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# PERFORMANCE AND PROFITABILITY STUDY OF BABY CORN AND TOMATO INTERCROPPING

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Intercropping baby corn and tomato may be an option to improve on-farm income on the resource-poor small farms. An experiment was conducted to examine the effect of tomato intercrop on various traits of baby corn, and to determine the appropriate combination from the different varieties of the two crops for maximizing performance and profitability. A replicated field study was conducted using four baby corn and two tomato cultivars at Rampur, Nepal in 2007. There were two open-pollinated ('Arun-2' and 'Rampur Composite') and two hybrid ('Bioseed 9681' and 'JK Puja') corn varieties. The tomato cultivars were 'BSS-418' and 'Umi' hybrids. The different combinations of corn and tomato varied in total crop productivity from the intercropping system. The combination of BSS 418 tomato with Arun-2 and Bioseed 9681 corn cultivars produced equal but higher total yield than the other mixtures. The average benefit cost ratio for intercrops vs. sole crops was 1.9:1. Individually, the benefit cost ratios were 3.0:1 and 1.4:1 for the sole tomato and corn, respectively. The land equivalent ratio was 1.78 for baby corn-tomato intercropping. The findings provide new information on the understanding of baby corn and tomato intercropping and its additional profitability over the sole crops.
**Keyword:** Baby corn, tomato, intercropping, economics, yield, benefit cost ratio, LER

## INTRODUCTION

Baby corn (*Zea mayz* L.) is an important vegetable product obtained from the maize plant. The edible part is the small young ear-corn before pollination (Lekagul, 1994). The young ear-corn tastes sweet when it is derived from sweet corn (Jan-orn et al., 1989). Fresh baby corn is easy to grow in the Pacific Northwest (Miles and Zenz, 2000). The economic importance of baby corn is reflected through its export figures of canned baby corn from 67 t (US $0.038 million) in 1974 to 36,761 t (US $33 million) in 1992 (Kumar and Kallu, 2005). These trends underline the value of baby corn as a cash crop for intensive agro-ecosystems in South Asia where small farmers grow three or more crops in highly diverse cropping systems (Sharma, 2009).

Tomato (*Lycopersicon esculentum* Miller) has been described as a versatile commodity and can be utilized to improve the flavor characters of other foods (Villareal, 1980). Tomato is grown in the lowland of Nepal during winter but its production and supply during summer and rainy season is constrained due to high temperature and heavy rainfall. Under such conditions maize-tomato intercropping provides an alternative for continuous market supply of tomato and higher economic return to the farmers. Tomato intercropping in maize plot is becoming popular but there is a lack of scientific information in terms of relative performances of corn varieties under such a mixed cropping system.

Cultivation of baby corn to diversify cropping patterns and to increase productivity of the cropping systems has been considered important for improving the livelihood of resource poor farmers in South Asia (Mathema, 1994; Kumar and De, 1998). Previous studies conducted in the region identified corn hybrids and open pollinated varieties (OPVs) that could be suitable for baby corn production in Nepal (Pathik, 2001) and India (Masana, 2004). Even though there may be specific traits requirements that could make a variety suitable for baby corn production (Puddhanon *et al*., 1992), some regular varieties of field corn, sweet corn, sugary enhanced sweet corn, and super sweet corn varieties may also be suitable for baby corn production (Miles and Zenz, 2004). Corn stalk plays an important role to anchor the crops that need staking to grow, and inclusion of these maize and tomato in intercropping helps in proper utilization of land for economic benefit without degradation of natural environment (Gautam *et al.*, 2004). Intercropping systems provide greater potential than monoculture for sustained production of food and income, especially for poor farmers in developing countries with limited resources (Francis, 1989). The approach of vegetable in maize based cropping system intends to increase production per unit of land area through intensified cropping, and help ensure cropping system sustainability through crop rotation, recycling of unused parts of plants, and reduction in the use of agro-chemicals (AVRDC, 1998). Al-Alal and Johry (2003) concluded that the most advantage for using maize and tomato intercropping was to maximize usage unit of land and water to produce a maximum production.

Previous studies have shown that baby corn production could be an important on-farm income generation activity (Mathema, 1996; Kumar and De, 1998) and that there is additional profit from intercropping baby corn with other field crops (Thavaprakaas *et al.,* 2008). However, small farmers in South Asia often hesitate from trying a new technology that might involve certain degree of risk, baby corn production being one of such technologies. Therefore, this study was conducted to test baby corn as an intercrop with tomato. Tomato is a widely grown vegetable crop across South Asia. Growing baby corn with tomato would also be insurance to small farmers against a complete failure of one crop. Hence, the present experiment was conducted to examine the performance of baby corn and tomato varieties in different combinations, and to determine the benefit from this cropping system compared to the sole crops.

## MATERIALS AND METHODS

The field experiment was conducted at Rampur, Nepal from February 2007 to July 2007. The experimental site, situated at $27^0$40' N latitude and $84^0$19' E longitudes with an altitude of 228 m above mean sea level, represents the fertile lowland of inner *Tarai* of Nepal, which falls within the vast Eastern Gangetic Plains of South Asia (Sharma *et al*., 2007).

The four corn varieties used in the study included two hybrids (Bioseed 9681' and 'JK Puja') and two OPVs ('Arun-2' and 'Rampur Composite'). The two tomato hybrids were 'BSS-418' and 'Umi'. The experiment was conducted in a Randomized Complete Block in three replicates with factorial arrangements of varieties. The four corn and two tomato varieties were arranged in eight intercropping combinations. The corn sole and tomato sole were used as control treatments. The corn variety Rampur Composite was used as control because it is used as a baby corn cultivar. BSS-418 was used as a control plot for tomato because it is widely grown by the farmers in the region. The individual experimental plots of 3 m × 2.25 m size were planted with five rows of corn at 0.60 and 0.45 m row and plant spacings, respectively. Each hill of corn was planted with five seeds and thinned to three plants per hill 15 days after seeding. Tomato seedlings were transplanted in between hills of corn in each row, four seedlings per row. Thus, there were 75 plants of baby corn and 20 plants of tomato in each plot. Corn was planted on February 24 whereas 21-day old seedlings of tomato were transplanted on March 16, 2007. The soil in the experimental field was well drained and fertile with high organic matter content (4.8%) and 5.4 pH. The previous crop grown in the field was cabbage. The experimental field was well prepared by harrowing thrice and removing weeds and plant debris. Farm yard manure at the rate of 10 t/ha was well mixed at equal amount into soil in each plot before the seeding of baby corn. Additional nutrients were applied at the rate of 150, 75 and 40 kg/ha of N, P and K, respectively. One-third of the total N and full dose of P and K were used at the time of seeding corn. The remaining two-third of N was side dressed in two equal splits at 25 and 40 days after seeding. Irrigations were applied as needed to maintain good crop growth. The plots were kept free from weeds by hand weeding.

All the corn plants were detasseled on the day of tassel appearance. Four hills, i.e. 12 plants of baby corn and five plants of tomato were randomly selected from the center of each plot for recording observations. For corn**,** data were recorded on plant height, ear height, internode length, internode diameter, days to tasseling, days to silking, percent of plants with 1, 2 and 3 cobs, cob length and diameter, weight of husked and dehusked cob weights, ratio of husked to dehusked cob weight, stover yield, husk and silk yield, and husked and dehusked cob yield using the standard procedures described by CIMMYT (CIMMYT, 1985). For tomato**,** data were recorded on marketable number of fruits per plant and fruit yield.

Gross and net benefit, and benefit cost ratio were estimated for baby corn production. Gross benefit was determined by multiplying yields by market price. Net benefit was derived by subtracting total costs from gross benefit. Benefit cost ratio was derived by dividing gross benefit by total costs. Benefits and costs of sole crops of maize, baby corn, tomato, and baby corn-tomato intercrop were calculated from the total costs and gross benefit. Change in net benefit from existing practice to innovative practices was divided by change in total additional costs for adopting innovative over existing practice. Marginal rate of return (MRR) was estimated using the following formula.

$$\text{MRR}(\%) = \frac{\text{Change in net benfit}}{\text{Change in total cos t}} \times 100$$

Land equivalent ratio (LER) was estimated using the procedure given by Reddy (1989). The formula used to calculate LER is given below.

LER = (Yield of baby corn as intercrop ÷ Yield of baby corn as sole crop) + (Yield of tomato as intercrop ÷ Yield of tomato as sole crop)

Analyses of variance were computed to determine significance among treatments using MSTATC (1990) and Genstat Discovery Edition 3 (Genstat, 2007) softwares. The significance of differences among treatment means was tested using Duncan's New Multiple Range Test (Gomez and Gomez, 1984).

## RESULTS AND DISCUSSION

The analysis of variance revealed significant differences only for ear height, internode diameter, and percent of plants with one and three cobs for the main plot effect of baby corn variety (Table 1). Husked and dehusked cob weight and their ratio, yield of husk and silk, and husked and dehusked cob yield also differed significantly for the main effect of baby corn variety (Table 2). The main effect of tomato varieties were significant for husked and dehusked cob weight and dehusked cob yield only. The two factor interaction was significant only for internode diameter (Table 1), and husked and dehusked cob weight and their ratio (Table 2). The four baby corn varieties showed a good amount of variation for agronomic traits, though not always significant (Table 3).

The four baby corn varieties differed significantly for average cob diameter but not for average cob length (Fig. 1). JK Puja had significantly higher value for cob diameter than other varieties. The four corn varieties showed a great deal of intravarietal variation for the cob length (Fig. 2). All four varieties had a greater percentage of cobs with a length ranging between 7 and 10 cm. However, the relative varietal differences varied for percent of smaller and longer cobs. Rampur Composite, Arun-2 and JK Puja had the highest percentage of shorter (<7 cm), medium (7-10 cm) and long (>10 cm) cobs, respectively. Bioseed 9681 and JK Puja showed significantly higher average weight (Fig. 3) and yield (Fig. 4) of husked and dehusked baby corn, respectively. The response of tomato in terms of the number of fruits per plant and fruit yield significantly differed in combination with baby corn variety with the highest values with Bioseed 9681 and JK Puja (Fig. 5). This was true for both varieties of tomato (Fig. 6).

There was a range of values for benefit cost ratios for different cropping systems (Table 4). Benefits and costs of sole crops of maize, baby corn, and tomato, and baby corn-tomato intercrops using Rampur Composite of baby corn and BSS-418 of tomato revealed that the highest benefit cost ratio (3.0:1) was estimated in baby corn-tomato intercrop (Table 4). Tomato sole crop gave the benefit cost ratio of 2.5:1. The lowest (1.4:1) ratio was for maize sole crop, while baby corn sole crop produced the ratio of 1.9:1. The marginal rate of return varied for different shifts in cropping systems. The highest MRR (451%) was estimated in the shift of baby corn to baby corn-tomato intercrop (Figure 7). The shift from maize sole to baby corn sole had the lowest (99%) MRR. The land equivalent ratio for corn-tomato intercrop was estimated at 1.78.

The significant differences among the four baby corn varieties for a number of traits confirmed their genetic diversity. The lack of significant interactions for many traits showed that relative differences among the four baby corn varieties did not change significantly across the intercrops with the two tomato varieties. This is also indicative that tomato intercrop not necessarily affects the physiology of its companion baby corn plants. This finding supports the previous finding that properly managed intercrops do not interfere with the growth and development of the component crops in baby corn intercrop systems (Thavaprakaash and Velayudham, 2008).

The diameter of the ear influenced yield more than length of the ear. This suggests that while selecting baby corn varieties, ear diameter should be given importance considering consumers' preference. Even though the average length of the four corn genotypes did not differ significantly, there were arrays of intravarietal differences for ear length. These findings could be significant if there happens to be a premium baby corn price depending upon ear length or diameter. Due to their thicker cobs and higher percentage of longer cobs, hybrids could be considered superior to the OPVs for ear characteristics. The weight and yield of the husked ear was indicative of their dehusked state as well as the yield of the husk. This demonstrates that baby corn with high ear yield also produced higher yield of husk. Green husk is considered important as animal feed on small farms. This finding is significant in selecting baby corn for husked and dehusked yields for marketing purpose. This finding is in agreement with the previous report that baby corn ear and fodder yields are not

**Table 1. Mean squares from analysis of variance for various plant traits of four varieties of baby corn evaluated in combination with two varieties of tomato in a factorial arrangement of Rampur, Nepal, 2007**

| Source | df | Plant height | Ear height | Internode length | Internode diameter | Days to tasseling | Days to silking | Cob bearing plants (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | 1 cob | 2 cobs | 3 cobs |
| Replication | 2 | 0.1029 | 0.0548 | 9.975 | 0.0558 | 5.2 | 6.5 | 34.7 | 46.3 | 11.6 |
| Baby corn variety (A) | 3 | 0.0009 | 0.0429* | 3.684 | 0.1515** | 12.9 | 9.3 | 95.5* | 19.3 | 95.5* |
| Tomato variety (B) | 1 | 0.0159 | 0.0155 | 1.649 | 0.0041 | 13.5 | 6.0 | 26.0 | 00.0 | 26.0 |
| A × B | 3 | 0.0080 | 0.0032 | 2.797 | 0.0290* | 18.3 | 14.7 | 33.8 | 23.2 | 56.9 |
| Error | 14 | 0.0109 | 0.0051 | 1.632 | 0.0081 | 11.5 | 14.5 | 18.2 | 23.2 | 18.2 |

*, ** Significant at 0.05 and 0.01 probability levels, respectively.

**Table 2. Mean squares from analysis of variance for various yield related traits of four varieties of baby corn evaluated in combination with two varieties of tomato in a factorial arrangement at Rampur, Nepal, 2007**

| Source | df | Husked cob weight | Dehusked cob weight | Husked:Dehusked cob weight ratio | Stover yield | Husk and silk yield | Husked cob yield | Dehusked cob yield |
|---|---|---|---|---|---|---|---|---|
| Replication | 2 | 0.6 | 7.93 | 0.491 | 204 | 0.065 | 0.142 | 0.262 |
| Baby corn variety (A) | 3 | 136.9** | 39.18** | 1.736** | 63 | 10.253** | 11.271** | 1.039** |
| Tomato variety (B) | 1 | 174.3** | 26.92** | 0.092 | 44 | 2.285 | 6.722 | 1.169* |
| A × B | 3 | 51.1* | 5.16* | 0.325* | 103 | 2.687 | 3.931 | 0.329 |
| Error | 14 | 15.1 | 0.97 | 0.081 | 44 | 1.288 | 2.038 | 0.144 |

*, ** Significant at 0.05 and 0.01 probability levels, respectively.

**Table 3. Mean values for agronomic traits of four baby corn varieties evaluated in a corn-tomato intercropping system at Rampur, Nepal, 2007.**

| Treatments | Plant height (m) | Ear height (m) | Internode length (cm) | Internode diameter (cm) | Days to tasseling | Days to silking | Cob bearing performance (plants %) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 1 cob | 2 cobs | 3 cobs | 2-3 cobs |
| Rampur Composite | 2.364 | 1.239 a | 16.22 | 1.582 b | 60.17 | 63.50 | 15.28ab | 69.44 | 15.28ab | 84.72ab |
| Arun-2 | 2.334 | 1.169 ab | 17.90 | 1.440 b | 62.33 | 65.17 | 11.11b | 72.22 | 16.67a | 88.89a |
| Bioseed 9681 | 2.358 | 1.036 b | 17.58 | 1.775 a | 61.50 | 65.50 | 15.28ab | 68.06 | 16.67a | 84.72ab |
| J K Puja | 2.353 | 1.160 ab | 16.66 | 1.759 a | 63.67 | 66.50 | 20.83a | 70.83 | 8.33 b | 79.17 b |
| $LSD_{0.05}$ | ns | 0.0884 | ns | 0.1113 | ns | ns | 5.281 | ns | 5.281 | 5.281 |

**Table 4. Economic analysis of producing baby corn and tomato as intercrops evaluated at Rampur, Nepal, 2007**

| Cost and return items | | Cropping system | | | | |
|---|---|---|---|---|---|---|
| | | Sole corn crop | Rampur Composite baby corn | Tomato BSS-418 | Rampur Composite + BSS-418 Corn | Tomato |
| Total cost of cultivation (US $/ha)†‡ | | 356 | 2780 | 2879 | 3963 | |
| Total produce (kg/ha) | Grain / fruit | 2278 | 2378 | 34132 | 2260 | 31680 |
| | Non-grain biomass | 17000 | 57400 | | 54520 | |
| Gross benefit (US $/ha)¶ | | 513 | 5341 | 7314 | 11865 | |
| Net benefit (US $/ha) | | 157 | 2561 | 4435 | 7902 | |
| Benefit cost ratio | | 1.4 | 1.9 | 2.5 | 3.0 | |

†All costs including land preparation, crop management and marketing.
‡ US $1 = 70 Nepali Rupees (NRs).
¶ Selling price is estimated at, corn grain: NRs 15/kg; baby corn cob: NRs 150/kg; tomato: NRs 15/kg; non-grain biomass in grain corn crop NRs 0.1/kg; non-grain biomass from baby corn crop NRs 0.3/kg.

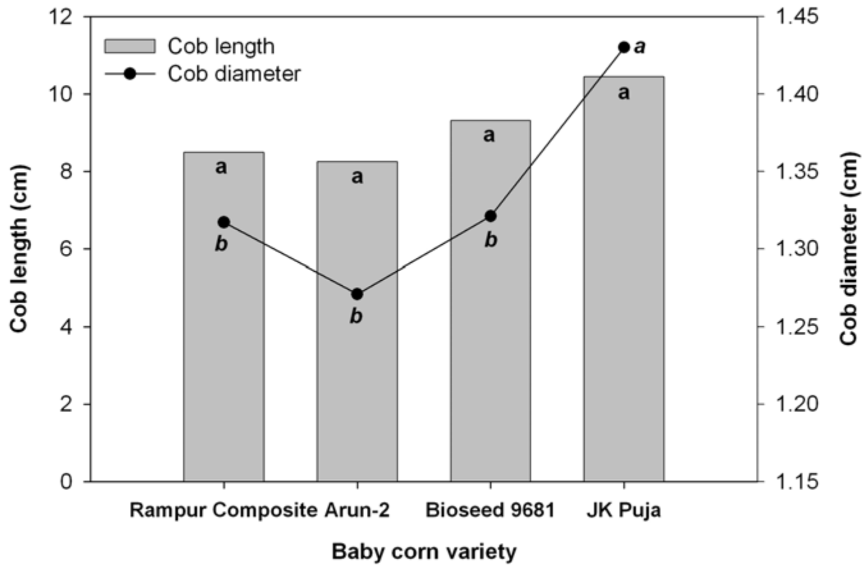


**Figure 1. Cob length and diameter of the four baby corn genotypes evaluated in a corn-tomato intercropping system at Rampur Nepal, 2007. For a given trait, the means followed by different letters are significantly different based on Duncan's New Multiple Range Test at P = 0.05.**

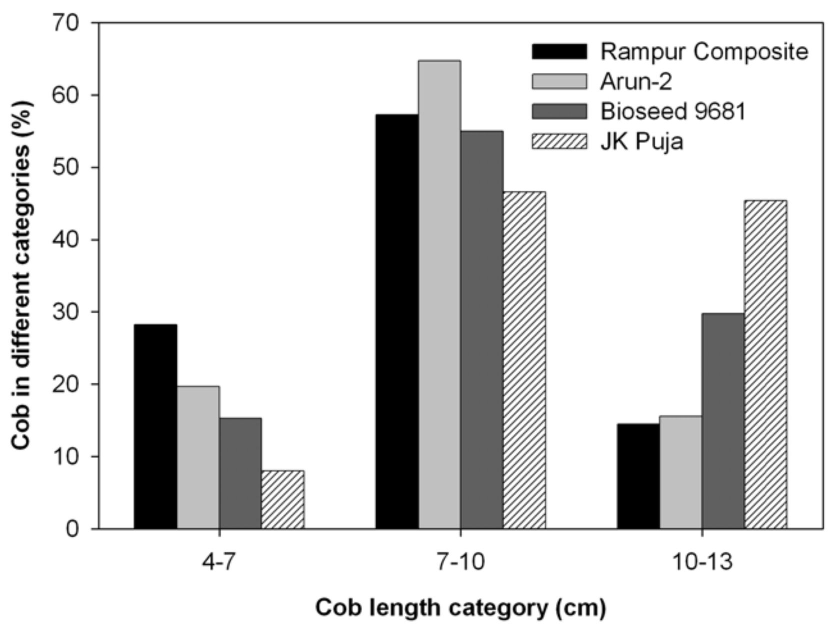


**Figure 2. Percent of baby corn cobs in different length categories in the corn-tomato intercropping system evaluated at Rampur, Nepal, 2007.**

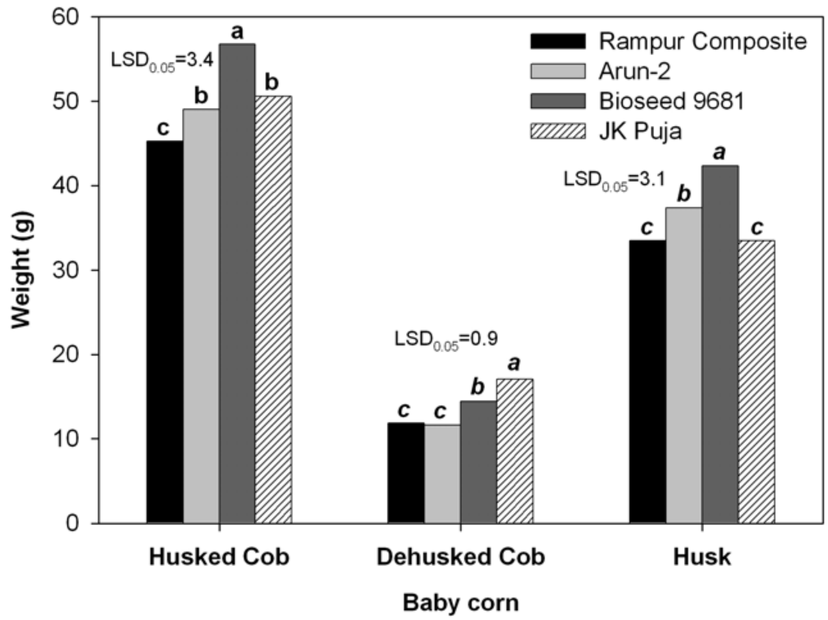


**Figure 3. Husked and dehusked cob weights of baby corn under baby corn-tomato intercrop in inner Tarai of Nepal (2007). For a given trait, the means followed by different letters are significantly different based on Duncan's New Multiple Range Test at P = 0.05.**

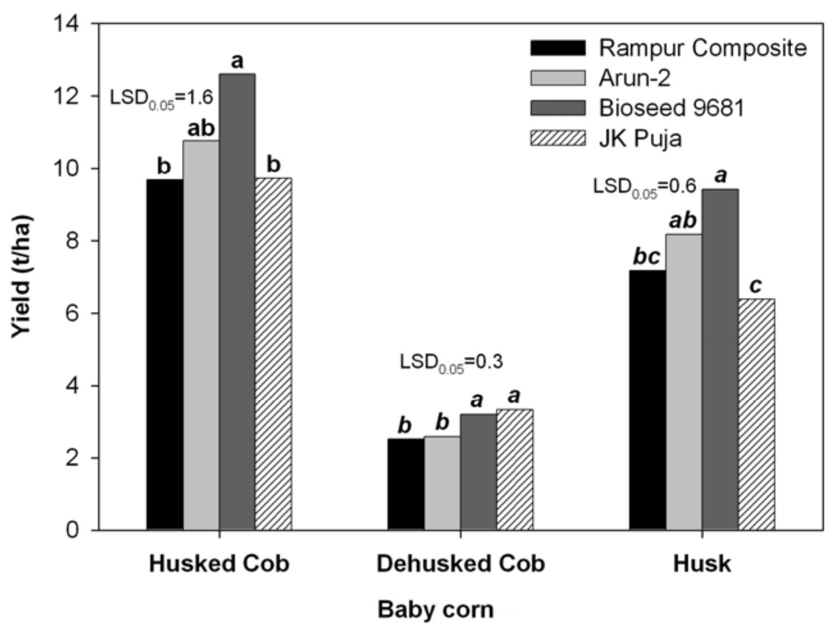


**Figure 4. Husked and dehusked cob yield of baby corn in a corn-tomato intercrop evaluated at Rampur, Nepal, 2007. For a given trait, the means followed by different letters are significantly different based on Duncan's New Multiple Range Test at P = 0.05.**

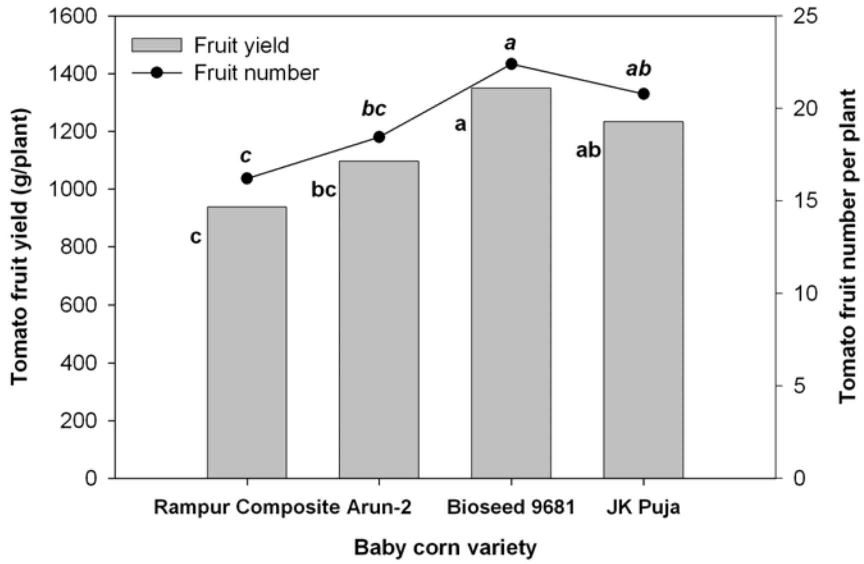


**Figure 5. Fruit yield and number of fruits per plant of tomato cultivars under baby corn-tomato intercropping at Rampur, Nepal, 2007. For a given trait, the means followed by different letters are significantly different based on Duncan's New Multiple Range Test at *P* = 0.05.**

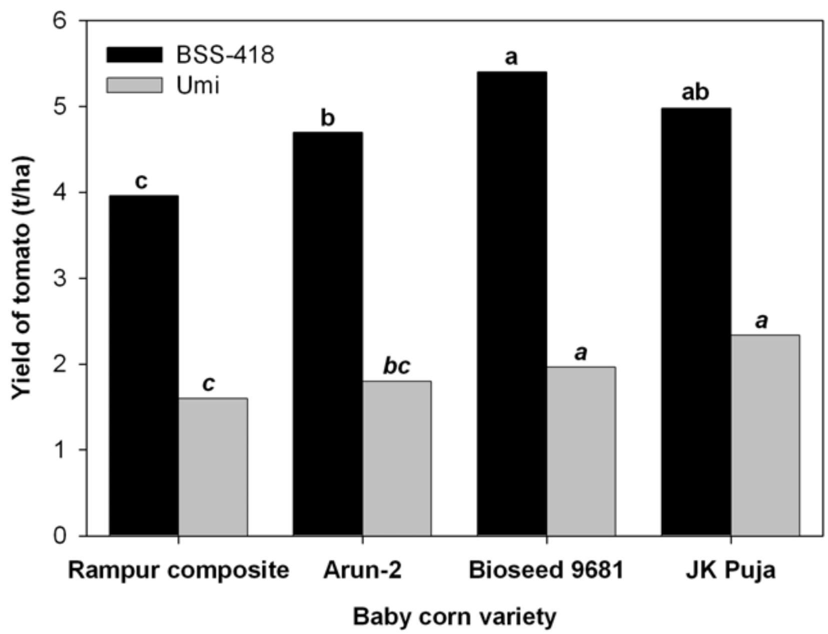


**Figure 6. Marketable fruit yield of tomato under intercropping with four baby corn cultivars at Rampur, Nepal, 2007. For a given variety (BSS-418 and Umi), the means followed by different upper case or lower case letters are significantly different based on Duncan's New Multiple Range Test at *P* = 0.05.**

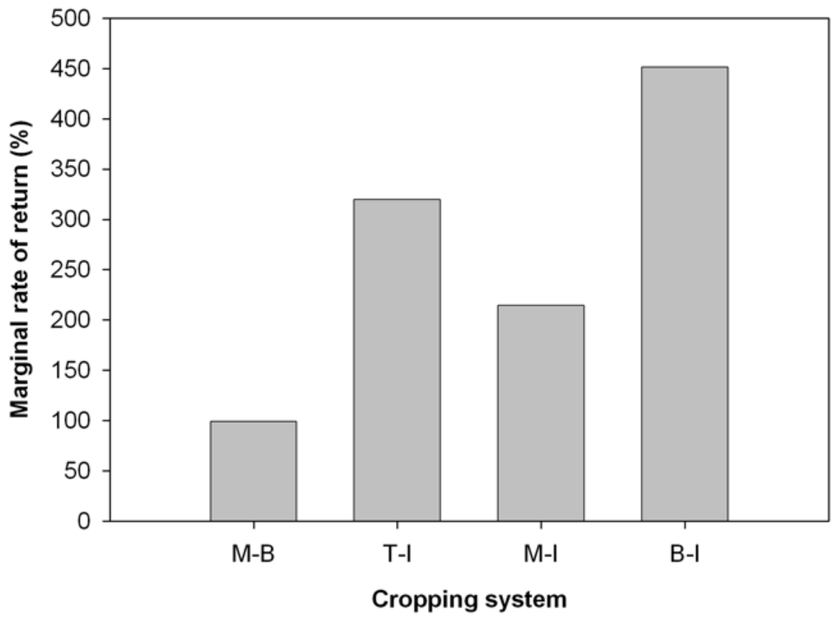


**Figure 7: Marginal rate of return from shifting of cropping systems. (M-B= Maize to baby corn, T-I = Tomato to baby corn-tomato intercropping, M-I= Maize to baby corn-tomato intercrop and B-I = baby corn to baby corn-tomato intercrop).**

affected in the intercropping systems when nutrient management for the companion crops are adequate (Thavaprakaash et al., 2008).It is important to note that the plots with the highest yielding baby corn (Bioseed 9681) also produced the highest yield of tomato. This finding provides a win-win situation for baby corn and tomato intercropping. The higher yield of tomato varieties associated with the plots that produced the highest yield of baby corn suggests that there might be some kind of physiological compensation between hybrid baby corn and tomato varieties. Ayala et al. (1992) had reported that maize has positive effect on plant growth and fruit yield of intercrop tomato. Al-Alal and Zohry (2003) reported that the damage of tomato fruits was decreased and marketable yield increased due to the height of maize plants that acted as shadow on tomato plants and protect fruits from sun rays and reduce the effect of direct burning on fruits.

The higher benefit cost ratio and MRR for baby corn-tomato intercrop demonstrate that this system could be highly beneficial as on-farm income generation activity for smallholders where there are market facilities available for the two commodities. There is little documentation on economic returns from intercropping of baby corn and tomato, however, the findings of our study supports previous reports that corn and tomato combination is highly profitable (Prakash et al., 2005; Hussain et al., 2008). The land equivalent ratio (1.78) estimated in this study compared well with previous estimate of 1.86 by Prakash et al. (2004).

## CONCLUSION

The results of this study suggest that there Arun-2 and Bioseed 9681 were more promising than other varieties for baby corn production. Similarly, tomato variety BSS 418 was compatible in intercropping system. The Arun-2 baby corn and BSS 418 tomato combination was most promising for optimizing yield and economy return of both crops. The findings have implications for corn vegetable cropping systems for improving livelihoods of the small farmers in South Asia.

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