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Evaluation of Biotic and Abiotic Stresses in Cereal and Vegetable Crops of Himachal Pradesh

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ABSTRACT

The findings of a study on evaluation of biotic and abiotic stress in major cereal and vegetables carried out in most vulnerable district Mandi of Himachal Pradesh reveal that all the biotic factors collectively accounted for a economic loss of worth Rs 78763 (62.82%) per ha while the inadequate and untimely availability of the most important abiotic input, the irrigation water caused loss of Rs 46613 (37.18%) per ha in the study area. The total economic loss due to biotic and abiotic stress was estimated at Rs 183984 per ha in Zone I followed by Rs 137097 and Rs 28910 per ha in zone III and Zone II, respectively with overall average of Rs 125376. The loss occurred due to biotic stress was higher in all the zones and it varied from 62.61 per cent in zone I to 79.62 per cent in Zone II with an average of 62.82 per cent. However, the economic loss per ha on account of abiotic stress in zone I, zone II and zone III was estimated at Rs 68800 (37.39%), Rs 5891 (20.38%) and Rs 43771 (31.93%), respectively. The higher absolute loss in zone I was due to the large scale cultivation of tomato (30.98% of cropped area) in K*harif* and cauliflower (33.97% of cropped area) in R*abi* season as cash crops perishable in nature and prone to insect pest and diseases. The findings, therefore, invite the attention of breeders to develop improved cultivars having less water requirement and resistant to climatic stresses especially for maize, cucumber, cauliflower, tomato, etc.

1. Introduction

India has many reasons to be concerned about the impacts of climate change because of the dependence of its large population on climate-sensitive farming for their livelihood. Presently, agriculture is facing ecological and economic challenges and population of developing nations such as India is likely to be most seriously affected as agriculture is extremely vulnerable to climate change. It is believed that agriculture and human well being will be negatively affected by the climate change (Anonymous 2008; Nelson et al. 2009). The major effects can be generalized as changes in the geographical limits to agriculture, changes in crop yields and impacts on agricultural system. While, the magnitude of impact varies greatly by regions, climate change is expected to impact agricultural productivity, cropping patterns, incidence of insect pest/diseases, availability of irrigation water and genetic diversity (Suryaprakash 2011; Kumari et al. 2012; Alam, 2013; Javeed and Manuhaar, 2013; Arumugam et al. 2014; Mahato 2014; Kambrekar et al. 2015). To mitigate adverse impacts, adaptation has a significant role on farm productivity as well as net revenue. According to Smit and Skinner 2002; Lema and Majule 2009; Falco et al. 2011; Akinnagbe and Irohibe 2014 most of the adaptation options were modifications to ongoing farm practices. The common strategies used were use of resistant varieties, crop diversification, changes in cropping pattern and improving irrigation efficiency

Himachal Pradesh is a mountainous state in the North-Western Himalayas with diverse agro-climatic conditions and altitude ranging from 350 to 7000 meters above mean sea level. About 90 per cent of the total population of the state depends upon agriculture for their livelihood. Also, agriculture plays a vast role in the socio-economic development of the people of the state. This sector contributes around 13 per cent to the Gross State Domestic Product (GSDP) in 2020-21 and provides direct employment

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to around 60 per cent of total work force of the state as per Economic survey of Himachal Pradesh of 2020-21. During the last decade the changes in global climate have adversely affected the potential areas of the state and continuously caused changes in cropping systems of the state. Although these changes may cause gains in some crops in some regions of the state, yet the overall impacts of climate change on agriculture are expected to be negative, threatening food security to the people of the state. Keeping the above background in view, a study was carried out mainly to assess the physical and economic losses occurred to major cereals and vegetables on account of biotic and abiotic stress impacting livelihood of the farmers in Mandi district of H.P

2. Methodology

Mandi district of Himachal Pradesh showing highest vulnerability due to erratic rainfall, number of rainy days, the geographical area, agriculture related characteristics such as irrigation facilities etc (Ratna, 2017) was selected to assess the impact of climate change on agrarian economy as the study area for the collection of primary data. This district falls in the three agro climatic zones *viz.* low hill montane sub tropical zone (Zone I), mid-hill sub humid zone (Zone II) and high hill temperate wet zone (Zone III) of Himachal Pradesh. A random sample of six villages (two from each zone) was selected and further a random sample of 25 farmers from each village comprising 50 from each zone and 150 from the study area through equal allocation method for detailed analysis was selected. For the collection of village level data, two key informants forming a total of 12 were chosen for the study. The primary data over a decade for the agricultural years 2004-05 and 2014-15 were collected on well designed and pre-tested schedules by personal interview method. The information includes physical and economic losses to crops due to various biotic and abiotic factors. The data were analysed using tabulation technique.

3. Results and Discussion

Physical crop losses due to biotic stress

Physical crop losses due to various biotic components like disease, insect-pest, stray & wild animal, bird attack and weeds infestation pose a major threat directly to production, productivity and indirectly to incomes and food security of rural families. The crop losses accruing on account of climate change might be in the form of disease and insect-pest attack. These losses, however, can be avoided by implementing proper crop rotations, chemical treatments and by using other adaptation strategies. Therefore, an attempt was made to understand and quantify various biotic losses. The results of such losses have been presented in Tables 1 to 3. Percentage losses in production of important cereals and vegetables due to various biotic factors across zones of the study area have been separately presented in Table 1 and 2 respectively. It can be seen from the Table 1 that on overall farm situation with 1.22 ha cropped area, the percentage loss due to disease incidences (DI) in cereals ranged from 1.28 per cent in barley to 11.16 per cent in wheat. The losses due to insect-pest attack (IPA) were found to be highest in maize crop (9.25 %) followed by wheat (4.48%) crop. As far as losses due to animal and bird attack (ABA) are concerned, these were found to be highest in maize (17.92%) followed by wheat (7.53%) and paddy (4.94%). Losses due to weeds infestation (WI) were observed to be low (below 1 %) for all crops in the study area. Rice was grown in zone I and zone II only and the weeds infestation problem was successfully controlled by chemical treatment. In other crops such as maize, wheat and barley, the farmers were adopting adequate measures against weed infestation right from sowing of the crop. As far as zone I is concerned, the disease incidence caused highest losses in wheat crop (11.90%) followed by rice (9.80%) and maize (6.30%). The losses due to insect-pest attack were found to be highest in maize (5.30%) followed by rice (3.34%) and wheat (3.16%). Further, no loss due to weed infestation in crops was reported on sample farms of zone I of the study area. As far as zone II is concerned, the disease incidence caused highest losses in wheat crop (13.76%) followed by rice (7.50%) and maize (6.44%). The losses due to insect-pest attack were found to be highest in maize (8.12%) followed by wheat (6.08%) and rice (4.80 %). Further, the losses due to stray & wild animal and bird attack were observed to be ranging from around 8 per cent in rice to as high as 25 per cent in maize of zone II of the study area. Further, loss due to weed infestation was found to be 0.30 per cent and 0.50 per cent for wheat and barley crops, respectively in zone II of the study area. In zone III of the study area, the disease incidence caused highest losses in maize (8.46%) and wheat (7.80%). The losses due to insect-pest attack were found to be highest in maize (14.34%) followed by barley (5.64%). Further, the losses due to stray & wild animal and bird attack were observed to be 22 per cent in maize of zone III of the study area. Further, no loss was reported due to weed infestation in any of the cereal crops of zone III.

Percentage losses in production of vegetables due to various biotic factors across zones of the study area are presented in Table 2. It can be seen from the table that on overall sample farm situation, the percentage loss due to disease incidence (DI) in vegetables ranged from lowest of 1.45 per cent in cucumber to 5.88 per cent in other vegetables. The losses due to insect-pest attack (IPA) were found to be highest in other vegetables such as pea, brinjal, spinach, frenchbean, chilli, potato, etc (4.87 %) followed by tomato (2.77 %) and cauliflower (2.08 %). As far as losses due to animal and bird attack (ABA) is concerned, it was

found to be highest in other vegetables (2.75 %) while in all other vegetables almost negligible amount of percent losses was estimated. No losses due to weeds infestation (WI) were observed to be there in any vegetable of the study area. This may be due to the reason that farmers were following adequate measures and cultural practices to ward against weeds infestation because of their cash earning nature. As far as zone I is concerned, the disease incidences caused highest losses in tomato crop (7.86 %) followed by other vegetable (4.51 %), cucumber (4.36 %) and cauliflower (3.80 %). Thus it can be inferred that the diseases caused 4 per cent to 8 per cent losses in zone I of the study area. The losses due to insect-pest attack were found to be highest in tomato (5.10 %) followed by cucumber (3.26 %) and other vegetables (3.21 %). Further, the losses due to animal and bird attack were again observed to be less than 1 per cent in zone I of the study area. Further, no loss due to weed infestation in crops was noticed on sample farms of zone I of the study area. As far as zone II is concerned, the only losses due to insect-pest incidences were observed to be in other vegetables and these were almost negligible (0.30 % of the total crop production). In zone III of the study area, the disease incidences caused highest losses in other vegetables (13.14 %) followed by tomato (5.00 %) and cauliflower (4.00 %). The losses due to insect-pest attack were found to be highest in other vegetables (11.10%) followed by tomato (3.20 %) and cauliflower (2.90 %). Further, the losses due to animal and bird attack were observed to be ranging from 0.30 (tomato crop) to 8.24 per cent (other crops) of the total vegetable production in zone III of the study area. No loss due to weed infestation was reported in any of the vegetable crop of zone III.

Table 1. Physical losses due to biotic stress in cereals across zones on sample farms

(q / farm)

Sr. No.	Crops/biotic factors	Zone I (1.94 ha)	Zone II (0.90 ha)	Zone III (0.90 ha)	All Zones (1.22 ha)
I	**Rice**				
1.	Disease incidence	0.439 (9.80)	0.245 (7.50)	N.A. (-)	0.149 (5.76)
2.	Insect-pest attack	0.150 (3.34)	0.156 (4.80)	N.A. (-)	0.070 (2.72)
3.	Animal and bird attack	0.302 (6.74)	0.264 (8.10)	N.A. (-)	0.127 (4.94)
4.	Weed infestation	N.A. (-)	N.A. (-)	N.A. (-)	N.A. (-)
II	**Maize**				
1.	Disease incidence	0.108 (6.30)	0.132 (6.44)	0.316 (8.46)	0.177 (7.07)
2.	Insect-pest attack	0.091 (5.30)	0.166 (8.12)	0.535 (14.34)	0.231 (9.25)
3.	Animal and bird attack	0.113 (6.55)	0.515 (25.14)	0.822 (22.04)	0.448 (17.92)
4.	Weed infestation	0.002 (0.10)	N.A. (-)	N.A. (-)	0.001 (0.03)
III	**Wheat**				
1.	Disease incidence	0.632 (11.90)	0.736 (13.76)	0.167 (7.80)	0.477 (11.16)
2.	Insect-pest attack	0.168 (3.16)	0.325 (6.08)	0.090 (4.20)	0.191 (4.48)
3.	Animal and bird attack	0.276 (5.20)	0.631 (11.80)	0.120 (5.60)	0.322 (7.53)
4.	Weed infestation	N.A. (-)	0.016 (0.30)	N.A. (-)	0.004 (0.10)
IV	**Barley**				
1.	Disease incidence	0.001 (0.70)	0.001 (0.40)	0.036 (2.74)	0.008 (1.28)
2.	Insect-pest attack	0.001 (0.60)	0.001 (0.10)	0.036 (5.64)	0.008 (2.11)

3.	Animal and bird attack	N.A. (-)	N.A. (-)	0.120 (9.22)	0.018 (3.07)
4.	Weed infestation	N.A. (-)	0.002 (0.50)	N.A. (-)	0.001 (0.16)

Note: DI=Disease incidence, IPA= Insect-pest attack, ABA= Animal and bird attack and WI= Weed infestation; and
G I = Group I, G II = Group II and AF = All farms
Figures in parentheses are the percentages of the losses in the respective category

Table 2. Physical losses due to biotic stress in vegetables across zones on sample farms

(q / farm)

Sr. No.	Crops/biotic factors	Zone I (1.94 ha)	Zone II (0.90 ha)	Zone III (0.90 ha)	All Zones (1.22 ha)
I	**Cauliflower**				
1.	Disease incidence	6.041 (3.80)	N.A. (-)	0.124 (4.00)	1.405 (2.60)
2.	Insect-pest attack	4.674 (2.94)	N.A. (-)	0.090 (2.90)	1.124 (2.08)
3.	Animal and bird attack	1.272 (0.80)	N.A. (-)	N.A. (-)	0.146 (0.27)
4.	Weed infestation	N.A. (-)	N.A. (-)	N.A. (-)	N.A. (-)
II	**Tomato**				
1.	Disease incidence	29.940 (7.86)	N.A. (-)	0.317 (5.00)	5.538 (4.29)
2.	Insect-pest attack	19.427 (5.10)	N.A. (-)	0.203 (3.20)	3.576 (2.77)
3.	Animal and bird attack	1.143 (0.30)	N.A. (-)	0.019 (0.30)	0.258 (0.20)
4.	Weed infestation	N.A. (-)	N.A. (-)	N.A. (-)	N.A. (-)
III	**Cucumber**				
1.	Disease incidence	1.503 (4.36)	N.A. (-)	N.A. (-)	0.168 (1.45)
2.	Insect-pest attack	1.124 (3.26)	N.A. (-)	N.A. (-)	0.126 (1.09)
3.	Animal and bird attack	N.A. (-)	N.A. (-)	N.A. (-)	N.A. (-)
4.	Weed infestation	N.A. (-)	N.A. (-)	N.A. (-)	N.A. (-)
IV	**Other vegetables***				
1.	Disease incidence	0.638 (4.51)	N.A. (-)	1.349 (13.14)	0.495 (5.88)
2.	Insect-pest attack	0.454 (3.21)	0.003 (0.30)	1.140 (11.10)	0.410 (4.87)
3.	Animal and bird attack	N.A. (-)	N.A. (-)	0.846 (8.24)	0.232 (2.75)
4.	Weed infestation	N.A. (-)	N.A. (-)	N.A. (-)	N.A. (-)

Note: DI=Disease incidence, IPA= Insect-pest attack, ABA= Animal and bird attack and WI= Weed infestation;
G I = Group I, G II = Group II and AF = All farms; and *= other vegetables include pea, brinjal, spinach, frenchbean, chilli, potato, etc
Figures in parentheses are the percentages of the losses in the respective category

Monetary losses due to biotic and abiotic stress

It is very important to estimate the monetary losses occurred on account of various factors to the select crops. Therefore, an attempt was made to know the actual monetary losses caused by various biotic stresses (disease, insect-pest, animal and bird attack and weed incidences) and major but most crucial abiotic factor, irrigation water. It can be seen from Table 3 that all the biotic factors caused a total loss of worth Rs 78763 per ha in the study area. The total losses due to various biotic factors were observed highest of Rs 115184 per ha in zone I and among crops these were Rs 33514 in other vegetables such as pea, brinjal, spinach, frenchbean, chill, potato, etc on the whole. The economic losses on all farms situation of zone I, zone II and zone III were observed to be Rs 115184, Rs 23019 and Rs 93326 per ha, respectively. The losses due to the most important abiotic factor (irrigation water) caused a loss of Rs 46613 per ha in the study area. The abiotic losses on all farms situation of zone I, zone II and zone III were observed to be Rs 68800, Rs 5891 and Rs 43771, respectively. The higher losses in zone I may be due to the large scale production of vegetables and scarcity of water in the study area. The total losses met by the sample farmers on account of biotic factors ranged from 62.61 to 79.62 per cent across zones while such losses due to scarcity of irrigation water varied from 20.38 to 37.39 per cent in the study area. However, at the overall level, these losses were around 63 per cent due to biotic and 37 per cent due to abiotic factor such as scarcity of irrigation water.

Table 3. Economic losses due to biotic and abiotic stress across zones on sample farms

(Rs per ha)

Sr. No.	Crops	Zone I	Zone II	Zone III	Overall
A.	**Biotic factor (disease, insect-pest, animal & bird and weeds)**				
1	Rice	8162	5439	-	4478
2	Maize	22288	13327	1768	8026
3	Wheat	2171	3534	15118	5376
4	Barley	278	479	1869	990
5	Cauliflower	15076	-	4989	9587
6	Tomato	14336	-	16536	14551
7	Cucumber	19359	-	-	6361
8	Other vegetables*	33514	240	53046	29394
	Sub-total	115184	23019	93326	78763
B.	**Losses due to scarcity of water**				
1	Rice	4228	2534	-	2201
2	Maize	2415	1832	1783	1915
3	Wheat	549	1333	1952	1549
4	Barley	-	-	1506	685
5	Cauliflower	6238	-	2541	4476
6	Tomato	34356	-	7960	22398
7	Cucumber	14076	-	-	4621
8	Other vegetables*	6938	192	28029	8768
	Sub-total	68800	5891	43771	46613
	Grand-total (A+B)	183984	28910	137097	125376

Note: G I = Group I, G II = Group II and AF = All farms; and *= Other vegetables include pea, brinjal, spinach, frenchbean, chilli, potato, etc

4. Summary

It can be concluded that the percentage loss due to disease incidence in cereals ranged from lowest of 1.28 per cent in barley crop to highest of 11.16 per cent in wheat crop. The losses due to insect-pest attack were found to be highest in maize crop (9.25 %) followed by wheat (4.48%) crop. As far as losses due to animal and bird attack are concerned, these were found to be highest in maize crop (17.92%) followed by wheat (7.53%) and paddy crops (4.94%). Losses due to weeds infestation (WI) were observed to be less than 1 per cent in all crops. Percentage losses in production of vegetables due to disease incidences ranged from lowest of 1.45 per cent in cucumber to highest of 5.88 per cent in other vegetables. The losses due to insect-pest attack were found to be highest in other vegetables (4.87 %) followed by tomato (2.77 %) and cauliflower (2.08 %) crops. Also, the losses due to animal and bird attack were highest in other vegetables (2.75 %) while in remaining vegetables such as cauliflower, tomato and cucumber almost negligible amount of percentage loss due to animal and bird attack was calculated. No losses due to weed incidences (WI) were observed in any vegetable in any of the zone of study district. This may be due to the reason that farmers were following adequate measures and cultural practices to ward against the various kinds of losses in vegetable crops because of their cash generating nature and high sensitivity.

From above discussion it can be concluded that all the biotic factors collectively caused a loss of worth Rs 19259 while due to non availability on time or inadequacy of the most important abiotic input (irrigation water), farmers suffered a loss of Rs 7148 in the study area. The losses due to various biotic stresses and irrigation water were observed to be highest in zone I. The biotic losses in zone I, zone II and zone III were observed to be Rs 81246, Rs 4185 and Rs 9529 respectively. Whereas, the abiotic losses in zone I, zone II and zone III were observed to be Rs 25308, Rs 1136 and Rs 3758 respectively. The higher losses in zone I may be due to the large scale vegetables production on commercial basis in the study area.

5. Policy intervention

New and improved cultivars resistant to changed climatic factors need to be developed and promoted in the study area especially of maize, cucumber, cauliflower, tomato crops which are more sensitive than wheat and barley. Similarly, Drought Prone Areas Programme (DPAP), Pradhan Mantri Fasal Bima Yojna (PMFBY) and Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) need to be implemented effectively for the benefit of farming community.

6. References

Akinnagbe OM and IJ Irohibe (2014). Agricultural adaptation strategies to climate change impacts in Africa: A review. *Bangladesh Journal of Agricultural Research* 39 (3): 407-418

Alam MQ (2013). Climate change, agricultural productivity and economic growth in India: The Bound's test analysis. *International Journal of Applied Research and Studies* 2: 11 http://www.ijars.in/iJARS%20670.pdf

Anonymous (2008). Climate change impacts on agriculture in India. IARI (Indian Agricultural Research Institute). New Delhi. India. http://agricoop.nic.in/ (15th April 2014)

Arumugam S, Ashok KR, Kulshreshta NS, Vellangany I and R Govindasamy (2014). Does climate variability influence crop yield? a case study of major crops in Tamil Nadu. *Agricultural Economics Research Review* 27 (1): 61-71

Falco SD, Yesuf M, Kohlin G and C Ringler (2011). Estimating the impact of climate change on agriculture in low-income countries: household level evidence from the Nile Basin, Ethiopia. *Environment Resource Economics* 52(4): 457-478

Javeed S and A Manuhaar (2013). Climate change and its impact on productivity of Indian agriculture. *Journal of Economics and Social Development* 9(1): 146-151

Kambrekar DN, Guledgudda SS, Katti A and M Kumar (2015). Impact of climate change on insect pest and their natural enemies. *Karnataka Journal of Agricultural Sciences* (Special issue) 28 (5): 814-816

Kumari A, Kaushal P, Dubey JK and DK Sharma (2012). Climate change – an impact study in Himachal Pradesh. *International Journal of Farm Science* 2(2): 95-101

Lema MA and AE Majule (2009). Impacts of climate change, variability and adaptation strategies on agriculture in semi-arid areas of Tanzania: The case of Manyoni district in Singida region, Tanzania. *African Journal of Environmental Science and Technology* 3 (8): 206-218

Mahato A (2014). Climate change and its impact on agriculture. *International Journal of Scientific and Research Publications* 4 (4): 1-6

Nelson GC, Rosegrant MW, Koo J, Robertson R, Sulser T, Zhu T, Ringler C, Msangi S, Palazzo A, Batka M, Magalhaes M, Santos RV, Ewing M and D Lee (2009). Climate Change: impact on agriculture and costs of adaptation. Food Policy Report, International Food Policy Research Institute, Washington DC

Ratna Jayant (2017). *A Study of Climate Change Impacting Agrarian Economy in Western Himalayas.* Unbublished Ph. D thesis submitted to CSK HPKV, Palampur.

Smit B and Skinner MW. (2002). Adaptation options in agriculture to climate change: a typology. *Mitigation and Adaptation Strategies for Global Change* 7: 85–114

Suryaprakash S (2011). Climate change – its impact on agriculture productivity and livelihood: the policy response: Rapporteur's report. *Indian Journal of Agricultural Economics* 66 (3): 572-581