Research Article

Production Economics and Determinants of Carrot (*Daucus carota* L.) production in Chitwan, Nepal

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Abstract

Carrot (*Daucus carota* L.) is an important agricultural commodity in the world. A study was conducted for comparative analysis of demographic, economics assessment, and determinants of carrot production between ward no. 11 and ward no. 15 of the Bharatpur metropolitan of Chitwan district. Altogether 80 carrot growers, 40 from ward no. 11 and 40 from ward no. 15 of Bharatpur metropolitan were randomly selected. Pretested semi-structured questionnaire was used to collect primary information from randomly selected farmers. Carrot growers were interviewed using face to face method in November 2019. Moreover, Two Focus Group Discussion (FGD$_s$) and two Key Informant Interviews (KII) were performed. All the data were entered in Statistical Package for Social Science (SPSS Statistics 20) and Microsoft Excel (Ms-2013) and analysis was done by using Microsoft Excel, SPSS, and Stata. In the majority of respondents, Poultry manure cost (37.16%) occupied the major portion of the cost of production followed by seed cost (30.18%). The average gross margin per kattha for carrot production found NRs. 4726.62 and the Benefit-cost ratio (BCR) was 1.50. The probability of cultivation of carrot on large scale was found to be 31.12% higher for the male gender of household head and 27% higher for the schooling of the household head. Farmers use the Nepa Drim, F1 variety which incurred higher cost in the seed. Splitting (26.25%) was identified as the most critical problem followed by cracking (21.15%) in the cultivation of carrot. It is recommended that the farmers involved in carrot farming in the study sites should be provided with Subsidy on seed, proper solution of physiological disorder problems and proper technical knowledge for optimizing the use of resources would help to increase the profit of carrot production in the Chitwan district of Nepal.

Introduction

Carrot (*Daucus carota* L.) is one of the most important vegetables belonging to the *Apiaceae* family (Rubatzky *et al*., 1999). It is a globally grown root vegetable. The color of root flesh may be orange, purple, yellow, white, and red. China, Uzbekistan, Russia, the United States, and Ukraine are the world's top carrot producing countries (Worldatlas, 2017). The estimated global carrot production in 2014 was 38.8 million tons which also forecasted the globally

increasing demand for it. The area under carrot in India was 64.33 thousand hectares with the production of 1147.08 thousand metric tons (Sangeetha & Shanthakumar, 2016). The area, production, and productivity of carrot in Nepal in the year 2015/16 has been reported to be 2933.9 ha, 37724.9 mt, and 12.9 m/ha respectively (MoAD, 2015/16, 2017). The average yield of our neighboring countries China and India is 38.54 and 30 tones/ha respectively (Ahmad, 2012).

In comparison to the global scenario, the reason behind the low productivity in Nepal is inadequate knowledge of the appropriate production method, lack of proper allocation of resources, and topography.

Carrot is a good source of carotenoids, dietary fiber, vitamins, and minerals (Nicolle et al., 2004). It consists of Beta carotene and an appreciable amount of thiamine (Vit B_1) and Riboflavin (Vit B_2) (da Silva Dias, 2014). Due to the high availability of carotenoids, carrot can provide us a significant amount of vitamin A (van Het Hof, 2000). As compared to other vegetables, the carrot can contribute more to the human diet. Antioxidant, anti-carcinogen and Immune-enhancer benefits, wound healing, cardiovascular and cholesterol disease lowering, Anti-diabetic, anti-inflammatory, antibacterial, and antifungal benefits of carrot have also reported by researchers (Silva Dias, 2014). Besides that, Carrot fleshy roots are used as salads, soups, and used in vegetable dishes (Amjad, 2005).

The production and productivity of carrot in Chitwan was 1437.5 metric ton and 12.5 metric ton/hectare (MoAD, Statistical Information on Nepalese Agriculture 2015/16, 2017). Among different provinces, Bagmati Province is the larger producer of carrot in the country. Chitwan is one of the major carrots producing districts of Nepal. The Released and Registered different varieties of Carrot in Nepal are Nantis ford, New Kuroda, Nepa Drim, F1, Sigma, Kuroda mark, and so on (AITC, 2018). Farmers of Makwanpur district have been growing carrots instead of traditional agricultural products due to high returns in carrot (The Kathmandu Post, 2017). They stopped growing of Maize, millet, beans, and carrot farming can improve living standards through an increase in income. These days, people are more aware of health-conscious and ion healthy diets. An increase in awareness among people about the importance of carrot results in a progressively increase in consumption. The commercialization of carrot can bring unimaginable changes in the living standard of life. Thus, there is great scope for carrot growing farmers to earn a huge amount of income. Moreover, Carrot can be an important vegetable to address food insecurity. So, we need to improve cultivation practices and exploit it to its maximum potentiality. In this context, it is necessary to conduct empirical research to generate knowledge on production economics and determinants of production. Moreover, this study provides information on gross margin and benefits in carrot production, determinants of production, and problems in production.

Table 1: Released and Registered Carrot varieties in Nepal.

Name of Released Varieties	Year of Release	Origin	Yield potential (Mt/ha)	Maturity (Days)	Recommendation Domain
Nantis Forte	1990	India	12.0	90-100	High hill
New Koruda OP	2010		50-60	100	Terai, Mid and high hill
Nepa Drim, F1	2010		25	120	Terai and hill
Sigma, F1	2010		25	120	Terai and hill
Kuroda Mark	2010		5-7	50-60	Terai and Midhill

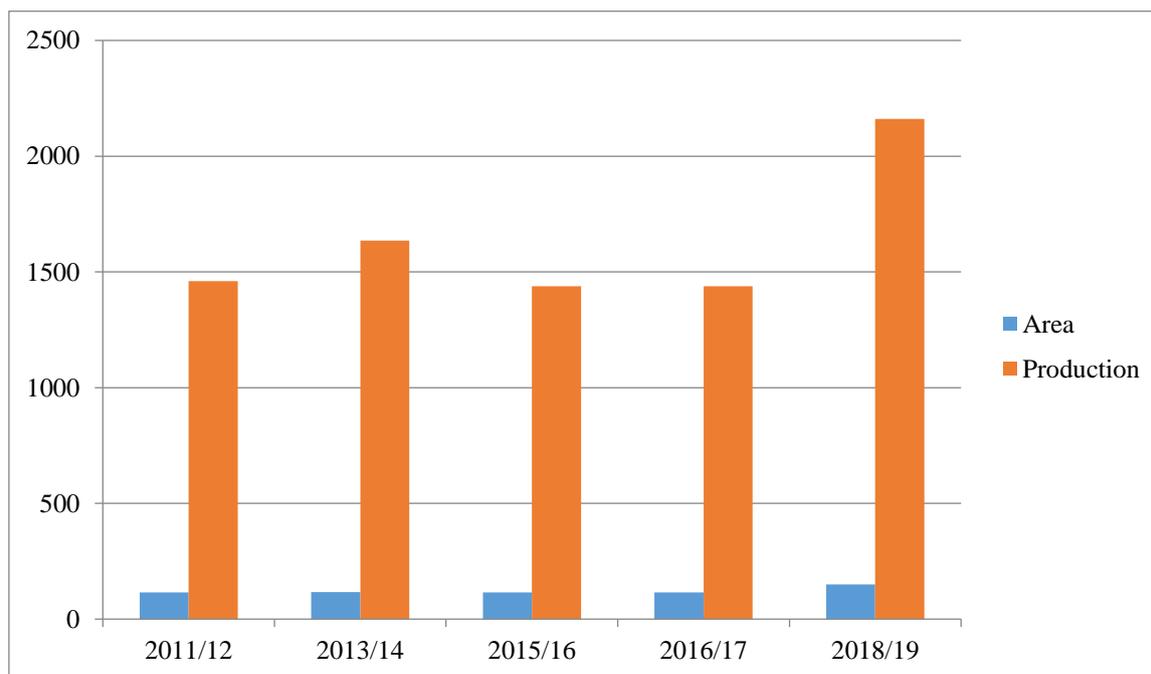**Source:** MoAD, Statistical Information on Nepalese Agriculture 2015/16, 2017.

Fig. 1: Production trends of carrot (in metric tons) and area (in hectare) under carrot production in Chitwan district of Nepal. (MoAD, Statistical Information On Nepalese Agriculture, 2011-2020)

Methodology

Study Area, Sample Size, and Data Collection Technique

The research was conducted in ward no.11 and ward no. 15 of Bharatpur Metropolitan of Chitwan district. It is a part of Bagmati province. The district was purposefully selected because it is one of the major carrot producing districts with the identifiable carrot growing farmers. Face to face interview method was used to collect primary data using the pretested semi-structure questionnaire in November 2019. Two Focus group Discussion (FGDs) and two Key Informant Interviews (KII) (Carrot producers, local leaders, Technical assistance, and vegetable zone officer) were performed. The number of relevant literature was reviewed for secondary information. 80 respondents were selected using a Simple random Sampling (SRS) method among farmers cultivating carrot for the last two years. 40 respondents from each ward of Bharatpur Metropolitan were selected (Fig. 1).

Methods and Techniques of Data Analysis

The data were entered in Statistical Package for Social Science (SPSS Statistics 20) Microsoft Excel (Ms-2013) and analysis was done by using SPSS, Stata, and Microsoft Excel. The following analyses were performed:

Gross Margin

Gross margin is the difference between gross return and the total variable cost incurred during production. Except for land, Carrot does not require any fixed cost. The gross margin was calculated using the following formula:

Gross margin = Gross return – Total variable cost
Where,
Gross return = Price × Total quantity in the market
Total Variable cost= Cost incurred by all variable items.

Adhikari (2009) already used a similar formula to gross margin.

Benefit-Cost Ratio

The benefit-cost analysis was performed by using the following formula

$$B/C = \frac{Gross\ return}{Total\ variable\ cost}$$

This formula was used by (Dahal & Rijal, 2019) for calculating benefit costs.

Analysis of The Basic of B: C Ratio

If B: C ratio < 1 then, the enterprise is in **Bankrupt** condition
If B: C ratio = 1 then, the enterprise is in **Just solvent** condition
If B: C ratio > 1 then, the enterprise is the in**solvent** condition

Probit Model

A Probit model was used to determine the factors that influence farmers to cultivate carrot in the large area in Chitwan district. For categorizing the size of the farm, an average farm size of 80 farmers was calculated. Farmers with the landless than the average were considered as smallholder carrot producer and more than that were considered as commercial carrot producers. Farmers of ward no. 15 were commercial carrot producers. The probit model had two categories independent variable and it is the probability model (Liao, 1994). In the binary probit model, Farmers cultivating carrot more than 15 kattha is taken as 1, while those cultivating less than 15 kattha is taken as zero. It is assumed that the ith farmers obtain maximum utility, it has commercial cultivation preference over small farm holders.
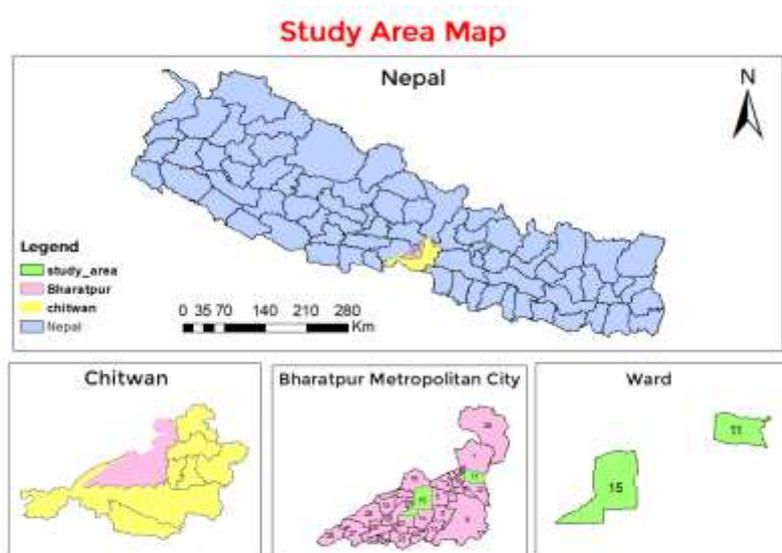

Fig. 2: Map of Research Site.

Socio-Demographic Characteristics

The majority of the Household head were male, 32(80.0%) of the household head of Bharatpur metropolitan ward no. 11, and 24 (60%) of the household head of Bharatpur metropolitan ward no. 15 were male. The difference was significant at a 10% level of significance. 97.55% household head of ward no.11 and 90% household head of ward no.15 follow agriculture as the main profession. The majority of the household of both wards was dominated by Brahmin and Chhetri. 80% household of ward no. 11 and 45% household of ward no.15 were Brahmin/Chhetri, 20% household of ward no. 11 and 25% household of ward no.15 were janajati and 30% household of ward no.15 belong to Dalit ethnicity. The difference was significant at a 1 % level of significance. 95% of the household of ward no.11 and 77.5% household of ward no.15 follow the Hindu religion. Result obtained was significant at a 5% level of significance. 15% household of ward no.11 belongs to the joint family whereas 40 % household of ward no.15 belongs to the joint family. The difference was significant at a 5% level of significance which was as shown in Table 2.

Cost of Carrot Production

The total variable cost for carrot production in the study area in one kattha land was calculated NRs. 9290.46. The cost of carrot production in 1 kattha of land was found to be lowest in ward no. 11 of Bharatpur Metropolitan (NRs. 7816) followed by ward no. 15 of Bharatpur Metropolitan (NRs. 10763.26). The profitability of any agricultural production depends on the cost of inputs. The major cost attributing items that were being used are Seed, Land preparation, Farmyard manure, poultry manure, Fertilizers (DAP and Potash), Herbicide cost, Micronutrient (Borax, Zinc), and Labour cost (Planting, weeding, fertilizer application, harvesting, and packing). In the study area, Poultry manure was found to be the first major cost attributing items among all variable items. Seed followed poultry manure in this respect. Herbicide cost was found to be the least cost attributing item. Poultry manure occupied the major portion (37.16%) of the cost of the production followed by the seed (30.18 %), Farmyard manure cost (16.51%), Labour cost

(10.16%), Micronutrient (Borax and Zinc) cost (2.60%), Land preparation cost (1.88%), Fertilizers cost (1.04%) and herbicide cost (0.46%). Chitwan is the largest producer of poultry products in Nepal. It produces NRs. 1.2 million worth of chickens per week and sales approximately NRs. 213 million worth of poultry manure annually (Thapa, 2016). So, the easy availability of poultry manure in the study area is the major cause of higher use of poultry manure. The cost incurred by seed in the study area was found higher than a similar type of study conducted in the organic and inorganic carrot of Chitwan (Adhikari, 2009) and selected districts of Punjab, Pakistan (Mahmood, 2017) ranges from 10-15%. In the study area, farmers cultivate the Nepa Drim,F1 variety which cost NRs 21500 per kg resulted in higher cost incurred in the seed. The cost incurred in Dap and Potash was lesser than other variables due to lower use of it than the recommended dose. The recommended amount of DAP and Potash are 3.33 kg / Kattha and 3.33 kg / Kattha respectively (AITC, 2018). The combination of both organic fertilizer (Farmyard manure and poultry manure) and Inorganic fertilizer (DAP and potash) in the study area are found effective. The influence of poultry manure and NPK (17-17-17) fertilizer on the growth and yield of carrot in Rwanda had found a significant influence on growth and yield of carrot (Habimana, 2014). Similarly, the Application of farmyard manure and inorganic fertilizer in Northern Nigeria are found in increased agronomic parameters of carrot (Ahmed, 2014).

A study conducted on the economics of production of potato in the Saptari district revealed that Seed, plant protection chemicals, DAP, and Potash were underutilized resources in his study (Mahatha, 2012). Also, (Goni, 2013) reported that chemical inputs, seed, and organic manure were underused during dry season vegetable production in Jere Boro state, Nigeria. In contrast to this finding, Chemical fertilizer and labor were overutilized resources in potato production in Guinea (Tolno, 2016). The details of the average cost of production per Kattha are shown in Table 3.

Table 2: Demographic characteristics of carrot growing farmers of the study area

Carrot grown area of Bharatpur metropolitan				
Variables	**Ward no.11**	**Ward no.15**	**Chi-square**	**p-value**
Gender of HHH(Male)	32(80.0)	24(60.0)	3.81*	0.051
Occupation HHH(Agriculture)	39(97.5)	36(90.0)	1.92[ns]	0.166
Ethnicity				
Brahamin/chhetri	32(80.0)	18(45.0)	16.14***	0.000
Janajati	8(20.0)	10(25.0)		
Dalit	0	12(30.0)		
Other	0	0		
Religion (Hindu)	38(95.0)	31(77.5)	5.16**	0.023
Family type(Joint)	6(15.0)	16(40.0)	6.27**	0.012

Figure in parenthesis indicate percent *, ** and *** indicate 10%, 5% and 1% level of significance

Table3: Average cost of carrot production per Kattha[*].

Cost attributing Items	The average cost in the Study Area (**NRs.)	The average cost in Bharatpur Metropolitan	
		Ward No. 11 (**NRs)	Ward No. 15 (**NRs)
Seed	2803.52	2363.28	3243.76
Land Preparation	175	250	100
Farmyard manure	1534	1128.14	1939.2
Poultry manure	3452.15	3212.48	3691.82
Fertilizers (DAP and Potash)	97	55.97	137.25
Herbicide cost	43	53.98	31.87
Micronutrient (Borax and Zinc)	242	209.23	274.69
Labour cost (planting, weeding, fertilizer application, harvesting and packing)	943.79	542.91	1344.67
Total	9290.46	7816	10763.26

* 1 hectare= 30 Kattha; ** The rate of 1 $= 1 USD= 121.31 NRs. (Nepalese Rupee) as of April 12, 2020.

Gross Return

The average total returns from carrot production in one Kattha of land in the study area was calculated NRs. 9289.63. The gross return obtained from carrot production in 1 Kattha of land in ward no 15 of Bharatpur metropolitan (NRs. 10763.26) was higher than ward no.11 (NRs. 7816) (Table 3).

Gross Margin

Gross margin in the study area = Gross return – Total variable cost

= NRs. (14016.25 - 9289.63)

= NRs. 4726.62 per Kattha

Gross margin in ward no. 11 of Bharatpur Metropolitan = Gross return – Total variable cost

= NRs. (10912.5 - 7816)

= NRs. 3096.5 per Kattha

Gross margin in ward no. 15 of Bharatpur Metropolitan = Gross return – Total variable cost

= NRs. (17120 – 10763.26)

= NRs. 6356.74 per Kattha

The average gross margin from carrot production in 1 Kattha of land in the study area was calculated NRs. 4726.62. The gross margin in ward no 15 of Bharatpur metropolitan (NRs. 6356.74) was higher than ward no.11 (NRs. 3096.5). The highest gross margin in ward no. 15 was due to having a higher gross return while the lowest gross margin in ward no.11 was due to having the highest cost of production. (Adhikari, 2009) reported that the gross margin for inorganic carrot production per kattha in Chitwan was NRs. 4550.93 (NRs. 136527.84 per hectare). The gross margin is positive which is an indicator of the financial viability of the farm business.

Benefit-Cost Ratio (BCR)

Benefit-Cost Ratio (BCR) in the study area $= \frac{Gross\ return}{Total\ cost}$

$= \frac{NRs\ 14016.25}{NRs.9289.63}$

$= 1.50$

Benefit-Cost Ratio (BCR) in Bharatpur metropolitan ward no. 11

$= \frac{Gross\ return}{Total\ cost}$

$= \frac{NRs.\ 10912.50}{NRs.\ 3096.50}$

$= 1.40$

Benefit-Cost Ratio (BCR) in Bharatpur metropolitan ward no. 15 $= \frac{Gross\ return}{Total\ cost}$

$= \frac{NRs.\ 17120}{NRs.\ 10763.26}$

$= 1.59$

The Benefit-Cost Ratio (BCR) of carrot in the study area was calculated 1.50: while the higher BCR was found in Bharatpur metropolitan ward no. 15 (1.59) than ward no.11 (1.40). This indicated that Farmers of ward no. 15 made more profit than farmers of ward no.11. The BCR of our study area was 1.50 which is higher than inorganic carrot (BCR= 1.44) and lower than of organic carrot (BCR= 1.52) (Adhikari, 2009) Moreover, a study carried in selected districts of Pakistan, estimated the benefit-cost ratio of carrot production to be 1.64 (Mahmood, 2017).

The BCR in the study area was found greater than one (>1) shows the feasibility of carrot production in Bharatpur. The BCR of NRs. 1.50 implies that; if we invest one rupee, we can get the returns of Rs 1.50. (Table 4).

Table4: Economic indicators of the carrot production

Items	Study area Amount (NRs.)	Amount in Bharatpur Metropolitan Ward No. 11 (NRs.)	Ward No. 15 (NRs.)
Total variable cost (NRs./Kattha)	9289.63	7816	10763.26
Gross return (NRs./Kattha)	14016.25	10912.50	17120
Gross margin (NRs./Kattha)	4726.62	3096.50	6356.74
Benefit-cost Ratio (BCR)	1.50	1.40	1.59

Source: Field survey, 2019

Table 5: Determinants of commercial carrot production in large scale

Variables	Coefficient	Std. Err.	t	P>t	[95% Conf. Interval]	
Age of HHH (years)	-.0060294	.0059721	-1.01	0.316	-.0179375	.0058786
Gender of HHH (@)	.3112294***	.1135559	2.74	0.008	.0848054	.5376534
Schooling of HHH (@)	.2720669**	.1165513	2.33	0.022	.0396702	.5044636
Occupation of HHH (@)	.2095892*	.1171483	1.79	0.078	-.0239978	.4431763
Access to Extension (@)	-.1874635*	.1001718	-1.87	0.065	-.3872005	.0122734
Training received (@)	-.00316	.0846259	-0.04	0.970	-.1718993	.1655792
Member of cooperatives (@)	-.1500775	.1017141	-1.48	0.145	-.3528896	.0527346
Family type (@)	-.2725401**	.118169	-2.31	0.024	-.5081625	-.0369178
Constant	.4661044	.3046819	1.53	0.131	-.141414	1.073623

Note: *, ** and *** indicate 10%, 5% and 1% level of significance

Summary Statistics

Number of observation = 80
F= 4.76
Prob > F = 0.0001
R-squared = 0.3489
Adj R-squared = 0.2755

Probit Model

A probit model was used to assess the factor influencing the commercial cultivation of carrot on large scale. Among the eight variables studied under the model Gender, Schooling, Occupation, Access to extension worker, and the family type was found to be statistically significant. It has been found that farmers who have access to extension service are more likely to cultivate carrot in a large area compared to those w without access to extension service (AITC, 2018). Agriculture as the main occupation and access to extension worker was significant at a 10% level of significance whereas the Schooling of household head and the Family type was significant at a 5% level of significance. The gender of the Household head was found significant at a 1% level of significance. The probability of cultivation on large scale was found to be 31.12% higher for those with male gender of household head and 27 % higher for those with the schooling of the household head. The age of household head, training received and member of cooperative had a negative relation with the commercial cultivation of carrot. The probability of cultivation of carrot on large scale was found to be 21% higher for the household head with agriculture as the main occupation. Access to extension workers was unlikely to cultivate carrot in a large area by 18.74%. It was found that family type was unlikely to cultivate carrot on large scale by 27.26 %.

Problems in Carrot Production

There are various problems during carrot production. To get a higher yield and maximum profit, we must find appropriate solutions. Chemical use in agriculture in recent years has led to many threats concerning the environment and human health. *Trichoderma spp.* has been used as a biocontrol agent and is gaining popularity in recent years. Among different disease in study area, fungal disease was havoc. *Trichoderma spp.* with compatible chemicals is one fungal disease management strategy which would aid in immediate action on plant pathogen and provide control over pathogens in long term as well (Pandey *et al*., 2019). The farmers have faced problems such as lack of improved varieties and chemical fertilizers, Lack of storage facilities. Splitting and Cracking were major problems found in the study area. It was found that 52. 50% of carrots were in normal condition but 26.25% and 21.25% were having cracked and splitting problems respectively. A similar study conducted in the Manahara-Kalimati corridor was found that 10 % and 15 % carrot were found cracked and splitted respectively (Bhattarai, Subedi, Gautam, & Chauhan, 2017); Table no: 6

Table 6: Problems in carrot production

Physiological disorder	value	Percentage (%)
Splitting	21	26.25
Cracking	17	21.25
Normal	42	52.50

Source: Field survey, 2019

Major Physiological disorder
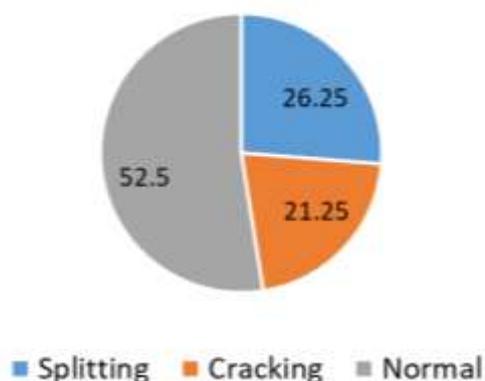

- Splitting - Cracking - Normal

Fig. 3: Diagrammatic representation of major physiological disorder problem in carrot.

Conclusion

The majority of the household of the research area is male where Brahmin/Chhetri is major ethnicity and agriculture is the main occupation in the research area. The majority of households follow the Hindu religion. The gross margin is a positive and Benefit-cost ratio (BCR) greater than one (1.50), which indicates the financial feasibility of carrot in the Bharatpur metropolitan of Nepal. Poultry manure has occupied a major portion of the cost (37.16%) among variable cost items. Seed cost has occupied the major portion of the cost of production (30.18%); better to follow the recommended seed rate which minimizes the seed cost. Moreover, Subsidy should be provided to the farmers to decrease the cost incurred by seed. The probability of cultivation of carrot on large scale is 31.12 % higher for the male gender of household head and 27% higher for the schooling of the household head. Splitting (26.25%) is identified as the most serious problem followed by cracking (21.25%) in carrot cultivation. Government, policymakers, and concerned bodies are needed to make proper coordination between them to address these problems. Extension worker must be highly mobilized to provide the knowledge of improved production practices to the farmers. Overall extension approach needs to be improved. Provide loan and subsidy for carrot producer so that they can adopt new innovation.

Authors' Contribution

N.P, H.A, B.B, M.A; designed the research plan and formulated the household questionnaire. N.P, H. A, B.B and M.A conducted household surveys and tabulated the data. S.R. analyzed the data and performed statistical tests. H.A, N.P, M.A, B.B wrote the manuscript. N.P, M.A, B.B reviewed and finalized the manuscript. All authors have read and approved the final manuscript.

Conflict of Interest

The authors declare no conflict of interest.

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