (21 kg on dry mass) containing 4000 gm of Nitrogen and 365 gm of Phosphorous in a year. Total population of Nepal in 2011 AD was 26,494,504 with average annual growth rate of 1.4% and 61% of adult. This means if human urine is collected properly only from adult Nepalese it could supply more than 64,646 mt of Nitrogen per year. Highly nutrient richer human urine should be promoted as an alternative to the chemical fertilizer because of it is cheap, locally available and less harm to health and environment than inorganic fertilizers. Therefore, this article presents the review of the research on use of human urine on vegetable production and to extend the findings to the farmers, readers so that the obvious wasted human urine could be utilizes as fertilizer. This paper is to inform about human urine as organic fertilizer, its application method and its effect on production of vegetables.

MATERIALS AND METHODS

Various scientific papers of the related topics are collected from internet, library and scientific publications. Similarly, information was collected from related organizations like Ministry of Agriculture, Department of Agriculture, Vegetable development directorate and others. This is the collective form of the findings.

DISCUSSION

**Organic fertilizer, a sustainable alternative to inorganic**

In Nepal, use of chemical fertilizer has grown significantly after the deregulation of fertilizer trade in 1997 and the overall use of fertilizer in nutrient terms has increased from 34.7 kg per ha of cropped area in 1997/98 to 57.9 kg ha⁻¹ of cropped area in 2000/01, with average annual growth rate of 18.6 % (Khanal and Manandhar, 2005).

Sharma and Agrawal (2004) reported that chemicals enter and get deposited in the fat of our body while eating chemically grown vegetables and drinking polluted water which ultimately causes various dreadful diseases like cancer. The indiscriminate use of chemical fertilizers increases soil acidification, impairs soil physical condition, reduces organic matter content, creates micro nutrient deficiencies, increases susceptibility to pests and diseases, decreases soil lives, increases soil, water and air pollution via agricultural run off and leaching (Joshi and
Singh, 2004). The over-application of chemical fertilizers creates a risk of soil fertility degradation, and causes environmental pollution (Tisdale et al., 1985). The change in the soil pH, soil acidification and lower humic acid contents are some key problems of overuse of synthetic fertilizers. The poor soil respiration rate and complete vanishing of natural decomposer communities from agro ecosystems has questioned the land sustainability and future food security (Suthar, 2008).

Organic fertilizers are animal and plant wastes containing natural forms of plant nutrients which if added to the soil improve its physical condition, replenish its humus content and support soil life. Organic wastes contain varying amounts of water, mineral nutrients and organic matter (Brady and Weil, 2002). There are many types of organic fertilizers among which FYM, animal manures, compost, animal urines, human urines, city waste; poultry manures, bone meal, vermin compost etc are mainly used in farming.

Nutrient content of FYM on average is 1.5% N, 1.0% P2O5 and 1.5% K2O (Tondon, 1995) whereas, nutrient in normally used animal manure ranges from 1.5 to 4 % N, 1 to 1.98 % P and 0.65 to 2.32 % K (Labios and Labious, 1994). Vermicompost improves the physical and biological condition of soil, improves soil fertility and pulverizes it through their churning and turning action in addition to contributing plant nutrients (0.60-0.66% N, 1.34-1.93% P and 0.40-0.42% K), improves aeration and water holding capacity (Shinde et al., 1992). Average nutrient content of cattle urine collected from gutter of Cattle shed Nepal was 0.49 % total Nitrogen, 3.243μg l-1 total phosphorous, 0.483% total potassium and 7.3pH (Khanal et al., 2011).

Now a day, human urine is increasing its applicability at farmers’ level. Human urine is highly rich in plant nutrients on readily available form. Urine used directly or after storage is a high quality, low cost alternative to the application of N-rich mineral fertilizer in plant production. Human urine is a liquid product of the human body that is secreted by the kidneys which contains large amounts of soluble nutrients- macro and micro nutrients (Gensch et al., 2011). Human excretes 0.8-1.5 liters urine per day containing 95 % water, significant quantities of main micronutrient (N 3-7 gram per liter, P and K) and dissolved ions of chloride, sodium, etc required by plants in dissolved forms (Richert et al., 2010).

An adult excretes about 580 kg urine per year with an average of 1.5 liters per day (Morgan, 2003). Urine contents 96.98% water, 0.53% (3.08kg/year) nitrogen mostly urea, 0.04% (0.23kg/year) phosphorous and 0.14% (0.81kg/year) potassium (Gao et al., 2002). They also found that NPK produce from urine (4.12 kg/year) was higher in quantity than faeces (1.63 kg/year). In human urine total nitrogen concentration ranged between (2.66 to 2.68 g/L) with available N form ammonium about 97% of the total N, Total P value ranged between 4.7 to 5 g/l and total K values ranged between 14.7 to 16 g/l (Annan, 2013).

Human urine if not collected Nitrogen in it leached to the ground causing high nitrate in groundwater if consumed causes methemoglobemia (a reduction in blood haemoglobin level) and also stimulates excessive growth of aquatic organism, algal bloom and eutrophication (Silva et al., 2000) so that human urine is best to utilized for crop production. Technical know-how, health effects and socio-cultural perceptions were some of the challenges preventing the full adoption of urine as an alternative for fertilizer use (Cofie et al., 2011) but many researches show that its use is safe.

Collection of human urine

Urine should be collected on close tank to avoid loss of Nitrogen in the form of ammonia. Urine should be collected and stored for 1 to 6 month to reduce the health risk from faecal cross contamination (Richert et al., 2010). Storage of urine at 20°C for equal or more than 6 month makes urine viruses and protozoa free which could be applied to all crops (WHO, 2006). The
pH of urine while excretion is about 6 but at storage degradation of urea to ammonium and carbon dioxide in presence of urease increases it to 9-9.3 (Jonsson et al., 2004)

**Application method of human urine**

Human urine stored in closed tanks and containers should be spread directly onto the soil to increase nutrient availability, reduce nutrient loss and also to reduce the risk of negative effect of pathogens, heavy metal, pharmaceuticals and hormones present on urine. Richert et al. (2010) mentioned that human could fertilize 300-400 m² of crop to a level of about 50-100 kg N/ha from one year’s urine collected from oneself. Urine is better to incorporate into the soil than spraying in air for efficient use of nutrients and reduced loss of N through the gaseous loss of ammonia (Rodhe et al., 2004). To save plant from burning effect on foliage and root apply urine at distance of 10-30 cm apart from planting spot avoiding touch of urine on foliage and roots (Richert et al. 2010). Immediate incorporation of urine in topsoil could minimize the ammonia loss to around 5% (Rodhe et al., 2004). Urine should be applied after 2 weeks of planting or emergence of first plant from seedling for vegetables (Richert et al., 2010).

**Effect of human urine on vegetable production**

Human urine can be used as fertilizer on the vegetable farming to increase yield as replacement to chemical fertilizer. Use of human urine for higher and healthy production of vegetables like spinach, amaranths, cabbage, tomato, sweet peppers etc were done by various scientist in various location.

Increased dry matter yield of cabbage and spinach with the application of human urine upto 200 kg N per hectar was mentioned by Mkeni et al., (2006) which was comparable with yield from urea. Morgan (2003) found higher yield of Lettuce, Spinach and tomato on plots fertilized with urine diluted in ratio of water to urine in 3:1 ratio and applied 0.5 liters of dilution 3 times a week than unfertilized plots on Zimbabwe. Lettuce on 30 days yielded 500 gram per plant on urine treated plots as compare to 230 grams per plant of untreated plots. Spinach on 30 days produce 350 gram per plant as compare to plants of unfertilized plots. Tomato on treated plots produces 6084 grams per plants as compare to 1680 grams on plots of unfertilized plots. Richert et.al. (2010) from the field trials in Burkina Faso using same rate of Nitrogen nutrient found no statistical difference between yields of egg plant using stored human urine (17.7 ton per hector) and mineral fertilizer (17.8 ton per hectar) which are statistically different from yield (2.8 ton per hectar) from unfertilized plants. They also found high yield of Tomato by the use of stored human urine (5.2 ton per hector) and mineral fertilizer (5.2 ton per hectar) which are statistically different from yield (2.8 ton per hectar) from unfertilized plots. Pradhan et al., (2009) urine fertilized tomato plants produced 4.2 times more yield than non-fertilized plants. In addition, urine use is more environmentally friendly and safe even though leaching of excess nutrient is possible if nutrient mismanagement occurs.

Human urine was used in trials carried out in Finland as a fertilizer to supply 180 kg N/ha on cabbage cultivation in comparison with industrial fertilizer and non-fertilizer treatments in which Pradhan et al., (2007) found that growth, biomass, and levels of chloride were slightly higher in urine-fertilized cabbage than with industrial-fertilized cabbage but clearly differed from non-fertilized. They obtain highest average total plant biomass (4.7 kg), commercial biomass (3.5 kg) and head circle (71.4 cm) at urine fertilized plot slightly greater than average total plant biomass (4.3 kg), commercial biomass (3.3 kg) and head circle (68.8 cm) at chemical fertilized plots. Adeoluwa and Cofie (2012) from research on green amaranths (Amaranthus caudatus) concluded that human urine application equivalent to 100 kg N ha⁻¹ produces higher total plant yield (58.17 t ha⁻¹) than total plant yield (34.34 t ha⁻¹) in the two plantings. They
also found that edible portion of vegetable from plot fertilized with urine did not reveal any significantly different pathological contamination compared to other fertilizer treatments used in this investigation and urine treatment improved soil nutrient exchangeable cat-ions and acidity.

Highest yield (436.03 kg per plant) comparable to inorganically (0.42 mg N/plant) fertilized plant twice a week yield (521.34 kg per plant) was obtained by Anan (2013) from the pepper plant in which human urine (0.45g N/L) was applied once a week than yield (431.68 kg per plant) from urine (0.90g N/L) applied twice a week and yield (416.80 kg per plant) from urine (1.35g N/L) applied thrice a week and also highly greater yield than unfertilized plant yield (138.93 kg per plant). Shrestha et al., (2013) found fruit yield per plant (553.9 g) of sweet pepper (Capsicum annum L.) was obtained from plants fertilized with human urine providing 100 kg N per ha in combination with compost and concluded that human urine performs better when used in combination with compost, and can be used as a promising fertilizer source in sweet pepper production.

Pradhan et al. (2010) conducted experimental demonstration in the cultivation of radish, potato, broadleaf mustard, cauliflower and cabbage where urine + ash or manure fertilized plots received 54 kgN/ha for radish, 51 kgN/ha for potato, 81 kgN/ha for broadleaf mustard and 77 kgN/ha for cabbage and cauliflower. They noted significantly higher broadleaf mustard biomass (19.7 ton/ha) from urine + ash fertilizer than biomass from animal manure (9.3 ton/ha) and without fertilization (7.2 ton/ha). The biomass of other vegetables are also better in urine + ash fertilizer than biomass from animal manure i.e. in radish root biomass 46.26 ton/ha compare to 22.5 ton/ha, in potato tuber biomass 1.5 ton/ha compare to 1.4 ton/ha, cauliflowers flower biomass 42.7 ton/ha compare to 24.0 and in cabbage head biomass 30.5 ton/ha compare to 19.3 ton/ha. Their experiment on Ghana on cabbage production shows that dose of 121 kg N/ha from urine produce higher head weight (19.79 ton/ha) than from manure (18.66 ton/ha) only, and also the combination of urine and poultry droplet which supply 121 kg N/ha produce higher head weight (23.40 ton/ha) compare to combination of NPK and poultry droplets (22.58 ton/ha).

**Effect of human urine on health and environment**

Collection, storage and incorporation of urine on soil minimizes exposure to air that result in less odors due to loss ammonia which protects from air pollution and health hazards. One month withholding period results in substantial risk level reduction and combined with the other barriers in the multiple barrier approach the result will be a risk far below 10-6 DALY for pathogenic bacteria, viruses and parasitic protozoa (WHO, 2006). Urine collected in eco-toilet where human urine and faecal matter collected separately are best way to solve sanitation problem, and this practice also improves the environment and increases the food production (Pradhan et al., 2010).

WHO (2006) put several barrier concept for safe use of urine fertilizer which are 1) source separation to minimize faecal contamination, 2) storage and treatment in order to sanitize urine and reduce microbial health risks, 3) application techniques i.e. reduce direct contact with edible part, 4) crop restriction suggest leafy vegetable are high risky but for stored urine it is not highly reduced  5) withholding period for crop to harvest from last urine application on an average is one month, 6) protective equipment, 7) hand washing, 8) food handling and 9) cooking and health and hygiene promotion.

Very high rate of N application (1600 kg N per hectar) supplied from human urine result salt stress to vegetable and lowers yield, increase salinity of soil (Mkeni et al., 2006) so it is less recommended to use high rate of human urine. The few pathogens in urine fertilizer actually
applied into the soil are not a high risk for agricultural production, since those pathogens are unable to gain access to the agricultural consumer products (Pradhan et al., 2007). Urine fertilizer needs to be used with care to reduce any possible risks; it should never be applied directly to any parts of the plants, since, in addition to possible microbial contamination, plain urine can physically damage many plants (Jonsson et al., 2004) Insect damage was lower in urine-fertilized than in industrial-fertilized plots and microbiological quality of urine-fertilized cabbage and sauerkraut made from the cabbage was similar to that in the other fertilized cabbages so that use of urine in cabbage does not pose any significant hygienic threats or leave any distinctive flavor in food products (Pradhan et al., 2007).

Heinonen-Tanski et al., (2007) found higher yield of cucumber yield after urine fertilization which was similar or slightly better than the yield obtained from control rows fertilized with commercial mineral fertilizer and none of the cucumbers contained any enteric microorganisms (coli forms, enterococci, coliphages and clostridia) and concluded that human urine collected in the separated toilet are safe to use in vegetable production.

Urine fertilization has been found to give a temporary set-back to the population of earthworms, but the effect is not permanent and after about 6 months, the population had recovered (Muskolus, 2008). Hormones and pharmaceutical residues are two types of micro-pollutants which occur in urine that could be enter into the human food chain with risk of toxicity but it was safe if urine is applied to the soil instead of spraying (Von Munch and Winker, 2009) The amounts of harmful heavy metals in urine are miniscule and much lower than wastewater sludge or even farmyard manure (WHO, 2006) so it is safe to use human urine on crop production.

CONCLUSION
Vegetables are important for food supply, health and income generation. Chemical fertilizers used in haphazard manner in vegetables cause deleterious effect on human health, animal health, soil health and environment. Human urine which if left unused could cause health hazard of human, soil, animals and environment, but it can be safely used with safe handling including sanitization as the alternative to chemical fertilizers to address the problem of low production, malnutrition and trade imbalance due to import of fertilizers and also the economy of country could be raised through export of organic vegetables. Human urine which contains higher concentration of Organic NPK could be used as organic alternative source to chemical fertilizer for higher and quality production of vegetables.

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Nepal Horticulture Society (NHS) expresses deep sorrow upon irreplaceable loss of Senior Horticulturist & Life Member NHS Mr. Hari Prasad Gurung due to his untimely demise on June 19, 2015.

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

Late Mr. Hari Pd. Gurung was born in Sept 1, 1937 AD in Ilam district. He completed his study (M. Phil. specialization on Pomology) from Wye College, UK in 1979 AD. He entered Nepal Civil Service (Agriculture) in 1961 AD and worked with Nepal Government in different capacities from Assist. Horticulturist to Director General of Department of Horticulture and at the last Sr. Agri. Advisor in MoAC till 1992 AD. He also served as an Executive Vice-President of NHS from 2001 to 2004.

The Society always cherishes his ever pleasing and cooperating nature.
नेपाल सरकार

कृषि विकास मन्त्रालय

कृषि तथा खाद्य सुरक्षा आयोजना

परिचय
कृषि तथा खाद्य सुरक्षा आयोजना वाहनस्ताहरुको सहयोगमा स्थापित Global Agriculture and Food Security Program (GAFSP) को अनुसार सहयोगमा नेपाल सरकार, कृषि विकास मन्त्रालय माफित मख्य रूपमा कार्यान्वयनमा रहेको ५५। आयोजनाको सुपरिवेक्षण विश्व बैंकले गर्दै आएको ५५।

आयोजनाको उद्देश्य
कृषि तथा पशुजन्य पदार्थको उत्पादन तथा उत्पादकल्च वाहाई खाद्य तथा पौष्टिक खाद्य पदार्थको उपलब्धिता र पहुँच वढाउनुका साथै खाद्य पोषण सम्बन्धि आनिवासिमा परिवर्तन ल्याउ प्राप्तिको समग्र खाद्य तथा पोषण अवस्थामा सुधार ल्याउने उद्देश्य आयोजनाको रहेको ५५।

आयोजना अवधि
यो आयोजनाको अवधि पाँच वर्ष रहेको ५५ र आ.व. २०७५/७६ देखि संचालनमा रहेको ५५।

आयोजना लागू भएका जिल्लाहरु
यो आयोजना छैन पश्चिमान्चल र सुदूर पश्चिमान्चल क्षेत्रका १९ जिल्लाहरु (मुस्ताङ, दोल्पा, हुम्ला, कालिकोट, मुगु, रुम्जुम्ला, रोपाला, पूर्वाञ्चल, सल्मान, सुखेंद्र, डैलेख, जाजरकोट, बफाङ, बाजुरा, चौटाहुङ, कोटी, दार्चुला, अझाम) मा कार्यान्वयन खुदरहेको ५५।

आयोजना कार्यान्वयन
आयोजना अन्तर्गत आ.व. २०७५/७६ देखि सानो अनुसार कार्यक्रमको कार्यान्वयन जिल्लास्तरमा भाइरहेको तथा चालु आ.व. २०७५/७६ मा पनि सानो अनुसारको कार्यक्रम आयोजना लागू भएका जिल्ला र सम्राटित गा.वि.स.हर्मा सुचारु हुने भएको लाई यस विषयमा सम्बन्धित जिल्ला कृषि विकास कार्यालयहरू, जिल्ला पशु सेवा कार्यालयहरू र जिल्ला जनस्वास्थ्य कार्यालयहरू, सो क्षेत्रका विभागित निर्देशनालयहरू (कृषि, पशु सेवा) तथा आयोजना व्यवस्थापन कार्यालयमा सम्भव्य गरी जानकारी लिन हुन अनुरोध ५५।

आयोजना सम्पर्क
आयोजना व्यवस्थापन कार्यालय,
गैरीवारा, काठमाडौं
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फ्याक्स नं. : ९७३-१-४००२०७५
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