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Effects of climatic variability and soil quality on the production of large cardamom in Dhankuta

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ABSTRACT

This research was objectively carried out to assess the current status of large cardamom production, major climatic induced impact on production and challenges faced by farmers of Dhankuta district and soil fertility status. The local farmers were categorized as large, medium and small. The farmers of Majhgaun-4 of Pakhribas municipality and Namjang-6 of Chhattar Jorpati municipality growing large cardamom were selected for this study. The field work was conducted applying stratified random sampling between July to August, 2019.Total 90 questionnaire survey and 2 key informant interview were organized to collect the primary data. Total 20 soil samples were collected from 0-30 cm depth. Besides, monthly data of temperature and rainfall were collected from Department of Hydrology and Meteorology. The result showed that the average household production of large, medium and small farmers of Majhgaun-4 has been decreasing with an average rate of 0.363 ton/ha, 0.088 ton/ha 0.078 ton/ha per year respectively. Mann Kendall's tau correlation showed that there was a significant relationship of average annual temperature and average temperature of critical season of Pakhribas and Dhankuta station having R values 0.733 and 0.643 respectively. The rainfall in both the station Pakhribas and Dhankuta , was decreasing with the rate of -2.696 and -8.618 mm/year. The relation between average household production and average temperature of critical season of Majhgaun was significant. The soil fertility of Majhgaun was the best. The principal component analysis showed that the highest challenges faced by farmers was disease and followed by drought. This research will be useful for large cardamom experts.

1. Introduction

Large cardamom (*Amomum subulatum)* is native plant species to Sikkim Himalayan, Bhutan (Rabgyal & Acharya, 2018 ; Sharma et al., 2019). It is newly introduced perennial cash crop typically cultivated within an altitude about 700-2000m above mean sea level (Vijayan, 2018 ; Singh & Pothula, 2013). India is now the second largest producer and the largest exporter of large cardamom, contributing about 37% of the world's production. Every year, Nepal exports more than 95% of the production to India (Singh & Pothula, 2013 ; MoAD, 2013 ; MoAD, 2016 ; Khatiwada et al., 2019). Large cardamom production has been declining with the deficit of rainfall and increasing temperature (Sharma et al., 2016 ; Vijayan, 2018).

Many natural systems are being affected by regional climate change particularly increased temperature putting the livelihood at risk (WMD, 2002) . Such climate change and associated impacts will upset natural and human systems independently or in combination with other determinants resulting change in productivity, diversity, functions and services of many ecosystems (Bodansky, 2001; IPCC, 2013).

Similarly, soil physical and chemical properties play a vital role in vegetation growth and crop production. The increasing temperature and length of day light and sunshine alters the behavior of *Amomum subulatum*, shifting phenological events such as flowering, fruiting and leaf shading (Malla, 2009 ; Chaudhary and Vista, 2015). Different soil types have different levels of support to the plant growth. Among all nutrients, Nitrogen (N), phosphorous (P), and potassium (K) are the primary macronutrients required for the plant growth. The extent to which nutrient is available to plant is determined by the soil texture, moisture content, acidity (pH). Mobility of the nutrient in the soil depends upon the physical properties of the soil such as texture, porosity and moisture content (Vijayan, 2018). However, such types of research are very limited in Nepal. Thus this study was objectively carried out to assess trend of production of large cardamom, change in the trend of climatic parameters, soil fertility and challenges faced by farmers of Dhankuta district.

2. Materials and Methods

2.1. Study area

Dhankuta is one of the hilly district in province number 1 in Nepal. It is situated between 26°53' to 27°19' north latitude and 87°8' to 88°33' east longitude (Figure 1). The altitude ranges from around 300m to 2500m. Two particular regions were selected as the study area, Namjang ward no. 6, ChhattarJorpati, and Majhgaun ward no. 4, Pakhribas municipality. Pakhribas municipality has total population of 22078 and area of 144.29 square km. similarly, Dhankuta municipality has total population of 36619 and total area of 111 square km.

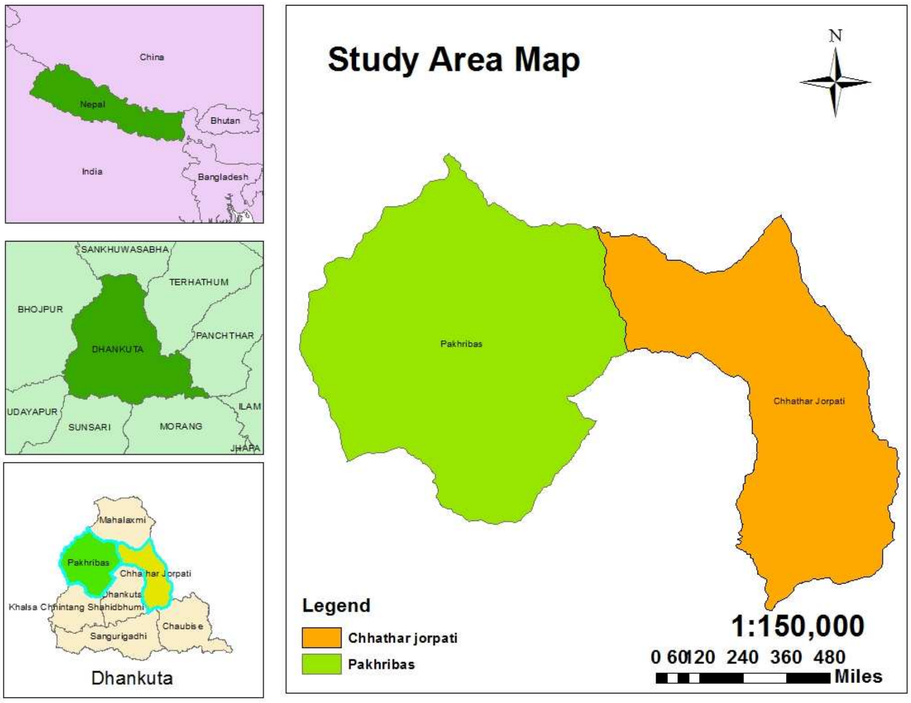

Figure 1. Study Area (Source: Field data, 2019)

2.2. Data collection

Stratified sampling method was applied to collect sample. Total 60 soil samples from 0-10, 10-20 and 20-30 cm depths, each 10 samples from Dhankuta Pakhribas sites. In addition, total 90 households were surveyed and 2 key informant interviews were done to collect the field data. Total temperature and rainfall data of 30 years were collected.

2.3. Data analysis

Soil Texture, pH, Organic matter , Total Nitrogen, Available P_2O_5 and Available K_2O were analysed using Hydrometer (Bouyoucos, 1962), Potentiometric 1:2 (Jackson 1973), Walkely and Black (Walkely& Black, 1934), Kjeldahl (Bremmer and Mulvaney, 1982), Olsen (Olsen et al., 1954) and Ammonium acetate (Jackson, 1973) methods respectively. Moreover, amount of nutrient will be classified following the classification given by NARC, Kathmandu, Nepal as mentioned on the table 1 below.

Table 1. Classification of nutrient required for plant

Classification	*Organic matter (%)*	*Total nitrogen (%)*	*Available phosphorous (kg/ha)*	*Available potassium (kg/ha)*
Very low	<1	<0.05	<10	<55
Low	1 to 2.5	0.05 to 0.1	10 to 30	55 to 110
Medium	2.5 to 5	0.1 to 0.2	30 to 55	110 to 280
High	5 to 10	0.2 to 0.4	55 to 110	280 to 500
Very high	>10	>0.4	>110	>500

The descriptive and inferential statistics was applied to analysze the collected data.

3. Results

3.1. Production of large cardamom in Dhankuta district

The production area and total production were decreasing according to year. The farmers cultivated around 335 ha and produced 230 ton with 0.687 ton/ha in 2008 which was declined only to 165 ha and produced 97 ton with 0.588 ton/ha (Table 2).

Table 2. Production trend of Large Cardamom in Dhankuta district

Year	*Productive area (ha)*	*Total Production (ton)*	*Ton /ha*
2008	335	230	0.687
2009	363	290	0.799
2010	286	175	0.612
2011	295	177	0.600
2012	295	186	0.631
2013	315	185	0.587
2014	230	135	0.587
2015	225	142	0.631
2016	275	145	0.527
2017	165	97	0.588

Source: (MoAD, 2018)

The annual production of large cardamom in Dhankuta district was decreasing with an average rate of 0.016 ton/ha which was 1.6% annually overall (Figure 2).

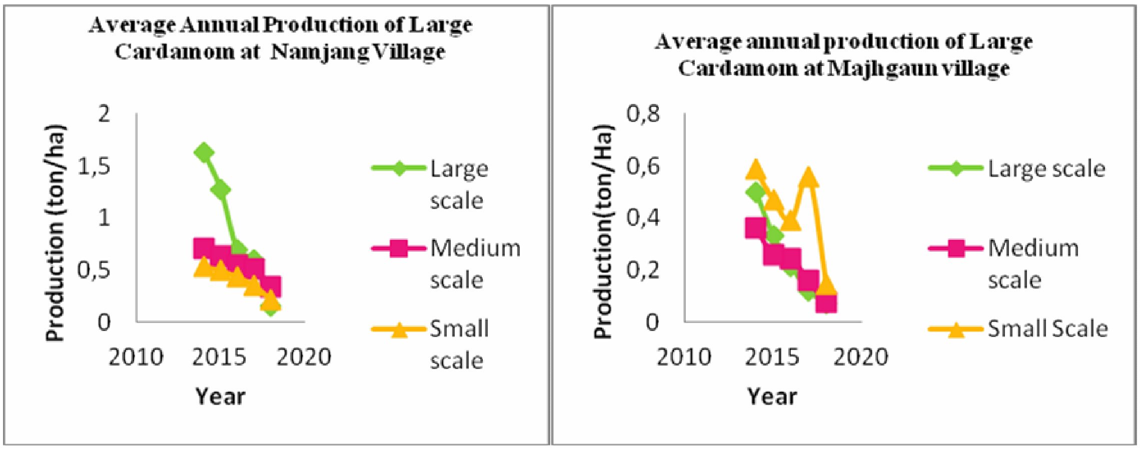

Figure 2. Average household production of Farmers in Namjang village and Majhgaun village

3.2. Crop and hazard calendar for large cardamom

Large cardamom starts flowering in mid-February and fruiting season extends up to mid- June. Depending on the altitude, climate and species, the crop matures during July to August and is harvested during September-October. This duration between flowering and fruiting (December to May) is a critical season for production of cardamom. Spikes grown in this season during January-February gives crop next year only after the maturation of one year. In recent years, farmers are facing the long drought in this critical season from December to May (winter and pre monsoon) due to the lack of winter monsoon (Table 3).

Table 3. Annual calendar of large cardamom and associated hazards

<table>
<tr><th>Month</th><th>Jan</th><th>Feb</th><th>Mar</th><th>Apr</th><th>May</th><th>June</th><th>July</th><th>Aug</th><th>Sept</th><th>Oct</th><th>Nov</th><th>Dec</th></tr>
<tr><td rowspan="2">Crop cycle</td><td>New spikes germination</td><td colspan="2">Flowering start</td><td colspan="3">Flowering & Fruiting</td><td colspan="2">Maturation/ Ripening</td><td colspan="2">Harvesting</td><td colspan="2" rowspan="2"></td></tr>
<tr><td colspan="3"></td><td>First weeding</td><td colspan="2">New plantation</td><td colspan="2"></td><td colspan="2">Second Weeding</td></tr>
<tr><td rowspan="4">Hazards</td><td colspan="5">Drought</td><td colspan="5">Landslide</td><td colspan="2"></td></tr>
<tr><td colspan="5">Aphids infection</td><td colspan="5">Water logging</td><td colspan="2"></td></tr>
<tr><td colspan="5">Mold/ Clomp Rot (Fungal disease)</td><td colspan="7"></td></tr>
<tr><td colspan="4"></td><td colspan="5">Leaf Eating Caterpillars</td><td colspan="3"></td></tr>
</table>

(Source: Field Study, 2019)

3.3. Temperature Trend

The record of average temperate of Pakhribas was increasing by 0.0324 ^{0}C which was increasing by 0.0297 ^{0}C in case of critical season of the cardamom. Mann-kendall's tau b correlation showed that there was a significant relationship between average annual temperature particularly average temperature of critical season and year having p-value was less than 0.05 and the r values were 0.449 and 0.388 respectively (Figure 3).

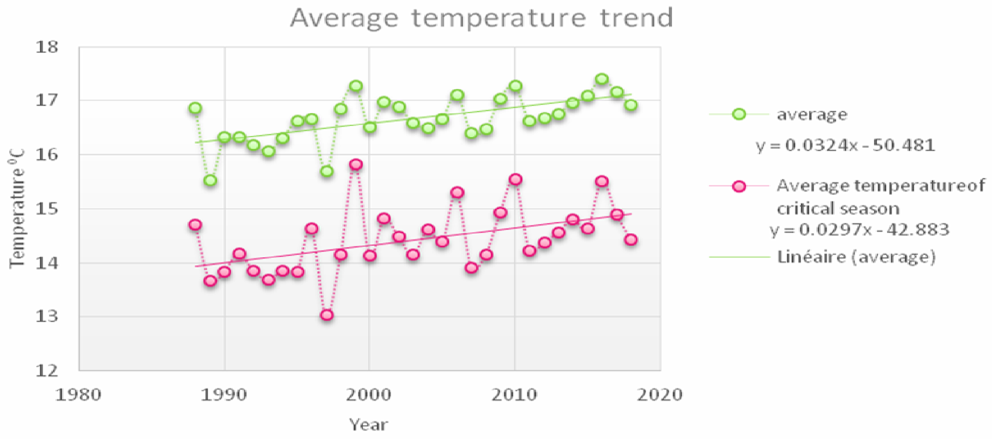

Figure 3. Temperature trend analysis of Pakhribas Station

The record of Dhankuta station showed that average annual temperature was increasing by an average rate of 0.091 °C and this of critical season was increasing with an average rate of 0.088 ^{0}C. Mann- Kendall's tau b correlation showed that there was a significant relation between average annual temperature, average temperature of critical season with year having p value less than 0.05 and r values 0.733 and 0.643 respectively (Figure 4).

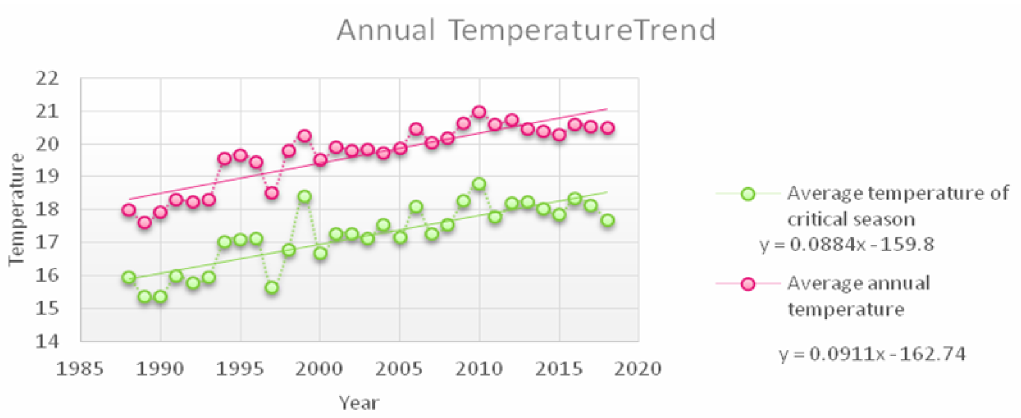

Figure 4. Temperature trend analysis of Dhankuta Station

The annual rainfall was increasing with 0.3607 mm but this of critical season was decreasing by 2.6964 mm annually. This would have obvious impact on the production of cardamom (Figure 5).

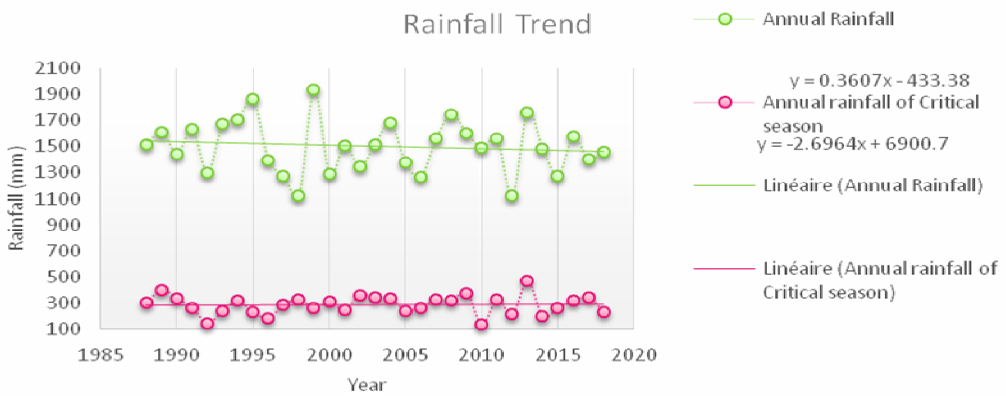

Figure 5. Annual rainfall trend in Pakhribas station

The annual rainfall was decreasing by 8.6184 mm and which was also decreasing by 0.3624 mm of rainfall in critical season. Mann- kendall's tau_b correlation showed that there was not a significant relationship between annual rainfall and year (r=-0.071) since p-value was greater than 0.05 (Figure 6).

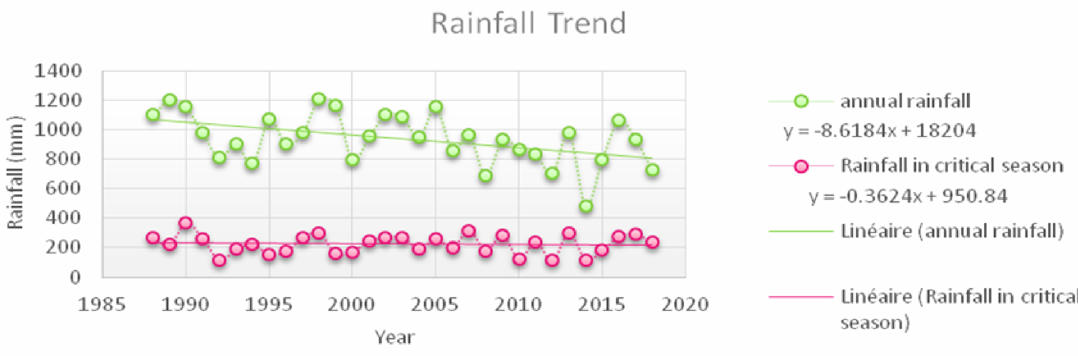

Figure 6. Annual Rainfall trend in Dhankuta station

3.4. Climatic condition and Large cardamom Production

Relation between Rainfall of Critical season and Average production of Large cardamom is shown in the figure 7.

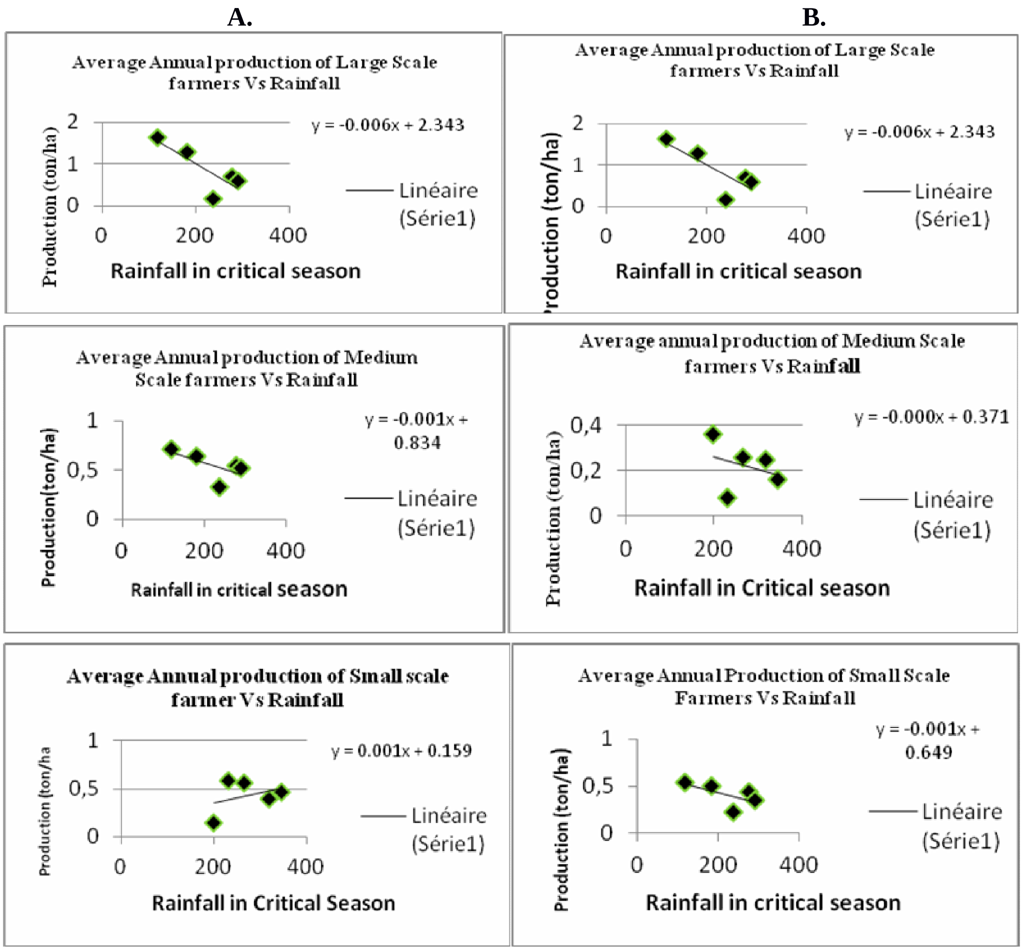

Figure 7. Graph showing the relation between the Rainfall of critical season and production of Majhgaun (A) and Namjang (B) village.

Relation between Average temperature of Critical season and Average production of Large cardamom is illustrated in the figure 8.

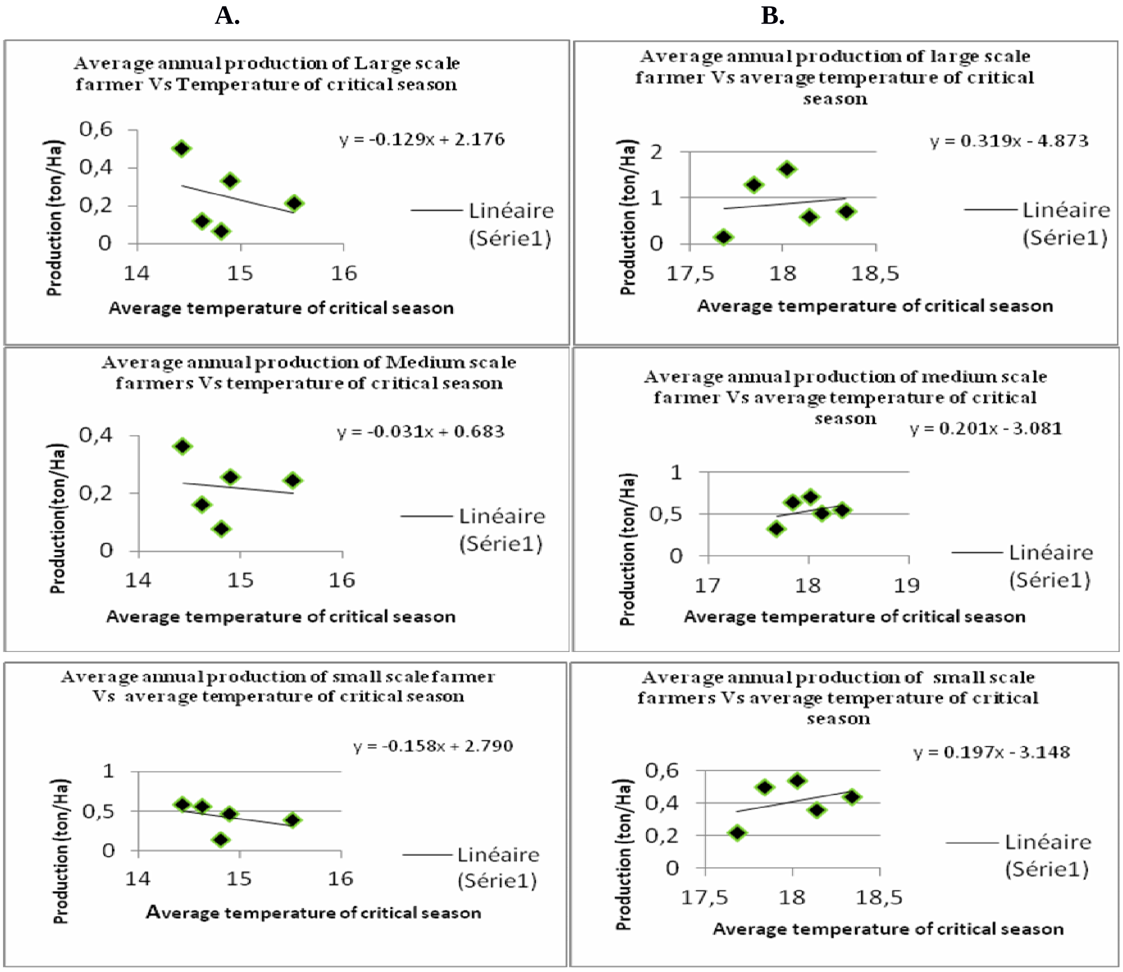

Figure 8. Graphs showing the relation between the Average temperature of critical season and production of farmers of Majhgaun (**A**) and Namjang (**B**) villages.

3.5. Soil fertility at Namjang, Chhattar Jorpati and Majhgaun, Pakhribas

The pH was higher 5.34 at Majhgaun, Pakhribas but the soil moisture percentage was just inverse to each other (Table 4).

Table 4. Soil parameter at Namjang, Chhattar Jorpati and Majhgaun, Pakhribas

Mean	*Namjang, Chhattar Jorpati*	*Majhgaun, Pakhribas*
pH	5.91	5.34
Organic matter (%)	2.771	3.524
Moisture (%)	24.13	18.46
Total Nitrogen (%)	0.071	0.098
Available Phosphorous (kg/ha)	38.384	61.341
Available Potassium (kg/ha)	274.85	283.41
Soil texture	Sandy Loam	Sandy loam

The independent t-test showed that there was significant differences Moisture (%) and Total Nitrogen (%) of Namjang, Chhattar Jorpati and Majhgaun, Pakhribas at 95% confidence level but this difference was insignificant of pH, Organic matter (%), available Phosphorous and Potash between these sites.

3.6. Soil Quality Rating (SQR)

The soil quality rating of all the sample was analyzed based upon the assigned range of values for commonly used parameters in Nepal as described by (Bajracharya, 2007). Mean value of was 1 at and 0.864 calculated (Tab.7).

Table 7. Soil quality rating

Study Area	Namjang, Chhattar Jorpati	Majhgaun, Pakhribas
SQR score	0.864	1

3.7. Challenges faced by farmers for large cardamom production

The principal component analysis showed that the highest challenges faced by farmers was disease and followed by drought.

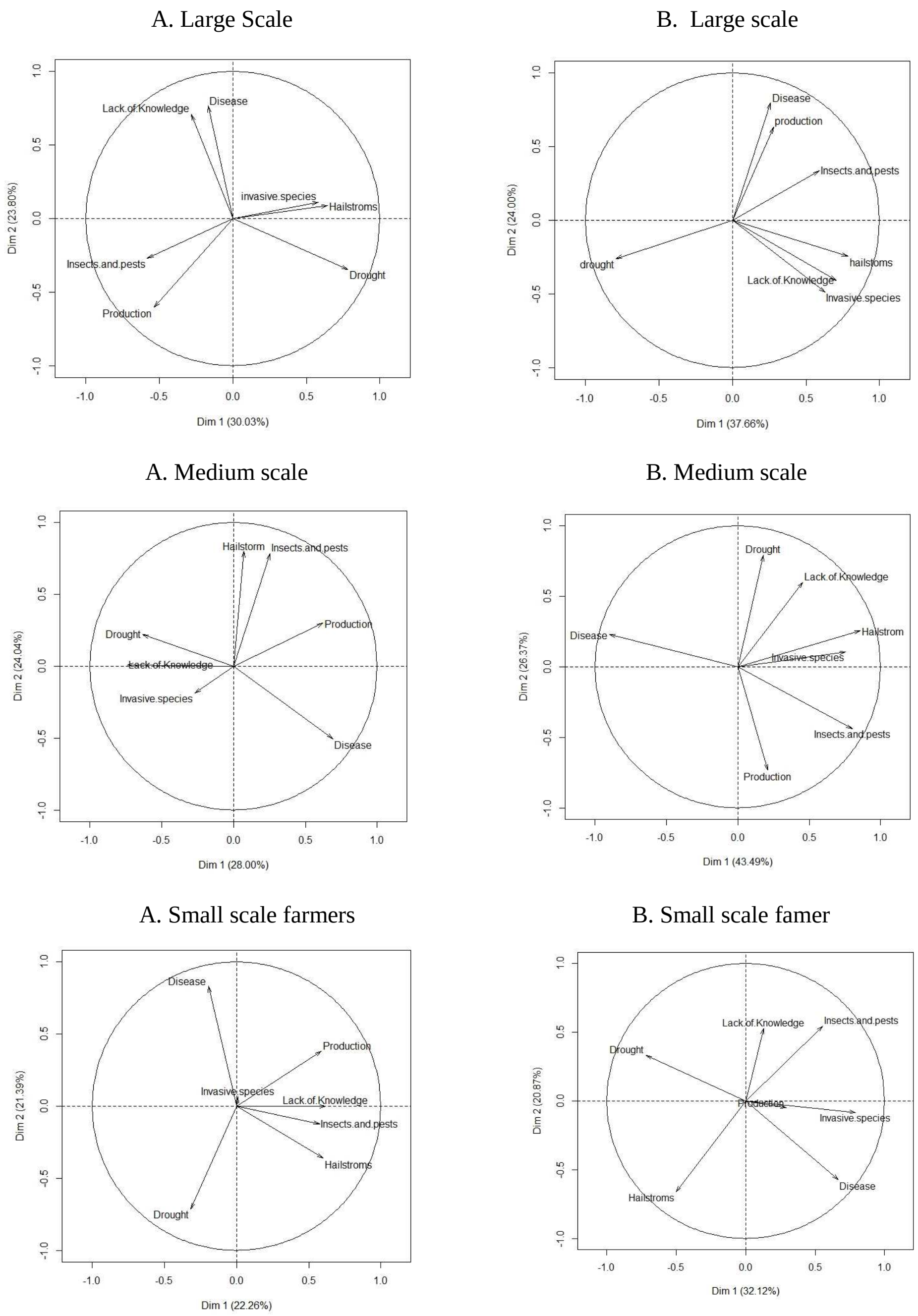

Figure 9. Challenges of farmers for production of cardamom

4. Discussion

The study related to production of large cardamom was varied in Dhankuta district. The overall production data of Dhankuta district was obtained from MoAD (2018), and the result showed that the trend was decreasing with the rate of 0.016 ton/ha which was 1.6%. The trend of average household production of Namjang showed that average household production of large cardamom of large scale farmers were decreasing with an average rate of 0.363 ton/ha per year which means an average loss of 36.3 % annually. The comparative study showed that the decreasing trend of productivity of large scale farmers was found to be higher in Namjang village than Majhgaun. The production decreased significantly and this trend has been going on from several years. Climatic and non- climatic factors might have influenced the production. The study done in the Sikkim Himalayan large cardamom also showed the similar results. Total production of cardamom in Sikkim has fluctuated in 2002, Sikkim produced a record large- cardamom yield (almost 5227 metric tonnes (t), up from 3710 t in 1999), and thus India became the largest producer worldwide, accounting for about half of the world's production. However, with the consistent decline in plantation area after 2004, production declined to 2745 t in 2008, and India dropped to second place, after Nepal. Production (Sharma et al., 2016). Viral diseases like Chirkey (Mosaic streak) and Foorkey (Bushy dwarf), incidence of pests and insects, drought, hailstorms might have resulted in the declining productivity. Some studies have also identified similar reasons.

The average annual temperature and average temperature of critical season for Pakhribas station showed an increased trend ($p < 0.05$). The average annual temperature of Pakhribas station was increasing with an annual rate of 0.029 ^{0}C per year. Similarly, the average temperature of critical season was also increasing with an annual rate of 0.032 ^{0}C per year. The trend in minimum air temperature observed in Pakhribas station was found to be not significant ($p>0.05$) however the trend showed decreasing trend. The trend of minimum air temperature was found to be significant ($p<0.05$) at Dhankuta station. The trend was found to be not significant ($p>0.05$). Likewise, the rainfall trend of both station was insignificant ($p>0.05$). These variation in climatic factors influenced crop yield.

The relation between climatic condition and large cardamom production were also studied for both regions. The study in Majhgaun showed that there was clear significant correlation between average annual production and Rainfall. Similar correlation was found between average production versus rainfall at at Namjang village. There was a contradictory result on the effects of temperature on crop yield. Our study was supported by (Chapagain, 2011) who did the similar study on large cardamom "Assessment of climate change impact on large cardamom and proposed adaptation measures in eastern hill of Nepal; A case study of Sankhuwasabha district". The result showed the positive correlation between productivity and temperature and also there was a correlation between temperature and productivity which means with an increase in temperature, the productivity was declining and with the deficit of rainfall the productivity was decreasing. And also similar studies were done on the impact of climate change on crop production. I took a further support from (Dhakal, 2014) who did the study on "Climate change and its impact on crop production, A case study of Khotang district, Nepal". Impact of climate change was studied for different plantation crop in India. Such a study on climate change and its impact on crop yields from Indian cardamom hills during 1978- 2007 were made to investigate whether there were significant changes in weather elements (Vijayan, 2018) and the study found that the deficit of rainfall in Sikkim might have impact on large cardamom production and the mean air temperature was also increasing which suggested that the environmental condition might not have been favourable for growth of plant.

Soil pH of Majhgaun was found to be lesser than Namjang. Comparative study showed that there was no significant difference between the standard soil pH obtained from soil pH of Namjang, but this was inverse at Majhgaun. The reason seems to be due to higher variation in altitude as we move into different agricultural zones. Soil texture was found to be similar from all the study sites. All the samples were classified as sandy-loamy soil. Soil sample contained 3.5242% and 2.77112% organic matter from Majhgaun and Namjang respectively. Sandy loamy type of soil is considered best for the large cardamom production (Chaudhary & Vista, 2015). Increase in temperature may activate the microbial population in the soil, thereby, leading to reduction in the level of soil organic carbon, soil micronutrients and enhance decomposition (Bajracharya et al., 2009). Soil moisture was found to be inadequate for the growth and production of large cardamom. For the better growth of plant, soil moisture should be 70% or more (Chaudhary & Vista, 2015). The changes in temperature and precipitation result in change in the availability of both surface and ground water. Relatively small changes in temperature and precipitation would have large effects on soil moisture status and the volume and timing of runoff Nepal is highly vulnerable to changing (Rijal, 2014). As drought influences plant growth via the soil water regime, effects of drought often accumulate slowly over a certain period of time (Mueller et al., 2007). Deficit of rainfall might have effect on the moisture availability on soil. Nutrient analysis showed amount of Nitrogen was low in both areas and wasn't in consistent to the standard amount of nitrogen required for agricultural land, Phosphorus and Potassium were in the range of medium to high based upon the classification given by NARC, Kathmandu, Nepal, and was in consistent to the standard amount of nutrition needed for agricultural land. Alteration in evapo-transpiration due to variability in climate and weather is major reason for change in moisture availability in the soil (Malla, 2009). Various physical and chemical parameters of the soil were analyzed and soil quality rating (SQR) was performed based upon 4 variables namely texture, pH, organic matter and fertility. The ranking values for these parameters were based upon the assigned range of values for commonly used soil parameters in Nepal (Bajracharya, 2009). The result suggested that SQR value was highest in soil sample of Majhgaun and good for the samples from Namjang. Farmers reported that they don't use any kind of fertilizers and organic manure in the cultivated land. This might be the reason behind the lowest nitrogen nutrient in both the study areas. Our study on assessment of soil quality was supported by the (Khadka, 2018) who did similar study on the "Soil fertility assessment and mapping of Chungbang farm, Pakhribas, Dhankuta, Nepal" and found that the soil is fertile enough for agriculture.

The major challenge faced by farmers of Dhankuta district was disease. Then, the second most ranked challenge was incidence of insects and pests and the third most faced challenge was drought. According to the farmers the major reason behind the declining productivity is disease and prolonged drought. Farmers of Majhgaun and Namjang have been facing lots of challenges. They do not have clear idea about overcoming the disease however ongoing research are being done related disease. Viral and fungal diseases like Chirkey, Foorkey are most common in eastern hills of Nepal. According to farmers incidence of insects and pest increase in hot and summer days. Hailstorm is also one of the major problem faced by farmers. Invasive species didn't primarily affect the crop production. It seemed to be less challenging. Due to the insufficient precipitation, farmers have been using irrigation. And for the prevention of diseases, they don't use pesticides or spray medicine. He added if this situation continues, then it will be a huge economic loss to the Nepal. Variation in temperature and rainfall have been affecting the climate and consequence is on the production (MoE, 2010, DHM, 2017).

5. Conclusion and Recommendation

The average household production of large, medium and small farmers has been decreasing annually. There was a significant relationship of average annual temperature and average temperature of critical season with production. The value ofannual and critical seasonal rainfall was decreasing. There was significant relation between annual average production of large scale and medium scale and rainfall of critical season. The soil fertility test showed that the soil of Majhgaun was found to be best for agriculture. The principal component analysis showed that the highest challenges faced by farmers was disease and followed by drought.

Intensive study should be carried to identify the appropriate reason of decreasing trend of production. The study should be extended whether variation in temperature and rainfall are the main causes of decreasing production. Farmers should be given appropriate awareness, knowledge and training to improve their production.

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