IMPACT OF ELEVATED CO_2 CONCENTRATIONS ON PREVALENCE OF MAJOR PLANT DISEASES ON SOYBEAN IN NAGPUR DISTRICT

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Abstract:
Free-air carbon di-oxide enrichment (FACE) helps to study increase carbon di-oxide on plants and ecosystems grown insitu under controlled conditions without enclosure. Study was conducted on plots prepared on agricultural land of Plant Pathology Department of Dr. P D K V'S College of Agriculture, Nagpur at GPS location 21.132238, 79.070187. Plots were sown with seeds in 10 rows of ten seeds each with a distance of 10-15cm from each other. In one plot only one type of seeds were sown. Experiment was carried out in 2017, 2018 and 2019 with sowing completed in first week of July. Simultaneously same process was followed in controlled Open Top carbon di-oxide Chambers. The soybean crop seeds are the cash crops of Vidarbha region. The above results were analyzed for vegetative growth and diseases. However, significant ($P<0.05$) negative relationship between temperature was observed with crops like, Other pulses (r^2= -.957, $P<0.05$), Groundnut kharif (r^2= -.843, $P<0.0$), Wheat (r^2= -.688, $P<0.05$) and Rabi Jowar (r^2= -.581, $P<0.05$). Thus, it may be concluded from the study results that the raising temperature has an adverse impact on the crop productivity. Furthermore, it is also evident that further studies involving more parameters should be carried out to understand in depth causality of the decline in crop productivity.

Keywords: FACE, CO_2 enrichment, OTC, diseases and soybean

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INTRODUCTION:

Free atmospheric CO_2 is only carbon source for plants. Recent increased concentration of CO_2 limits carbon di-oxide assimilation in C_3 crops with increasing carbon dioxide concentrations up to 800–1000 ppm stimulates photosynthesis (Amthor, 2001). It's reported that increased carbon di-oxide concentration does not directly translate in increased biomass, or yield. Crops such as cereals not only depend on photosynthesis but also on the length of the active phase of leaf photosynthesis and the (N) sink capacity of the grains. Fangmeier *et. al.* (2000) reported that barley (*Hordeum vulgare,* L.), carbon di-oxide increased the nitrogen (N) sink capacity of the grains but also accelerated flag leaf senescence, which, in turn, reduced the length of the period of photosynthetic.

The effects of elevated CO_2 have been simultaneously studied with non-limiting supply of water, nutrients and temperatures for crop growth. Under these controlled conditions, average yield stimulation for C_3 crops with a doubling of CO_2 has been estimated at 30%, while estimates based on results from field-scale experiments under more realistic conditions were lower. According to Kimball *et. al.* (2002), CO_2 stimulates biomass in C_3 grasses by an average of 12% grain yield in wheat (*Triticum aestivum,* L.) and rice (*Oryza sativa* L.) by 10–15% and tuber yield in potato (*Solanum tuberosum,* L.) by 28% while the yield increase in C_4 crops is much lower. Under restricted nutrient (mainly N) in free-air CO_2 enrichment (FACE) setup, a mean increase of wheat grain yield by only 7% was reported, in contrast to a higher water-limited conditions. Hence CO_2 increase wheat grain yield in water-limited plants may nearly compensate for effects of water shortage (Amthor, 2001).

Analogous to pastoralist crops, dry matter product in species of temperate champaigns on rich soils responds appreciatively to an increase in CO2. In a FACE trial, yield of imperishable ryegrass (*Lolium perenne, L.*) swards with high N- toxin input increased from 8 up to nearly 30 after 3 times and in white clover (*Trifolium repens, L.*), a legume entering N via natural N2 obsession, yield increased from 11 to 20 (*Hebeisen et.al., 1997*). Yield stimulation of a admixture of both species equalled 18, anyhow of time, fertilization position or slice frequency.

Free- air CO_2 enrichment (FACE) trials allow study of the goods of elevated CO_2 on shops and ecosystems grown under natural conditions without quadrangle (Ainsworth, 2005). The results confirm from former chamber trials light- logged carbon uptake, quotidian C assimilation, growth and above- ground product increased while specific splint area and stomatal conductance dropped in elevated CO_2. There were differences in FACE. Trees were more responsive than herbaceous species to elevated CO_2. Grain crop yields increased far lower than anticipated from previous quadrangle studies. The broad direction of change in photosynthesis and product in elevated CO_2 may is analogous in FACE and quadrangle studies, but there are major quantitative differences trees were more responsive than other functional types; C4 species showed little response and the reduction in factory nitrogen was small and largely reckoned for by dropped Rubisco. The results from this review may give the most presumptive estimates of how shops in their native surroundings and field- grown crops will respond to rising atmospheric CO_2 but indeed with FACE there are limitations, which are also bandied.

Cotrufo *et. al*., (1998) reported that elevated CO_2 and N concentration in plant tissues and data to support the hypothesis that reductions in the quality of plant tissue commonly occur when plants are grown under increased carbon di-oxide conditions. Analysis of existing reports showed an average 14% reduction of N concentrations in plant tissue grown under elevated CO_2 regimes.

Climate influences both the occurrence and the temporal and spatial distribution of plant diseases. The major factors controlling disease growth and development are temperature, light, and water; similarly, these factors affect host plant species and condition (Rosenzweig et. al., 2001; Agrios, 2005). The environment can affect plant pathogens such that survival, vigour, multiplication rate, sporulation, direction and distance of inoculum dispersal, spore germination, and penetration can be influenced (Kang et al., 2010). Plant diseases develop within a welldefined, optimal range of climatic variables (such as temperature, rainfall, relative humidity, etc.); however, the occurrence and severity of a disease in an individual plant is determined by the variation of each climatic variable within the optimal range for disease development, such that climate affects all life stages of the pathogen and host (Agrios, 2005). In general, high humidity and temperature must be favourable and cooperate in the initiation and development of plant diseases and in the germination and multiplication of fungal spores of most pathogens (Agrios, 2005). In addition, powdery mildew conidia are anomalous in their ability to germinate at low humidity. Some germinate even at 0% relative humidity (Yarwood, 1978), such as the conidia of Erisiphe (Khan et. al., 1998); the spores of Erysiphe necator germinate at temperatures of 6 to 23 °C and relative humidity of 33 to 90% (Bendek et. al., 2007). Because the response of plant pathogens to climate change varies widely, the occurrence of pathogens must be characterised as a function of temperature and humidity. Climate is becoming more extreme and unpredictable (Paul et. al., 2009), and climate change is affecting plants in natural and agricultural ecosystems (Stern, 2007). Climate change is also disrupting and altering the distribution of pests and diseases, which poses a threat to agriculture (Rosenzweig et. al, 2001; Scherm et. al, 2000; IPCC (2001); Williams and Osborne, 2009). Changes in precipitation patterns and temperature can cause severe epidemics in crops as some types of pathogens prefer others (Coakley et. al., 1999; Chakraborty, 2005; Rosenzweig and Tubiello, 2007).

If these changes create unfavorable conditions for pathogens, disease may be reduced or may not occur at all. The severity depends on the characteristics of individual pathogens and their evolution in relation to environmental factors, as well as the extent of temperature and moisture changes in agroecological areas. The range of many pathogens is limited by climatic conditions for infection and development. Studies in this direction have been conducted and in many cases geographic spread has been predicted (Chakraborty and Dutta, 2002; Baker et. al, 2000; Boshoff et. al, 2002; Evans et. al. 2008). When the host is present, pathogens with short life cycles, high reproductive rates, and effective dispersal mechanisms respond rapidly to climate change, resulting in faster adaptation to climatic conditions (Coakley et. al., 1999). Nevertheless, little research has been conducted on the effects of climate change on plant diseases in the 21st century (Garrett et. al., 2006). Therefore, future research should focus on obtaining relevant information to determine how pathogens will respond to climate change. Harvell et al. (1999) demonstrated that warm winters with high nighttime temperatures facilitate pathogen survival, accelerate vector and fungal life cycles, and promote aerial sporulation and fungal infection. In addition, the results of the aforementioned study suggest that the number of pathogens migrating northward increases as temperatures rise, making previously inhospitable areas more suitable now. Climate change will modify host physiology and resistance and alter pathogen developmental stages and rates; for example, studies by Eastburn (2010) on soybean found that elevated CO_2 and O3 caused changes in soybean crown density and leaf age. In Arabidopsis, Lake and Wade (2009) found more stomata in resistant cultivars and fewer in susceptible cultivars, and resistant cultivars become more susceptible to powdery mildew; Gregory et. al. (2007) detected no effect on potato growth or crown structure such that b-1-3 glucanase levels increased; Kobayashi et. al. (2006) found that in rice, the number of shoots per plant was increased under elevated CO_2. The most likely effect of climate change is the poleward shift in agricultural climate zones, resulting in a shift in the geographic distribution of host pathogens.

MATERIAL AND METHODS:

Study Area:

The study was conducted on 10 plots established on agricultural land of the Dr. P D K V'S College of Agriculture, Nagpur, GPS, 21.132238, 79.070187. Each plot, seeds were sown in 10 rows of 10 seeds each. The seeds were sown at a distance of 10-15 cm from each other. In one plot, only one type of seed was sown.

In 2017, 2018 and 2019, the seeds were sown in the first week of July, depending on the rainfall and climatic conditions. Simultaneously, the seeds were also sown in controlled open CO2 chambers in the Department of Plant Pathology, Dr. P D K V'S College of Agriculture, Nagpur. The seeds sown were the cash crops of Vidarbha region which was decided by conducting the survey of previous databases of Nagpur districts of Agriculture Statistical Department at and which crops are highly affected by the diseases in Vidarbha district. Soybean (Glycine max, L.) was selected as the crop.

The crops were also grown under elevated conditions such as elevated CO2 or elevated temperature or both in open CO2 chambers (OTC).

IDENTIFICATION OF PLANT DISEASES

Preliminary Diagnostic Equipment for Diseases Identification:

These include a hand lens, a sharp knife, a clear glass or jar container, a plastic container, and rubbing alcohol. A hand lens is often necessary to see fungal growth on a lesion. The knife is used to make cross-sections of the stem tissue. Clean the knife after each use with a cloth or cotton swab soaked in rubbing alcohol. The glass jar is used for the bacterial flow test, and the reservoir is used as a moisture chamber to induce fungal growth from infected tissue.

Disease Diagnostic Information and Preparation of Samples

Attempting to diagnose a disease involves several steps. First, it is almost impossible to diagnose if the plant is dead or very close to death. A good sample will contain several examples of the symptoms and ideally several samples that show how the disease is progressing in the plant. Information on how many plants are affected, when the symptoms appeared, how the disease developed in the field, and how severe it is.

Additional help is available at plant diagnostic clinics run by Dr. P. D. K. V.'s Department of Plant Pathology in Nagpur.

Isolation of Sample:

Samples were brought to the laboratory in separate sterilized polythene bags. (Alexopoulos, 1961 and Malik, 1996). The sample surface was sterilized for 3 min with 1% NaOCl and rinsed in four successive changes of sterile distilled water. The surface sterilized fruits showing symptoms of diseases were then sliced into 2mm² pieces and plated on to sterile potato dextrose agar (PDA) in Petri dishes in three replicates. The plates were incubated in an inverted position at 26-30ºC for five days.

Identification of Fungal Disease:

Identification of isolated fungi was done taking into consideration macro and micro morphological characteristics. Colonial growth aerial mycelium presence or absence colour of the colony wrinkle and ferrous presence pigment production etc. where some of the morphological characters recorded the infected tissue where observed under the compound microscope by staining them with lacto phenol or cotton blue (Barnett and Hunter, 1998).

Statistical Analysis of data

In the present study all the data generated was analysed using applicable statistical tests with the help of PASW18.0 software (formerly known as SPSS18.0). The significance position was chosen to be 0.05 (or equally, 5) by keeping in view the consequences of such an error. That to make the significance position as small as possible in order to cover the null thesis and to help, as far as possible, from inadvertently arriving at false conclusions.

RESULT & DISCUSSION:

Soybean Plant

Root Height

The **Table 6.15** illustrates the comparison between root height of soybean plant grown at ambient and elevated (by 1 to 3°C) temperature. It was evident from the data that after one week of seed germination, average root growth at ambient temperature was 23.2±1.8mm, however, the average height of soybean root at an elevated temperature (by 1 to 3°C) was 21.2±2.5mm. The comparative assessment indicated significant (P<0.05) difference in the root height after 1 wk. Furthermore, after 15 days of plantation, the average root growth at ambient temperature was 26.4±3.6mm, which was significantly (P<0.05) more than that observed (23.8±4.5 mm) at an elevated (by 1 to 3°C) temperature. In addition to this after 1 month of plantation average root growth at ambient temperature was 28.1±5.2mm, which was significantly (P<0.05) higher than that observed (25.4±8.2mm) at an elevated (by 1 to 3°C) temperature. Furthermore, after 2 months of plantation the average root growth at ambient temperature was 37.9±6.8mm, which was significantly (P<0.05) more than that observed (35.6±3.5mm) for soybean plants grown at an elevated (by 1 to 3°C) temperature. It was apparent from the comparative assessment of the data that there was a significant (P <0.05) difference in the root height of soybean plant grown at ambient temperature and elevated temperature **(Fig.6.11)**. Thus, it may be concluded from the experimental data that there was an increase in the root height at higher temperature for the soybean plants.

Shoot Height

The **Table 6.16** shows the comparison between shoot height of soybean plant grown at ambient and elevated temperature. It was evident from the data that after one week of seed germination, average shoot growth at an ambient temperature was 35.3±3.2mm, however, the average height of soybean shoot at an elevated temperature (by 1 to 3°C) was 33.1±4.0mm. The comparative assessment indicated remarkable (P<0.05) difference in the shoot height after 1 wk of plantation. Furthermore, after 15 days of plantation, the average shoot growth at ambient temperature was 39.1±4.8mm, which was significantly (P<0.05) higher than that observed (36.4±15.8mm) at an elevated (by 1 to 3°C) temperature. In addition to this after 1 month of plantation average shoot growth at ambient temperature was 42.6±2.1mm, which was significantly (P<0.05) higher than that observed

(38.5±6.1mm) at an elevated (by 1 to 3°C) temperature. Furthermore, after 2 months of plantation the average shoot growth at ambient temperature was 48.8±6.2 mm, which was significantly ($P<0.05$) different than that observed (45.0±2.9mm) for soybeanplants grown at an elevated (by 1to 3°C) temperature. It was apparent from the comparative assessment of the data that there was no significant difference in the shoot height of soybean plant grown at ambient temperature and elevated temperature **(Fig.6.12)**. Thus, it may be concluded from the experimental data that there was no noticeable change in the shoot height at higher temperature for the soybean plants.

Total Height

The **Table 6.17** indicates the comparison between total height of soybean plant grown at ambient and elevated temperature. It was evident from the data that after one week of seed germination, average total growth at an ambient temperature was 55.1±5.2 mm, however, the average total height of soybean at an elevated temperature (by 1 to 3°C) was 54.3±4.7mm. The comparative assessment indicated no significant difference in the total height after 1 wk. Furthermore, after 15 days of plantation, the average total growth at ambient temperature was 66±4.7mm, which was significantly ($P<0.05$) higher than that observed (63.2±16.9mm) at an elevated (by 1 to 3°C) temperature. In addition to this after 1 month of plantation average total growth at ambient temperature was 68.4±6.2mm, which was moderately higher than that observed (63.9±13.5mm) at an elevated (by 1 to 3°C) temperature. Furthermore after 2 months of plantation the average total growth at ambient temperature was 83.4±7.1mm, which was significantly ($P<0.05$) more than that observed (80.6±4.2mm) for soybean plants grown at an elevated (by 1 to 3°C) temperature. It was apparent from the comparative assessment of the data that there was significant ($P <0.05$) difference in the total height of soybean plant grown at ambient temperature and elevated temperature **(Fig.6.13)**. Thus, it may be concluded from the experimental data that there was decrease in the total height at higher temperature for the soybean plants

Biomass

The **Table 6.18** shows the comparison between biomass of soybean plant grown at ambient and elevated temperature. It was evident from the data that after one week of seed germination, average biomass at an ambient temperature was 9.2±2.1g; however, the average biomass of soybean at an elevated temperature (by 1 to 3°C) was 8.9±1.6g. The comparative assessment indicated no significant difference in the biomass after 1 wk. Furthermore, after 15 days of plantation, the average biomass at ambient temperature was 15.2±2.3g, which was significantly ($P<0.05$) higher than that observed (13.4±2.7g) at an elevated (by 1 to 3°C) temperature. In addition to this after 1 month of plantation average total growth at ambient temperature was 16.1±3.1g, which was significantly ($P<0.05$) higher than that observed (13.4±8.9g) at an elevated (by 1 to 3°C) temperature. Furthermore after 2 months of plantation the average total growth at ambient temperature was 18.4±4.5g, which was significantly ($P<0.05$) more than that observed (16.0±1.0g) for soybean plants grown at an elevated (by 1 to 3°C) temperature. It was apparent from the comparative assessment of the data that there was significant ($P <0.05$) difference in the biomass of soybean plant grown at ambient temperature and elevated temperature **(Fig.6.14)**. Thus, it may be concluded from the experimental data that in general there was a decrease in the biomass at higher temperature for the soybean plants.

Conclusions drawn on the basis of data obtained from the Farmers of Study region

The **Table 6.19** shows responses of farmers regarding the effect of change in climate on plant yield. It was evident from the responses that according to 77.5% farmers climate change adversely affect the plant yield. 13% farmers indicated that plant yield was affected due to climate change. However, 9.5% farmers indicated that the plant yield will be unaffected due to change in climate. It apparent from the information that according to significantly ($P<0.05$) high percentage of farmers the plant yield adversely affected due to change in climate

It was observed that a significantly ($P<0.05$) high percentage of farmers indicated that the climate change has adversely affected the crop yield **(Fig.6.15)**.

CONCLUSION

In the present study the data pertaining to the crop productivity for the study region was obtained from the Govt. offices. Upon receipt of the data it was processed to determine the relationship between the variables i.e. crop productivity and the temperature. The results obtained after performing Pearson Correlation Coefficient analysis are presented in following **Table**. It was evident from the results that in general there was negative relationship between the crop productivity and the temperature. However, significant ($P<0.05$) negative relationship between temperature was observed with crops like, Other pulses (r^2= -.957, $P<0.05$), Groundnut kharif (r^2= -.843, $P<0.0$), Wheat (r^2= -.688, $P<0.05$) and Rabi Jowar (r^2= -.581, $P<0.05$). Thus, it may be concluded from the study results that the raising temperature has an adverse impact on the crop productivity. Furthermore, it is also evident that further studies involving more parameters should be carried out to understand in depth causality of the decline in crop productivity.

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CONFICT OF INTEREST:
As far as this study is considered authors have no conflict of Interest. Authors have not received any type of grants for conducting above

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Time Period	Temperature	Mean Root Height	SD	MD	t'	P
After 1 Wk	Ambient	23.2		-1.0	3.162	<0.05
	Elevated (by 1 to 3 degree celsius)	24.2	2.5			
After 15 days	Ambient	26.4		-2.4	3.886	<0.05
	Elevated (by 1 to 3 degree celsius)	28.8	4.5			
After 1 Month	Ambient	28.1		-2.3	4.101	<0.05
	Elevated (by 1 to 3 degree celsius)	30.4	8.2			
After 2 Months	Ambient	35.6		-2.3	3.336	<0.05
	Elevated (by 1 to 3 degree celsius)	37.9	3.5			

Table 6.15: Comparative assessment of root height of soybean plants grown in ambient and elevated temperatures in agricultural land of Nagpur District.

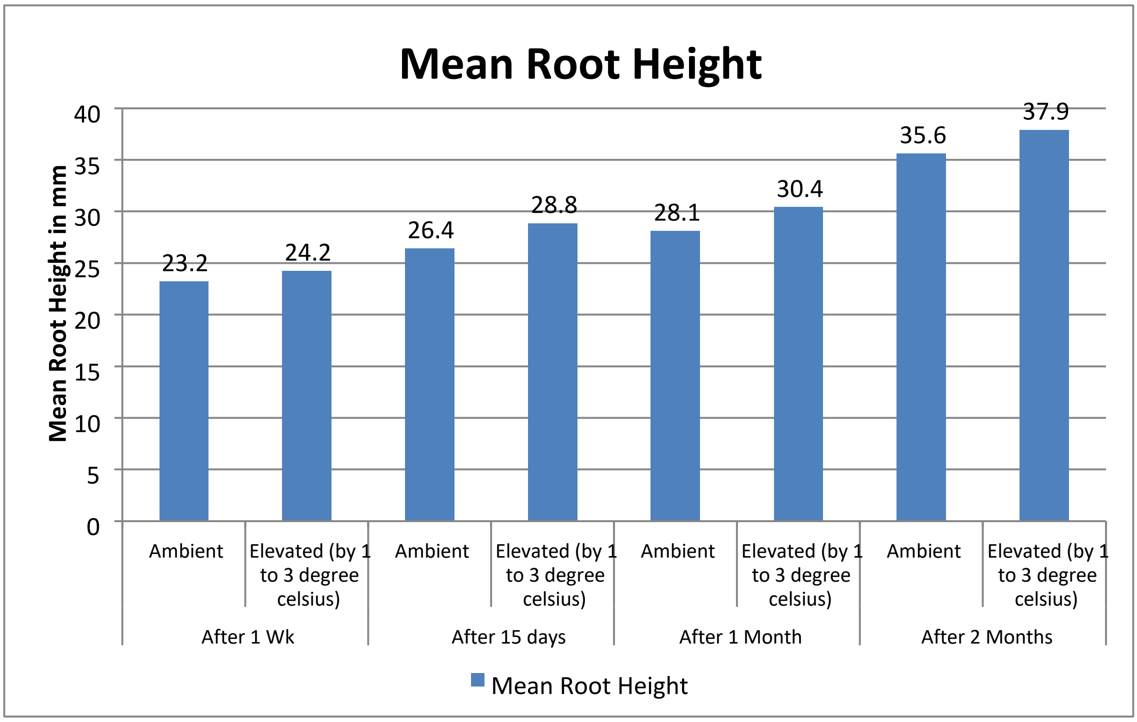

Fig.6.11: Mean Root Height of Soybean Plant

Time Period	Temperature	Mean	SD	MD	t'	P
After 1 Wk	Ambient	35.3	±3.2	2.2	3.116	<0.05
	Elevated (by 1 to 3°C)	33.1	±4.0			
After 15 days	Ambient	39.1	±4.8	2.7	4.234	<0.05
	Elevated (by 1 to 3°C)	36.4	±15.8			
After 1 Month	Ambient	42.6	±2.1	4.1	6.253	<0.05
	Elevated (by 1 to 3°C)	38.5	±6.1			
After 2 Months	Ambient	48.8	±6.2	3.9	5.625	<0.05
	Elevated (by 1 to 3°C)	45.0	±2.9			

Table 6.16: Comparative assessment of shoot height of soybean plants grown in ambient and elevated temperatures in agricultural land of Nagpur District.

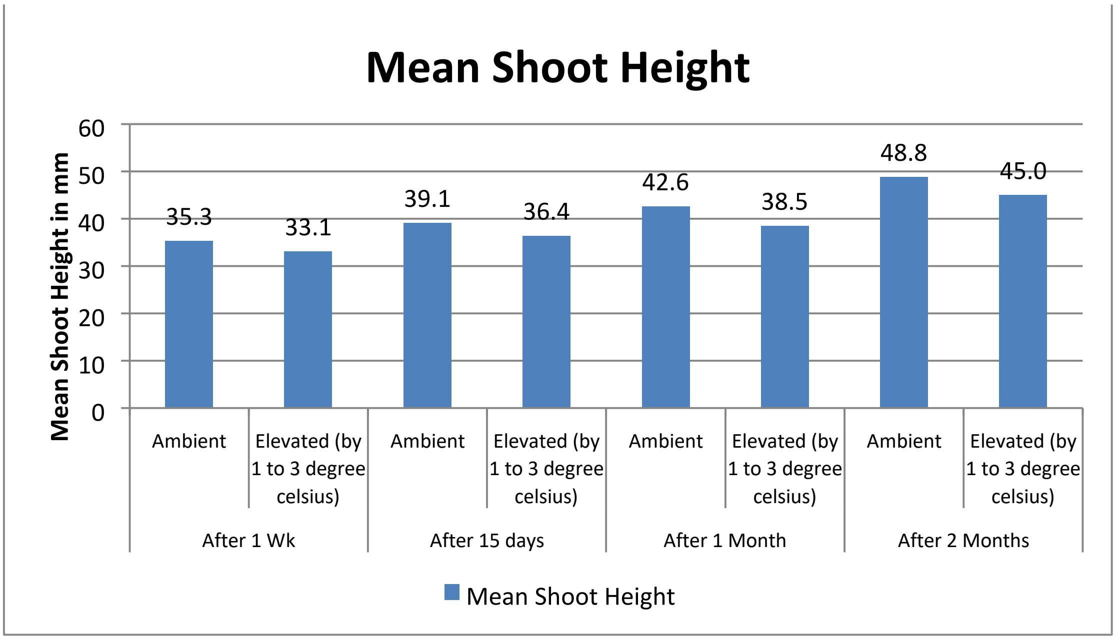

Fig.6.12: Mean Shoot Height of Soybean Plant

Time Period	Temperature	Mean	SD	MD	t'	P
After 1 Wk	Ambient	55.1	±5.2	0.8	1.223	NS
	Elevated (by 1 to 3°C)	54.3	±4.7			
After 15 days	Ambient	66	±4.7	2.8	3.124	<0.05
	Elevated (by 1 to 3°C)	63.2	±16.9			
After 1 Month	Ambient	68.4	±6.2	4.5	6.532	<0.05
	Elevated (by 1 to 3°C)	63.9	±13.5			
After 2 Months	Ambient	83.4	±7.1	2.8	3.124	<0.05
	Elevated (by 1 to 3°C)	80.6	±4.2			

Table 6.17: Comparative assessment of total height of soybean plants grown in ambient and elevated temperatures in agricultural land of Nagpur District

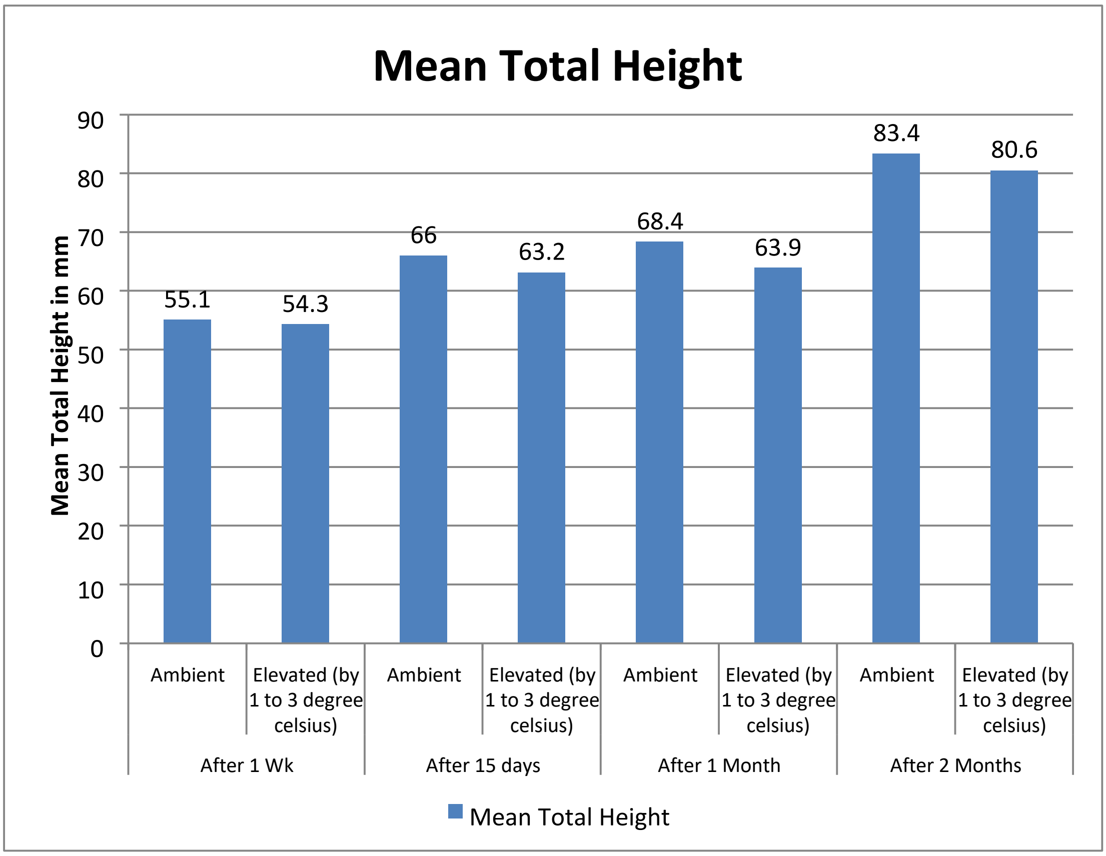

Fig.6.13: Mean Total Height of Soybean Plant

Time Period	Temperature	Mean	SD	MD	t'	P
After 1 Wk	Ambient	9.2	±2.1	0.3	0.449	NS
	Elevated (by 1 to 3°C)	8.9	±1.6			
After 15 days	Ambient	15.2	±2.3	1.8	2.988	<0.05
	Elevated (by 1 to 3°C)	13.4	±2.7			
After 1 Month	Ambient	16.1	±3.1	2.7	3.896	<0.05
	Elevated (by 1 to 3°C)	13.4	±8.9			
After 2 Months	Ambient	18.4	±4.5	2.4	3.212	<0.05
	Elevated (by 1 to 3°C)	16.0	±1.0			

Table 6.18: Comparative assessment of Biomass of soybean plants grown in ambient and elevated temperatures in agricultural land of Nagpur District

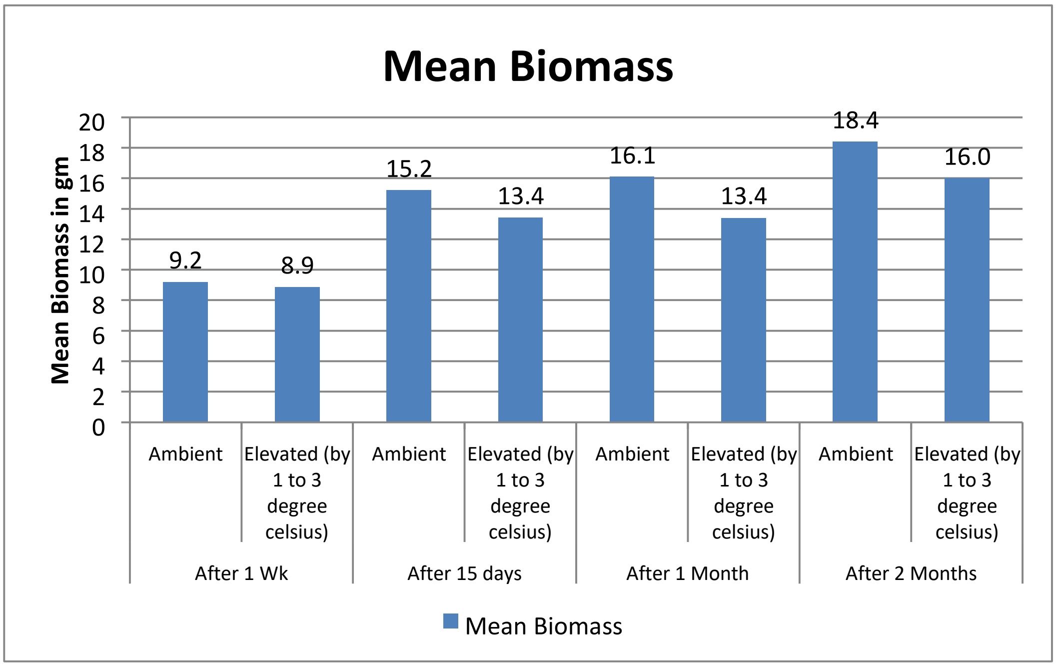

Fig.6.14: Mean Biomass of Soybean Plant

Effect	Frequency	Percentage
Unaffected	19	9.5
Affected	26	13.0
Adversely Affected	155	77.5
Total	200	100

Table 6.19: Responses of farmers regarding effect of change in climate on plant yield

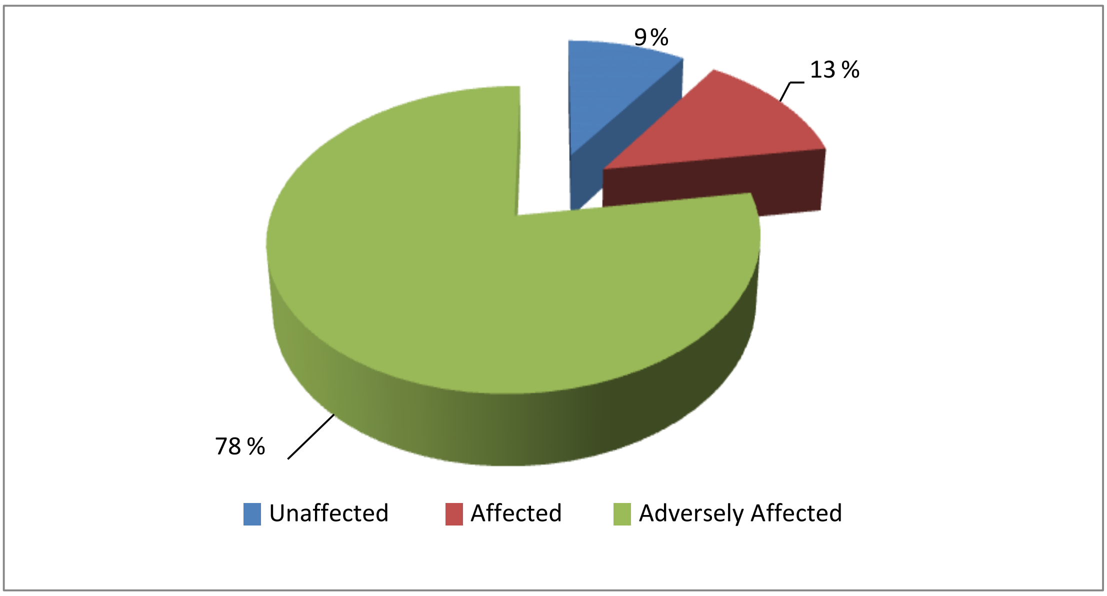

Fig.6.15: Effect of change in climate on plant yield