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Growth index and infestation by *Prostephanus truncatus* affected by temperature and humidity; created in *In-vitro* conditions

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Abstract
The research is based on comparing the data of effects of temperature and humidity on growth index and infestation of *Prostephanus truncatus* on *Zea mays* of 5 different districts of India based on creating in-vitro conditions similar to the district of Bahraich, Ghazipur, Agra, Bikaner and Mysore. This research provides reanalyzed information and quantitative description needed for predicting the growth index and infestation rates in different environments. The in-vitro conditions with the conditions similar to Mysore was observed and the growth index and infestation was 3.67, 4.06 & 4.33 and 63.46, 65.34 & 70.65 for 20-30 ºC, 30-40 ºC and 40-50 ºC at 20-40% of humidity which was highest. The growth increased at 40-60 and decreased at 60-80%. The growth index and infestation was lowest in the area of Bikaner which had 33.35ºC as the highest temperature with 29.82% of humidity. The in-vitro conditions with the conditions similar to Bikaner showed growth index and infestation of 1.23, 1.53 & 1.71 and 40.32, 43.36 & 46.66 for 20-30 ºC, 30-40 ºC and 40-50 ºC at 20-40% of humidity. The growth index and infestation increased at 40-60%. The Growth index and infestation was intermediate in Bahraich, Ghazipur and Agra. Hence, infestation rate is high when the humidity ranges from 40-60% and the temperature ranges below 20ºC. Predicting population and development trends along with infestation and growth index trends is important for accurately timing insect sampling programmes and control tactics.

Keywords: Prostephanus truncates, humidity, temprature, growth index, infestation

Introduction
Prostephanus truncatus is one of the most obnoxious pest of the stored grain. This pest is able to destroy almost 40% of the stored grain and hence it is required to know the trends that avoids its growth. Temperature and humidity play a vital role in affecting growth index and infestation. However according to C. G. Athanassiou *et al*. (2017) [7] that the pest fails to develop on non-amylaceous commodities which in essence to this research clears that the amount of amylase and water content is necessary for its development and growth. Its survival and spread is absolutely marginal in non-host commodities. Growth index and infestation are two important factors that can be studied to understand the trends of its population explosion in the world in different kinds of climatic conditions with respect to temperature and humidity.

Material and method
1. Collection of plant
On the basis of availability, the specimens of *Zea mays* were collected from different parts of India i.e. Bahraich, Ghazipur, Agra, Bikaner and Mysore for rearing the pest *Prostephanus truncates.*

Study Area: The study was conducted in the zoology department of A.N.D.N.N.M. Mahavidhyalaya, Kanpur, U.P. which is under the C.S.J.M. University of Kanpur.

2. Assessment of physical characters
Sun dried grains were stored in air tight jars to avoid mouldiness. Completely-intact and un-infested grains were selected for further procedure.

2.1: Grain moisture content and its removal
Checking of the moisture of grain was done by Silva [10] method. 50grams of grain was taken and placed on previously weighed crucibles. It was then heat dried between 95-105ºC in hot air oven until the grain weight was absolutely constant. Moisture content = Initial weight – Final dried weight

2.2: Grain weight
Grain weight was taken to study the infestation. So, 50 grams of fresh grans were taken for weighing and the data was noted out. The process was repeated every week for 3 months.

2.3 Removal of hidden infestation
The infestation of algae, fungi, other organisms and insects were eliminated by heat sterilization of the grain from 60-70ºC for 20-30 min.

3. Collection of Insect: Eggs of *Prostephanus trucatus* were collected from CSA University Kanpur U.P. that infested *Zea mays var. Baby Azad. Zea mays var. Baby Azad* was used as inoculum.

3.1. Rearing of pest: Eggs of *Prostephanus trucatus* were collected from the *Zea mays var. Baby Azad* and then used as inoculum in different varieties of *Zea mays* collected from Bahraich, Ghazipur, Agra, Bikaner and Mysore for further experiment and observation. Rearing was done on *Zea mays* collected from Bahraich, Ghazipur, Agra, Bikaner and Mysore. Ample amount of food and air supply was provided in an in-vitro conditions similar to the environment with a controlled temperature of 32ºC with relative humidity

of 60% was set up for neonate larvae that were kept individually. Soon larvae turned into adults. Adults were kept in separate jar in pair for mating and spawning. The jars were covered with muslin cloth for proper aeration. Periodical examination at an interval of a week was done during whole experiment.

4. Districts of different topographical areas of India

1-Bahraich (moderate water availability with moderate temp.); 2-Ghazipur (moderate water availability with moderate temp. and humidity), 3-Agra (moderate water availability with moderate temp. and humidity), 4-Bikaner (scarce water availability with high temp. and low humidity), 5-Mysore (high water availability with moderate temp. and high humidity), 6- Control (of 32ºC with relative humidity of 60%).

5. Procedure of treatment: The stable temperature and humidity was created in in-vitro conditions. The readings were noted as soon as first symptoms of infestation were observed. Readings were noted after an interval of every 7 days for about 3 times to see their growth index and infestation by *Prostephanus truncatus*.

(a) Data collection: Data was collected from the setup of experiment that went under treatment, after every 7 days. C.R.D. Design was used for the experiment.

(b) Statistical analysis: Abbott's formula was used and then analysis was done using the ANOVA method, for the correction of the experimental data:

$$\text{F-Value} = \frac{\text{Variance of } 1^{st} \text{ data set}}{\text{Variance of } 2^{nd} \text{ data set}}$$

(c) Calculation of weight loss: These losses can ne estimated by

$$\frac{\text{Total yield of maize (q ha-1)} - \text{Yield of healthy maize (q ha-1)}}{\text{Total yield of maize (q ha-1)}}$$

(d) Growth indices calculation: Dividing the % of adult emerged from the ean no. of days for the adult formation (sum of larval and pupal period)

Result

The following research was conducted in in-vitro conditions that were similar to the temperature and humidity of Bahraich, Ghazipur, Agra, Bikaner and Mysore. Along with that the seeds of maize were also collected from their native lands in order to provide better acclimatization of the pest towards the conditions. It was observed that the regions with higher humidity and moderate to high temperature was optimum for *Prostepanus truncates.*

It was observed that the growth index and infestation was very high in the area of Mysore which had 37ºC as the highest temperature with 66% of humidity. The in-vitro conditions with the conditions similar to Mysore was observed and the growth index and infestation was 3.67, 4.06 & 4.33 and 63.46, 65.34 & 70.65 for 20-30 ºC, 30-40 ºC and 40-50 ºC at 20-40% of humidity (Table-2). The growth increased at 40-60 and decreased a little bit 60-80% still keeping high rate when the temperatures were constant that is 4.87, 4.90 & 4.94 and 3.90, 3.99 & 4.23; similar trends were seen in infestation 67.38, 68.38 & 68.92 and 54.63, 56.45 & 58.05 (Table-3,4)

It was observed that the growth index and infestation was lowest in the area of Bikaner which had 33.35ºC as the highest temperature with29.82% of humidity. The in-vitro conditions with the conditions similar to Bikaner was observed and the growth index and infestation was 1.23, 1.53 & 1.71 and 40.32, 43.36 & 46.66 (Table-2) for 20-30 ºC, 30-40 ºC and 40-50 ºC at 20-40% of humidity. The growth increased at 40-60 and decreased a little bit 60-80% still keeping high rate when the temperatures were constant that is 2.03, 2.21 & 2.24 and 1.99, 1.81 & 2.08; similar trends were seen in infestation 45.36, 49.02 & 49.33 and 39.82, 42.45 & 44.00 (Table-3,4)

The Growth index and infestation was intermediate in Bahraich, Ghazipur and Agra as seen in table2, 3 & 4; however similar trends were seen in these too. This clears the fact that the infestation rate is high when the humidity ranges from 40-60% and the temperature ranges between 30-50ºC. These trends help in controlling these pest and hence clearly shows that if the humidity is controlled and the area is dry with temperature below 20ºC then the pest can be controlled in a very effective way without using any kind of harmful pesticide. These trends help in the storage of the maize grain in hermetic containers in bulk in an effective way in areas that have different kind of humidity and temperature. This research is helpful in showing the growth index trends and infestation with respect to the climatic conditions i.e. humidity and temperature.

Table 1: Temprature and humidity in different districts (topographic areas) of India

S. No.	District	Annual high temperature (ºC)	Annual low temperature (ºC)	Warmest month (ºC)	Coldest month (ºC)	Wettest month (mm)	Driest month (mm)	Humidity (%)
1.	Bahraich	44.00	30.00	42.34	11.59	397.13	0.57	48.62
2.	Ghazipur	34.3	23.86	43.89	12.65	302.33	0.29	47.96
3.	Agra	32.73	21.32	42.00	10.53	292.03	2.75	46.86
4.	Bikaner	33.35	24.15	41.00	12.00	78.91	0.64	29.82
5.	Mysore	37.00	24.00	36.12	17.31	321.99	7.99	66.56
6.	Control	-	-	-	-	-	-	-

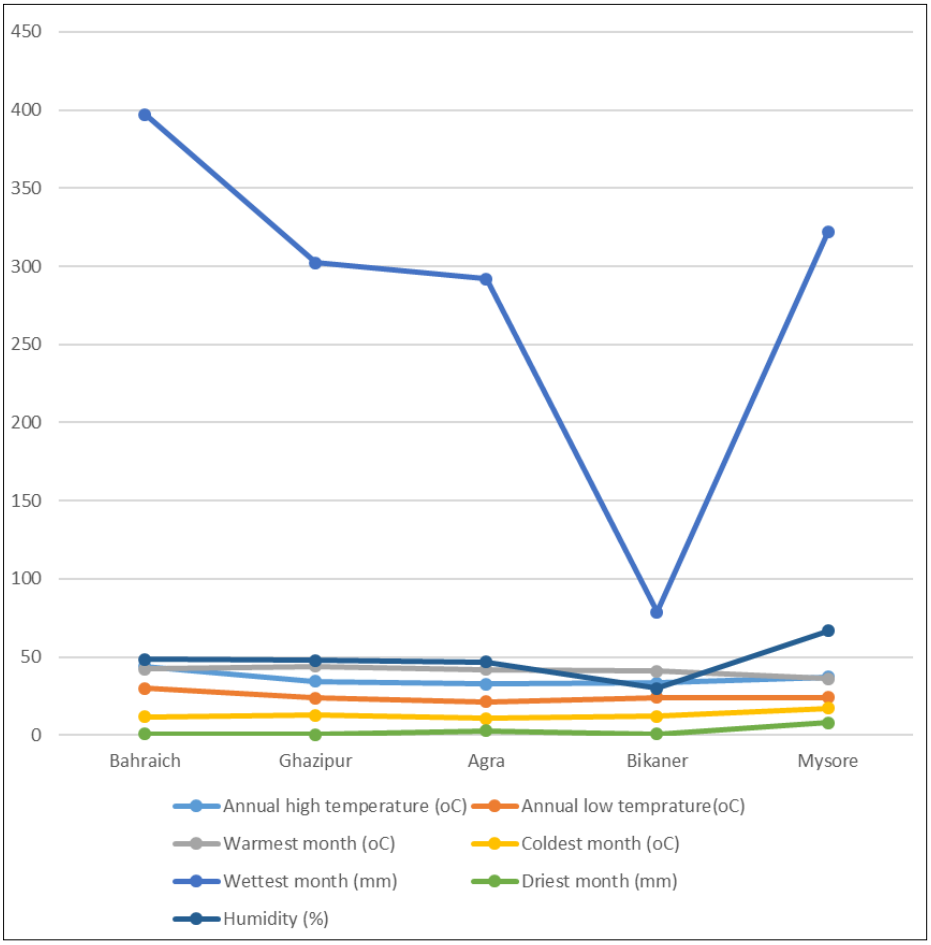

Fig 1: Temprature and humidity in different topographic areas of India

Table 2: Growth index and infestation at 20-40 % of humidity with different temperature:

		20-30 (ºC)		30-40 (ºC)		40-50 (ºC)	
S.No.		Growth index	Infestation	Growth index	Infestation	Growth index	Infestation
1.	Bahraich	1.88	58.78	1.97	61.45	2.43	66.95
2.	Ghazipur	2.13	62.76	2.34	66.23	2.93	67.37
3.	Agra	1.99	52.16	2.12	54.12	2.67	54.34
4.	Bikaner	1.23	40.32	1.53	43.36	1.71	46.66
5.	Mysore	3.67	63.46	4.06	65.34	4.33	70.65
6.	Control	-	-	-	-	7.68	95.76

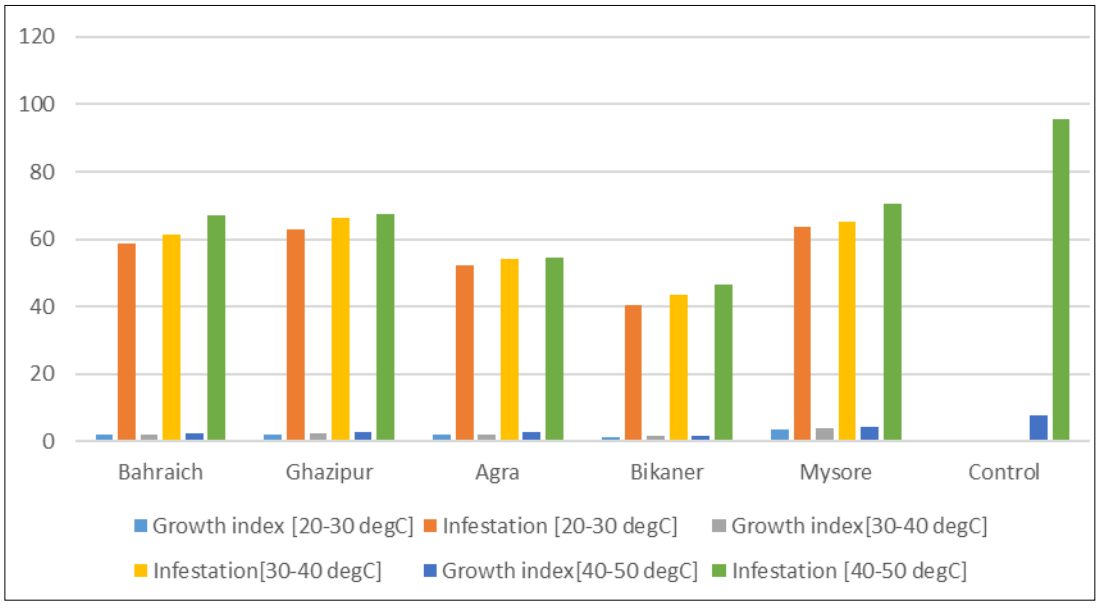

Fig 2: Growth index and infestation at 20-40 % of humidity with different temperature

Table 3: Growth index and infestation at 40-60 % of humidity with different temperature:

		20-30 (ºC)		30-40 (ºC)		40-50 (ºC)	
S. No.	**District**	**Growth index**	**Infestation**	**Growth index**	**Infestation**	**Growth index**	**Infestation**
1.	Bahraich	2.63	62.54	2.72	63.78	2.77	64.59
2.	Ghazipur	3.01	63.67	3.05	67.56	3.09	69.67
3.	Agra	2.89	56.65	2.99	57.63	3.04	59.05
4.	Bikaner	2.03	45.36	2.21	49.02	2.24	49.33
5.	Mysore	4.87	67.38	4.90	68.38	4.94	68.92
6.	Control	-	-	7.72	96.65	7.79	96.78

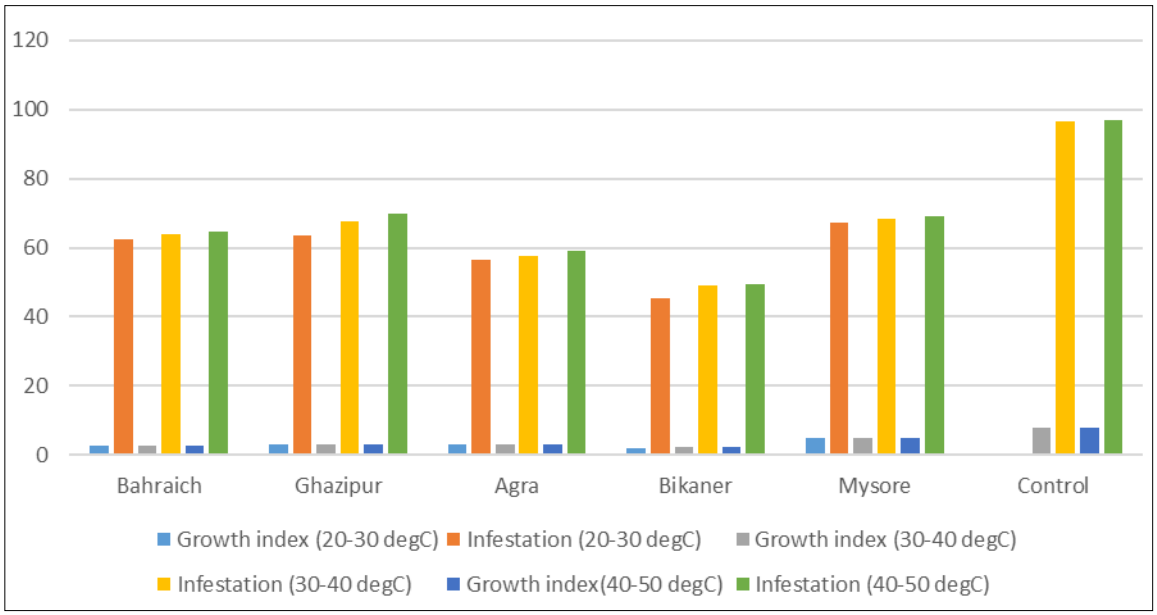

Fig 3: Growth index and infestation at 40-60 % of humidity with different temperature:

Table 4: Growth index and infestation at 60-80 % of humidity with different temperature:

		20-30 (ºC)		30-40 (ºC)		40-50 (ºC)	
S.No.	**District**	**Growth index**	**Infestation**	**Growth index**	**Infestation**	**Growth index**	**Infestation**
1.	Bahraich	2.34	61.66	2.67	62.76	2.79	63.88
2.	Ghazipur	2.45	62.03	2.71	65.34	3.01	68.78
3.	Agra	2.49	55.36	2.96	59.56	3.12	61.33
4.	Bikaner	1.81	39.82	1.99	42.45	2.08	44.00
5.	Mysore	3.90	54.63	3.99	56.45	4.23	58.05
6.	Control	6.92	96.25	6.99	96.99	7.67	97.35

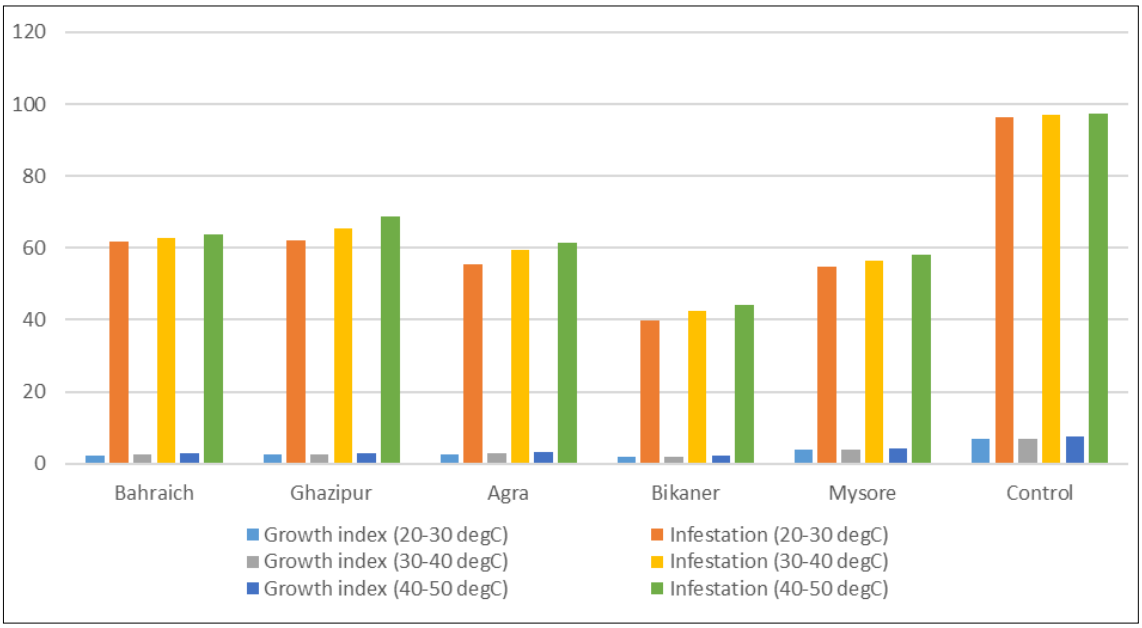

Fig 4: Growth index and infestation at 60-80 % of humidity with different temperature:

Fig 5: Showing the insect *Prostephanus truncates*

Fig 6 & 7: Showing infestation by the pest

Fig 8: The head of *Prostephanus truncatus* under microscope-

Discussion

It was observed that the growth index and infestation was very high in the area of Mysore which had 37ºC as the highest temperature with 66% of humidity. The in-vitro conditions with the conditions similar to Mysore was observed and the growth index and infestation was 3.67, 4.06 & 4.33 and 63.46, 65.34 & 70.65 for 20-30 ºC, 30-40 ºC and 40-50 ºC at 20-40% of humidity (Table-2). The growth increased at 40-60% when the temperatures were constant that is 4.87, 4.90 & 4.94; similar trends were seen in infestation 67.38, 68.38 & 68.92(Table-3, 4). As observed in the research by Honest Machekano *et al*. (2020) [11] Prostephanus truncatus adults had higher cold tolerance and basal heat than larvae; with significant thermal plasticity. It was also observed that moderate temperature with long durations were more effective than high temperature with short durations.

It was observed that the growth index and infestation was lowest in the area of Bikaner which had 33.35ºC as the highest temperature with29.82% of humidity.

The in-vitro conditions with the conditions similar to Bikaner was observed and the growth index and infestation was 1.23, 1.53 & 1.71 and 40.32, 43.36 & 46.66 which was relatively low amongst all the other districts (Table-2) for 20-30 ºC, 30-40 ºC and 40-50 ºC at 20-40% of humidity. The growth increased at 40-60% when the temperatures were constant that is 2.03, 2.21 & 2.24; similar trends were seen in infestation 45.36, 49.02 & 49.33 (Table-3, 4). As observed by C. G. Athanassiou *et al*. (2017) [7] that the pest failed to develop on other grains or non-amylaceous commodities which in essence to this research clears that the amount of water content is necessary for its development and growth. Its survival and spread is negligible to marginal in non-host commodities.

The Growth index and infestation was intermediate in Bahraich, Ghazipur and Agra as seen in table2, 3 & 4; however similar trends were seen in these too. This dissipates the fact that the infestation rate is high when the humidity varies between 40-60% and the temperature varies from 30-50ºC. According to the research Honest Machekano *et al*. (2020) [11] heat tolerance traits were improved by desiccation acclimation. In all cases, more improved heat tolerance were exhibited in all adults than the larvae. Conversely, water loss rates were increased by heat acclimation in larvae than adults. These trends help in controlling these pest and hence clearly shows that if the humidity is controlled and the area is dry with temperature below 20ºC then the pest can be controlled in a very effective way without using any kind of harmful pesticide. These trends help in the storage of the maize grain in hermetic containers in bulk in an effective way in areas that have different kind of humidity and temperature. This research is helpful in showing the growth index trends and infestation with respect to the climatic conditions i.e. humidity and temperature.

Conclusion

If the humidity is kept low i.e. under 10-20% with either very high temperature such as 50-60ºC or the temperature is kept below 20ºC then the pest can be controlled effectively in hermetic storage. However keeping the temperature high at 50-60ºC may cause damage to the stored grain that's why it's better to keep humidity below 20% and the temperature under 20ºC, which is the most effective way to control the growth of the pest. These research trends help in the storage of the dried grain in hermetic containers in high amount in effective ways. This research is helpful in showing the growth index trends and infestation with respect to the climatic conditions i.e. humidity and temperature. Rise in

temperature above 50ºC may help in avoiding the growth of the pest but can degenerate the grains. However, the optimum temperature range with very low humidity can be effective to control the pest in the same environment.

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Declaration: Conflicts of interest
I, Safia Asgher, hereby declare that there is no conflict of interest regarding this research work.

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