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Limited impact of climate change on seed maturation time in *Myrica esculenta Buch-Ham. Ex. D.Don in* Himalayan region

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Abstract**—** *Climate influences plant recruitment at a global scale. Asynchronized reproduction with climatic factors may lead to failure of regeneration. The object of the present study was to monitor flowering and fruiting phenology in one important under canopy forest species Myrica esculenta, Buch-Ham. Ex. D.Don of the Himalayan region. The study was undertaken at two times across a decade on similar sites 2004 and 2013. Variation in time of fruiting and flowering was insignificant between 2004 and 2013. In Yr 2004 across all the dates the fruits and seeds were bigger in size in compared to Yr 2013 but there was no significant difference in fruit size, weight of 100 fruits and number of fruits per 100g. However, seed size (P<0.01), weight of 100 seeds (P<0.05) and number of seeds per 100g (P<0.05) varied significantly in Yr 2004 and Yr 2013. In Yr 2013 maximum germination 63.33± 3.33% occurred when fruit moisture content was 69.48 ± 0.93% and moisture content of seed was 31.96 ± 0.94%. ANOVA showed that moisture content of fruit and moisture content of seed (P<0.01) varied significantly across the years whereas there was no significant difference in germination in both the years. It was apparent from the study that each species will respond differently and have its own adaptation strategy against changing climate. Generalizing, that all species will show variations in their phenophases due to climate change may be an incorrect assumption. It is evident that all species will develop their own adaptational strategies to cope with climatic irregularities.*

Keywords**— *Maturity, Phenology, Germination, Moisture content***

I. INTRODUCTION

In the past 100 years the mean temperature over the globe has increased by approximately 0.6˚C (Kerr 2004). The vulnerability of Indian Himalayan region (IHR) to global warming impact is high. Studies indicate that Himalayan forest ecosystems has been severely impacted by predicted future climate change. Even a rise in 1-2ºC, much less than the most recent projections of warming during this century will impact most ecosystems by affecting species composition, productivity and biodiversity (Ravindranath et al. 2006). Minor climatic irregularities could greatly affect future forest growth and regeneration.

Plant phenology is one of the most widely used traits to study climate change impact and has acquired a new importance because of its relation to climate change (Chapman et al. 2005). Climate has a large influence on plant recruitment (Adler & Hille Ris Lambers, 2008) and temperature and precipitation are critical drivers for plant distribution at the global scale (Woodward, 1987). Reproduction phenology is an important life history trait that influences fitness in a variety of ways. Mismatch reproducing time and season, may lead to failure in finding to match demands of growing off springs with temporal peaks in food resources (Inouye, 2008). Plants are adapted to the annual seasonal cycle and all the life cycle stages are regulated by seasonal climatic changes. It is imperative to keep record of all cyclical events, as these events can be critical to survive and reproduce (Mozai and Bhatnagar, 2005). Although several species have responded to climate changes throughout their evolutionary history, there is concern as to how different ecosystems and populations will respond to this rapid rate of climate change.

Despite several studies on the overall impact of climate change of plants the effect on plant regeneration has largely been neglected (Hedhly et al. 2009). Climate influences recruitment of plant species (Lloret et al., 2004; Fay and Schultz, 2009; Dalgleish et al. 2010; Mondoni et al. 2012). The regeneration from seeds could be enhanced, reduced or delayed due to irregularity of temperature and rainfall (Walck et al. 2011).

Myrica esculenta, Buch-Ham. Ex. D.Don occurs commonly in chir-pine (Pinus roxburghii) and banj oak (Quercus leucotrichophora) as an under canopy species (Shah & Tewari, 2010). It forms distinctive clusters preferably on

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moisten sites. *M. esculenta* is widely distributed between 900-2100m elevation from Ravi eastwards and towards Assam (Anon 1962). It is a common evergreen under canopy dioecious tree species generally attain height between 3 to 6.5m in chir pine (*Pinus roxburghii*) and banj oak (*Quercus leucotrichophora*) forests (Shah & Tewari 2010). The species produces edible wild fruits and contributes significantly in the income source of local communities in Kumaun and Garhwal Himalayan region (Dhyani and Dhar, 1994; Shah and Tewari, 2010). We monitored the flowering and fruiting phenology and seed parameters of this under canopy forest species of the Himalayan region at two times in 2004 and 2013 after a gap of one decade on similar sites to assess the impacts of warming on the phenophases of this economically important species..

II. MATERIAL & METHODS

Study site & tree characteristics: The study sites is situated in the Kumaun Central Himalaya lie between 29°8´- 29°38´ N latitude and 79°21´- 79°45´ E longitude. For the present study total 3 sites were selected. All the three sites were situated between 1480-1600 m altitude and on the south and south eastern aspect. The trees selected for seed collection had a clear bole, good crown, sufficient number of fruits and were disease free. Five average sized, healthy trees were selected and marked at a distance of about 100m from each other at each site. Diameter at 1.37 m and height of each selected individual The mean tree diameter at breast height ranged between 82.4 ± 6.11 cm and 105.6 ± 3.02 cm.

Reproductive Phenological observation: February and June is the period of high reproductive phenological activity in the species. Phenological changes were observed in M. esculenta on ten marked individuals at weekly intervals.

Seed collection and maturity parameters- Fruit collection of *M. esculenta* started from the last week of April up to the end of May from all the sites in two years, 2003 and 2014. Fruits were collected weekly intervals for the assessing the maturity time, till availability of fruits on trees. The fruits were directly collected from the tree and de-pulped in the laboratory.

The physical fruit parameters were measured by taking three replicates of 100 fruits for assessing the fruit colour, surface area of fruit (mm^2) (L×W) and weight (g). Similar parameters were determined for seeds also. Fruit/ seed weight was estimated with digital electronic balance and size with the help of a digital vernier caliper (measuring range between 1mm and 150mm)

For each collection dat moisture content of fruits/ seeds was estimated taking three replicates of 100 fruits and seeds each and expressed on fresh weight basis. The fruits and seeds were dried at 103 ± 2°C for 16 ± 1 hour (ISTA, 1993) and then reweighed.

Moisture content was calculated as-

$$MC\% = \frac{\text{Fresh weight- Dry weight}}{\text{Fresh weight}} \times 100$$

The seeds were surface sterilized with 0.1 % $HgCl_2$. For germination 4 replicates of 100 seeds each were used. Seeds were germinated on top of the paper at 25±1˚C in a seed germinator at each collection date. Seeds were counted as germinated only when visible radical was about 1mm in length. Water was added as required during the experiment. Germination percent was calculated as the total number of germinated seeds out of 100 tested seeds within the test period.

Climatic Observation: The climatic data for the year 2004 and 2013 were taken from Aryabhatt Research Centre for Observational Sciences, Nainital

III. RESULT

Climatic Observations: The mean maximum temperature in the year 2004 and 2013 did not show any major changes and remained close to 20.2˚C. However, the mean minimum temperature were lower in 2013 than in 2003 (12.1˚C in 2003 and 10.8˚C in 2013). The average rainfall was relatively higher in 2013 than 2004 by 52.4cm (Fig. 1). The climatic data of years 2004 and 2013 of the study showed no significant difference in mean maximum temperature (0.05˚C) and mean minimum temperature (1.3˚C).

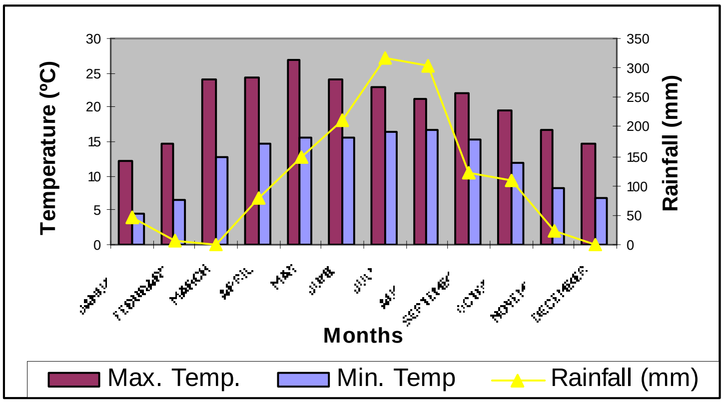

Fig.1: Temperature and rainfall data of the year 2004

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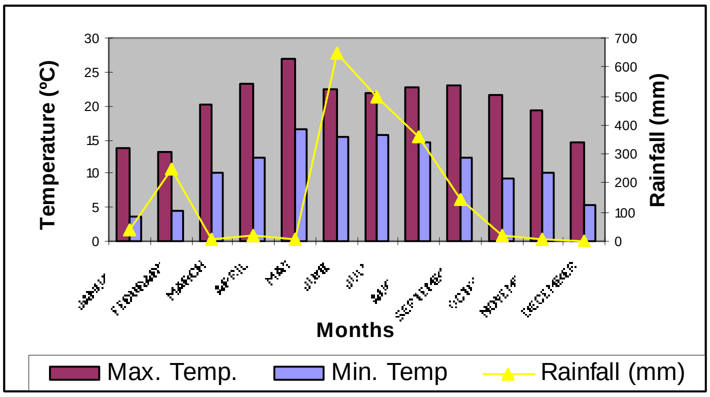

Fig.2: Temperature and rainfall data of the year 2013

Phenological Observations: In year 2004 seed fall started in fourth week of April and was complete by the second week of May whereas in Yr 2013 it started at the same time but was extended upto third week of May. Male flowers started appearing in third week of August and flowering was over by the third week of October. Male flowers appeared from August end and flowering was complete by the last week of October. Maximum flowering was observed between August end and September second week. Though in year 2004 phenological activities were earlier by five to six days but the difference in dates of phenological activities were not significant.

Seed maturity: In year 2004 across all the dates the fruits were bigger in size in compare to year 2013. At the first collection the difference between the fruit size in Yr 2004 and 2013 was 20.1mm^2 and at final collection the fruit size difference across two years was 5.7mm^2. The difference in weight of 100 fruits was 0.4g during the first collection and 6.3g at final collection. The number of fruits per 100g at first collection was 333.3±12.01 in Yr 2004 and 346.67±6.66 in Yr 2014 and at final collection it was 160 ± 11.54 and 180 ± 5.77 in the respective years (Fig. 3). Analysis of variance (ANOVA) showed that there was no significant difference in fruit size, weight of 100 fruits and number of fruits per 100g in Yr 2004 and Yr 2013.

Seeds were also bigger in year 2004 in compare to 2013. During the first collection the difference between the seed size was 10.2mm^2 and at final collection the fruit size difference across two years was 6.5mm^2. The difference in weight of 100 seeds across the years was 2.9g during the first collection and 0.07g at final collection. The number of seeds per 100g at first collection was 1000±57.7 in year 2003 and 1160±85.04 in year 2014 and at final collection it was 653.3 ± 6.66 and 667.67 ± 66.6 in the respective years (Fig. 3). Analysis of variance (ANOVA) showed that seed size ($P<0.01$), weight of 100 seeds ($P<0.05$) and number of seeds per 100g ($P<0.05$) varied significantly in Yr 2004 and Yr 2013.

In year 2004 the initial fruit moisture content was 68.3 ± 0.66% and seed moisture content was 33.2 ± 0.73%. With each collection fruit and seed moisture content declined and reached 60.5 ± 1.16% and 23.1 ± 0.97% at final collection. In Yr 2013 the initial fruit and seed moisture content was 75.10 ±0.40% and 36.95 ± 1.52% and gradually reached 67.44 ± 0.39% and 29.47 ± 0.95% at final collection (Fig. 3). In Yr 2004 maximum germination was 60 ± 5.77% when fruit moisture content was 65.4 ± 1.45% and seed moisture content was 30.4 ± 0.79%. In Yr 2013 maximum germination 63.33± 3.33% occured when fruit moisture content was 69.48 ± 0.93% and seed moisture content was 31.96 ± 0.94% (Fig 3). Analysis of variance (ANOVA) showed that fruit moisture content ($P<0.01$) and seed moisture content varied significantly across the years whereas there was no significant difference in germination in both the years.

IV. DISCUSSION

In some species germination occurs soon after seed dispersal while in others it is delayed either due to dormancy or unfavorable climate. Depending on the species forecasted, changes in ecological cues may, delay or enhance regeneration from seeds. Species show varied reaction to climatic irregularities. However the outstanding question is how the different phenophases will be impacted across the whole ecosystem under varying climate change scenarios (Houghton et al. 2001). One of the main challenges is to determine to what extent the reported correlation between seed maturation and temperature (usually the mean temperature over a fixed date period) actually indicates the causal mechanisms (Shah et al. 2013). Any change in the timing of phenological events would mean shifts in all phenological events right from initiation of flowering to fruit/ seed ripening and fall with a huge possibility of large production of infertile seeds and viability loss.(Shah et al. 2014).

There are some studies which indicate shifts in phenological activities and seed maturation time in some species of Himalayan region. Shah et al. 2014, Joshi & Joshi, 2011 and Maikhuri et al. 2003 observed early flowering in *Rhododendron arboreum* another under canopy tree species of *Quercus* forests in the Himalayan region. Shah et al. 2013 observed early maturation in *Pyracantha crenulata* over a period of eight years. However, in the present study

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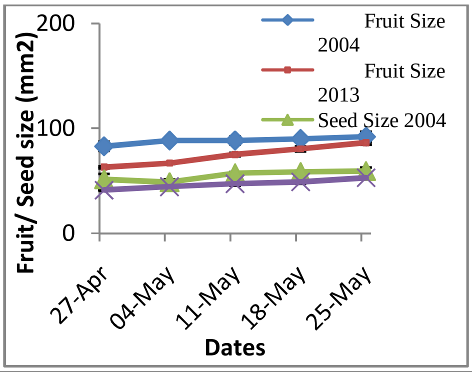
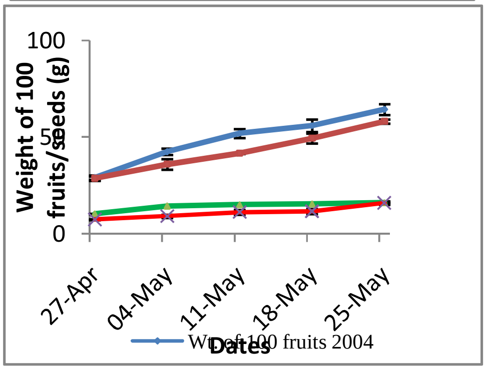
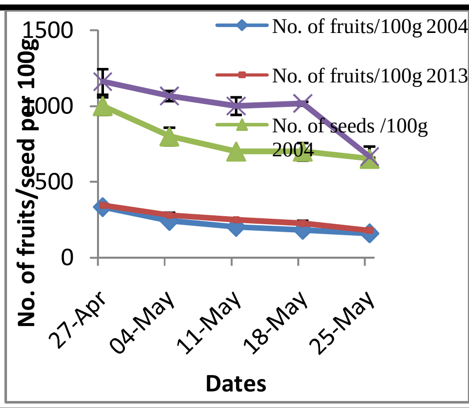
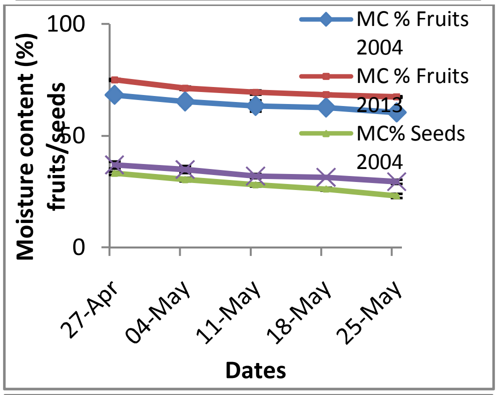
there was no significant variation in flowering, fruiting and seed maturation time in *M. esculenta* over a period of ten years. In year 2004 as well as in 2013 seed maturation took place in the second week of May though there were differences of a few days. In both the years seed maturation took place when fruit moisture content was between 65 and 70% and seed moisture content was between 30 and 32%. Similar result was also observed by Shah et al. 2010 in *Myrica esculenta* seed maturation time. Sparks et al. 2005 also observed no variation in flowering phenology of stringing nettle (*Urtica dioica*) one of the host plant of red admiral butterfly over the past two decades. It was apparent from the study that each species will respond differently and have its own adaptation strategy against changing climate. Generalizing, that all species will show variations in their phenophases due to climate change may not be apparent. The question arises which species are more prone to survive against the back drop of changing climate the ones that are adapting or the ones that more rigid and do not showing wide phenological variations. Populations may have three possible fates under rapidly changing climate: survival through migration, persistence with adaptation to face new conditions in present locations or extinction (Aitken et al. 2008). The ultimate question is which species is most likely to survive, one that is rigid and does not show adaptational traits or the ones that are highly adaptable to climate change. More studies covering several species over several years are required to answer this question.









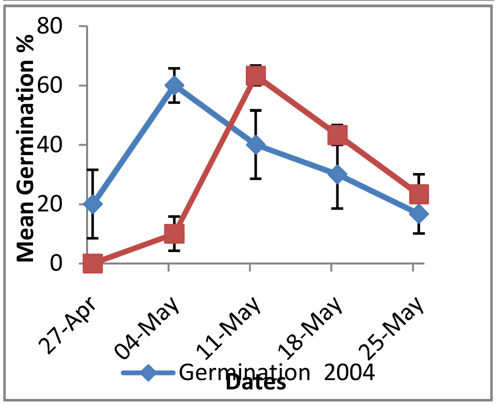


Fig .3: Variation in physical parameters of fruits and seeds and mean germination of M. esculenta over the collection period from April end to May end in years 2004 and 2013.

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