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Studies on comparative performance of different tasar silkworm grainage houses

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Abstract
Antheraea mylitta D. is a semi-domesticated silkworm being reared outdoor. After the commercial crop rearing, it undergoes pupal diapause to avoid unfavourable environmental conditions. For seed (egg) production, the diapausing seed cocoons are preserved in the grainage houses till the completion of diapausing period. The tasar seed production mainly depends on the quality of cocoons as well as prevailing abiotic factors there around. Hence, the efforts were made to study the performance of different tasar silkworm grainage houses *viz.*, green shade net grainage house (GSNGH), tubular structure grainage house (TSGH) and pucca grainage houses (PGH) in terms of maintaining abiotic factors especially temperature and relative humidity. Each of these grainage houses and the space beside these grainage houses that is natural condition were provided with the instruments to record the temperature and relative humidity. The data on maximums of temperature and mid-day relative humidity were recorded on daily basis. The temperature in grainage houses varied with the natural conditions, hence no much fluctuations were seen whereas the relative humidity in GSNGH and PGH was similar to natural conditions. It is deduced that the GSNGH house followed by PGH and TSGH are best for tasar silkworm grainage in terms of availability and maintenance of optimum temperature and relative humidity.

Keywords: *Antheraea mylitta*, tasar silkworm, grainage house, abiotic factors

Introduction
Sericulture is one of the oldest agro based industry in India and probably dates back to the beginning of the Christian era [1]. The importance of silk in Indian economy is evident by the fact that 18 per cent of the global raw silk is produced in India. In the textile sector, sericulture is the second largest employer of the country next only to handloom industry and provides employment to more than 50 lakh people [2]. In India the silk are produced commercially through the cultivation of all five silk varieties *viz*., mulberry, tropical tasar, temperate tasar, muga and eri silkworms.

Among non-mulberry (vanya), the tropical tasar silk is produced by silkworm, *Antheraea mylitta* D. and it is preferably used for commercial exploitation in the tropical zone of India [3].Tasar culture is a forest based activity practiced by poor and tribal of India [4]. It is practised in different states *viz.* Jharkhand, Chhattisgarh, Orissa, West Bengal, Bihar, Maharashtra, Madhya Pradesh, Uttar Pradesh, Andhra Pradesh and Telangana [5]. According to Central Silk Board, Bengaluru Annual Report 2017-18 [6], tasar raw silk production during 2017-18 is reported to be 2988 MT which accounts for 9.36% of total raw silk production and 30.36% of total vanya raw silk production in India.

A. mylitta is a semi-domesticated silkworm being reared outdoor. It is reared twice (Bivoltine) or thrice (Trivoltine) in a year depending on location and period of rearing [7]. The first, second and third crops are practiced during June-August, September-October and November-January, respectively. The process of rearing starts from brushing of disease free eggs on to the natural host trees like *Terminalia arjuna*, *Terminalia tomentosa* and others host trees to harvest of cocoons having pupae which gets transformed from feeding larval instars. After the commercial crop rearing (2nd crop of bivoltine and 3rd crop of trivoltine) both bivoltine (BV) and trivoltine (TV) undergoes pupal diapause from January to May and November to June, respectively to avoid unfavourable environmental conditions. For seed (egg) production, the diapauses entered seed cocoons are preserved in the grainage houses till the completion of diapausing period *i. e.* up to adult emergence. It is reported that long period of diapause and exposure to varied climatic conditions results in loss of substantial per cent of cocoons due to

pupal mortality and erratic moth emergence [8]. Since the tasar raw silk production is mainly depends on the quality of cocoons, the efforts were made to study the comparative performance of different tasar silkworm grainage houses in terms of maintaining abiotic factors especially temperature and relative humidity.

Materials and Methods

The cocoons for the studies were harvested from the second crop Daba bivoltine (DBV) eco-race of *A. mylitta*, reared on *T. arjuna* during October 2018 at different places of Bilaspur region of Chhattisgarh. These diapause cocoons were preserved for seed production in the ensuing year in three types of grainage houses *viz*., green shade net grainage house (GSNGH), tubular structure grainage house (TSGH) and pucca grainage houses (PGH). The standard preservation techniques [9] were followed during the preservation.

The green shade net grainage house was a temporary and low cost structure with a size of 70′ X30′ X10′ having the capacity of 2,00,000 seed cocoons to preserve. It is erected on cement poles with bamboo thatched sheets as roof top and covered on all sides with green shade net without verandah. It is equivalent to natural conditions barring shade net covering (Figure 1). The tubular structure grainage house was measured to be 60′X20′X15′ with 5′ verandah. It was having the capacity of 1,50,000 seed cocoons to preserve. Though it is permanent construction above ground level but it is simple structure covered with green shade net on all the sides. The central structure and verandah were topped with cement sheets separately (Figure 2). The pucca grainage house was of size 35′X20′X12′ with a capacity to preserve 1,00,000 seed cocoons. It is solid and permanent structure with walls of 2.5′ thickness having space in between and concrete roof top. It is insured from the reach of direct sunlight with a 8′ verandah on all sides. This inner thick wall is provided with nine numbers of windows and four cross ventilators opening towards the verandah. The outer wall of verandah includes the provision of wire mesh. The inner and outer walls were plastered and white washed. The whole structure of pucca grainage house is at a height of 4′ from the ground level (Figure 3).

Each of these grainage houses and the space beside these grainage houses *i.e.* natural conditions were provided with the instruments to record the temperature and relative humidity. The data on maximum temperature and mid-day relative humidity were recorded on daily basis. The analysis of the compiled data was carried out.

Results and Discussion

In the month of February 2019, the average maximum temperature recorded in green shade net grainage house, tubular structure grainage house, pucca grainage house and under natural condition was 28 °C, 27 °C, 24 °C and 32 °C, respectively. The lowest average maximum temperature was 24 °C *i.e.* 8 °C lower than under natural conditions in the pucca grainage house while the green shade net grainage house and tubular structure grainage houses recorded 4 °C and 5 °C lower than natural conditions, respectively. During the month of March 2019, the decreasing order of average maximum temperature was 37 °C under natural conditions, 33 °C in green shade net grainage house, 31 °C in tubular structure grainage house and 30 °C in pucca grainage house while it was 44 °C and 47 °C under natural conditions, 40 °C and 42 °C in green shade net structure grainage house, 35 °C and 38 °C in pucca grainage house and 24 °C and 38 °C in tubular structure grainage house during April and May 2019, respectively (Figure 4). In the green shade net grainage house and under natural conditions, the lowest and highest maximum temperature were recorded as 22 °C and 27 °C on 16th February 2019 and 34 °C and 37 °C on 22nd February 2019, respectively. Though tubular structure grainage house recorded 25 °C as lowest temperature, it showed increasing trend from 32 °C on 26th February 2019 to 37 °C on 28th February 2019. During March 2019, the maximum temperature showed increasing trend from 31 °C on 1st March 2019 to 44 °C on 31st March 2019 under natural conditions. Similar was the condition in green shade net grainage house and pucca grainage house. However the maximum temperature recorded in the tubular structure grainage house was more or less same throughout the month with ± 7 °C as variation. The same increasing trend was observed under natural conditions during April month and no much variation in the maximum temperature of each grainage house was observed. The lowest maximum temperature was recorded in tubular structure grainage house followed by pucca grainage house and green shade net grainage house. In the month of May 2019 the highest temperature of 49 °C was recorded for most of days under natural conditions but in case of green shade net grainage house, the same trend was observed as it was in April 2019. However both tubular structure grainage house and pucca grainage houses recorded more or less same maximum temperature (Figure 5).

Among the relative humidity recorded, the lowest average mid-day relative humidity was in case of tubular structure grainage house for all the months and it was 8%, 7%, 10% and 3% lower than the natural conditions during February, March, April and May 2019, respectively. The highest average relative was recorded in case of pucca grainage house *i. e.* 47% in February and March 2019, 36% in April 2019 and 34% in May 2019 (Figure 6). Though green shade net grainage house and pucca grainage house recorded different average mid-day relative humidity in February 2019 as 46% and 38%, 45% and 35% in March 2019, 31% and 29% in April 2019, respectively but no such differences were observed for the May 2019 as both recorded same average mid-day relative humidity of 28% (Figure 7). During February 2019, there was increase in mid-day relative humidity in all the grainage houses on 8th day of the month where the green shade net grainage house recorded highest of 75% mid-day relative humidity and it was 7% more than that recorded under natural conditions (68%). Again there was increase in mid-day relative humidity on 16th February 2019, highest mid-day relative humidity was recorded in tubular structure grainage house (81%) followed by green shade net grainage house (74%). In the month of March 2019, the highest mid-day relative humidity was recorded on 18th day *i.e* 83% in green shade net grainage house, 68% in tubular structure grainage house and pucca grainage house and 64% under natural conditions. For nearly five days during April 2019 *i.e* from 17th to 21st, there was steady increased mid-day relative humidity in all the grainage houses and under natural conditions. Later though mid-day relative humidity gradually decreased in grainage houses except under natural conditions for few more days. From the second week of May 2019, all the grainage houses started recording lower mid-day relative humidity than the previous month till last week of May 2019 (Figure 7).

It was observed that there was increasing trend of temperature in all the grainage houses from February to May 2019.

Among these grainage houses, lowest average maximum temperature recorded was in case of pucca grainage house followed by tubular structure grainage house and green shade net grainage house which recorded lesser than that recorded under natural conditions during February and March 2019. Similarly the green shade net grainage house recorded higher average maximum temperature in April and May 2019. The lowest mid-day relative humidity was recorded in tubular grainage house while the highest was observed in pucca grainage house in all the months of study except April 2019 where it was little lower than under natural conditions but higher than all other grainage houses.

The fluctuation of temperature and relative humidity was observed in all the grainage houses and under natural conditions from 1st February to 31st May 2019. The temperature in grainage houses varied with the natural conditions, hence no much fluctuations were seen whereas the relative humidity in green shade net grainage house and pucca grainage house was similar to natural conditions *i.e* relative humidity was equal or higher than natural recorded and less fluctuated. But under tubular structure, the relative humidity fluctuated greatly and was lower than the other grainages for most of days. The relative humidity fluctuated to an extent of 15%-81% in the tubular structure grainage house. The fluctuation in temperature recorded in the green shade net grainage house was similar to natural conditions but under pucca grainage house and tubular structure grainage house, the fluctuation did not follow the natural conditions. The perforation in the net structure might have allowed natural air to have two-way movement into and outside green shade net grainage house, thus regulating the temperature and relative humidity.

The temperature among different grainage structure was low in pucca grainage house compared to other grainage houses for most of the months. Since pucca grainage house was provided with windows and exhaust fans, the heat inside was reduced through air filtration [10, 11]. The relative humidity was more in both pucca grainage structure and green shade net structure and it was lowest in tubular structure. In pucca grainage house, the relative humidity was maintained by wet gunny bags. It was found that the optimum temperature and relative humidity was ideal in the green shade net grainage house. The present results are in conformity with Kumar *et al*., 2012 [7] and Rathore *et al*., 2018 [11]. From the preceding observations, it is deduced that the green shade net grainage house followed by pucca grainage house and tubular structure grainage house are best for *A. mylitta* grainage in terms of availability and maintenance of optimum temperature and relative humidity.

Conclusion

An ideal grainage requires optimum temperature (25±5 ^{0}C) and relative humidity (70-80%) to result into lowest pupal mortality during preservation, synchronised male and female moth emergence, recovery of maximum coupled moth *etc* (Rathore *et al*, 2018) [11]. Hence, based on the present studies it is concluded that the green shade net grainage house which is near to nature provides these optimum conditions and hence it is ideal system for tropical tasar grainage.

Acknowledgement

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Fig 1: Green Shade Net Grainage House

Fig 2: Tubular Structure Grainage House

Fig 3: Pucca Grainage House

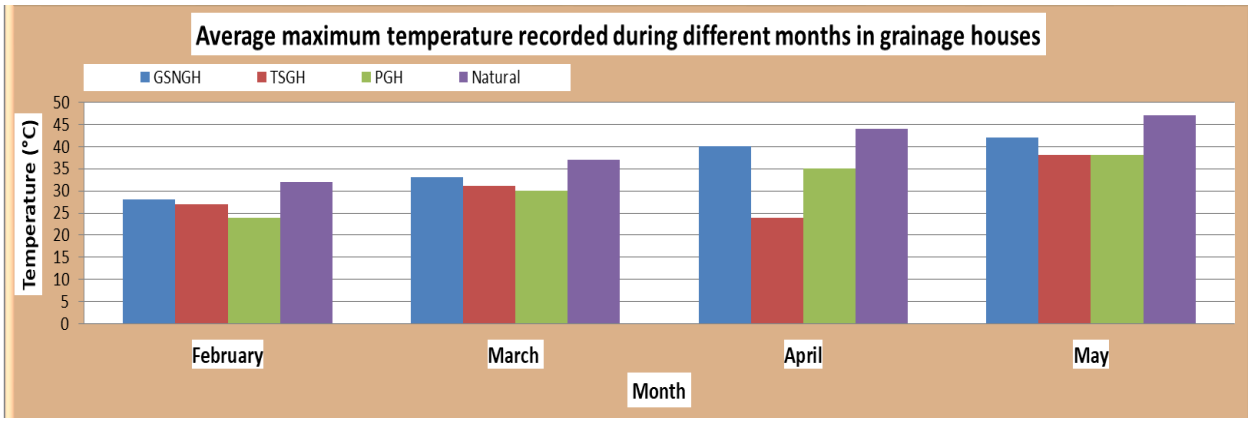
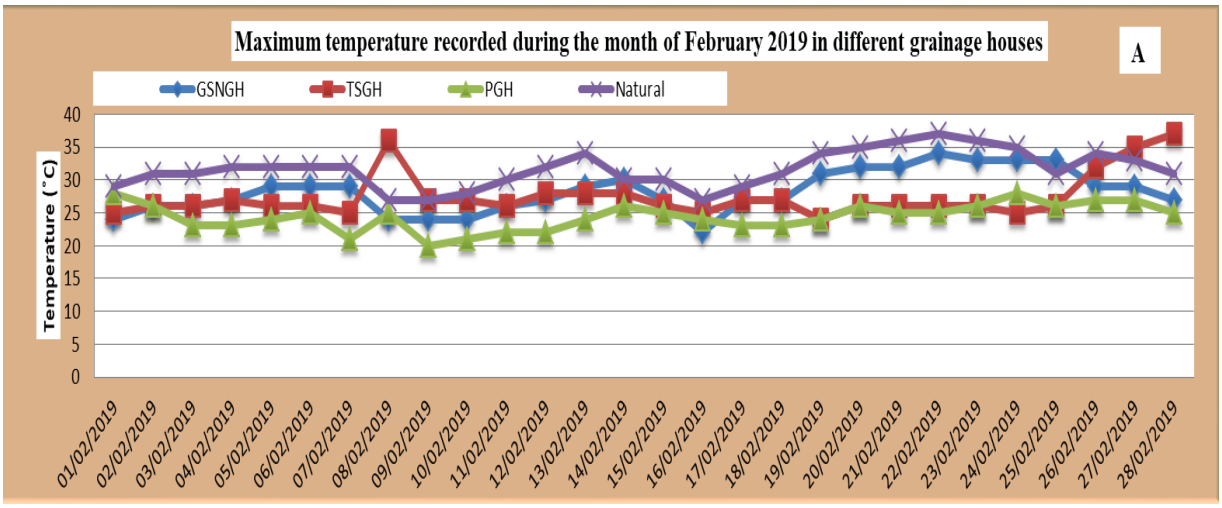
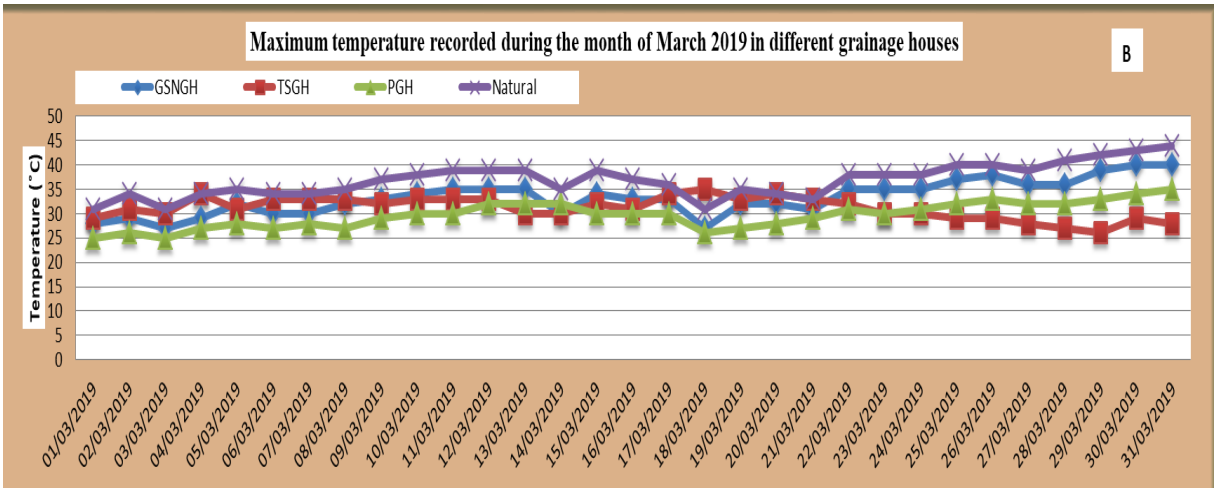
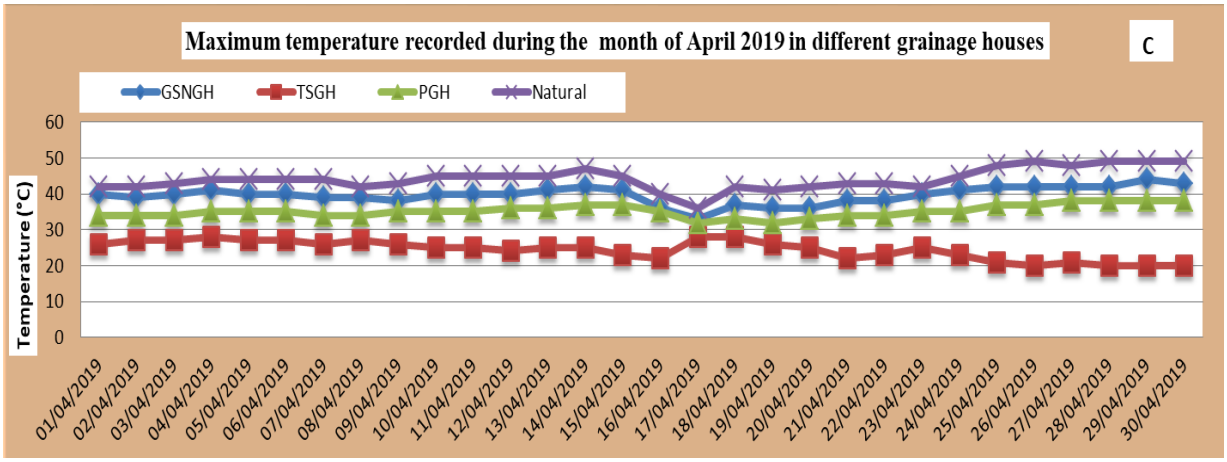


Fig 4: Average maximum temperature recoded during different months in grainage houses







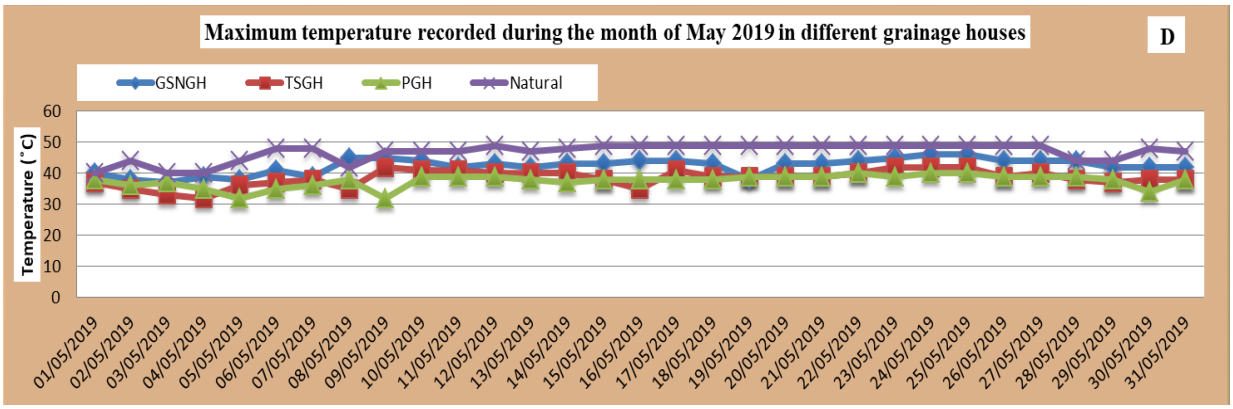


Fig 5: Maximum temperature recorded during the months of February (A), March (B), April (C) and May (D)2019 in different grainage houses

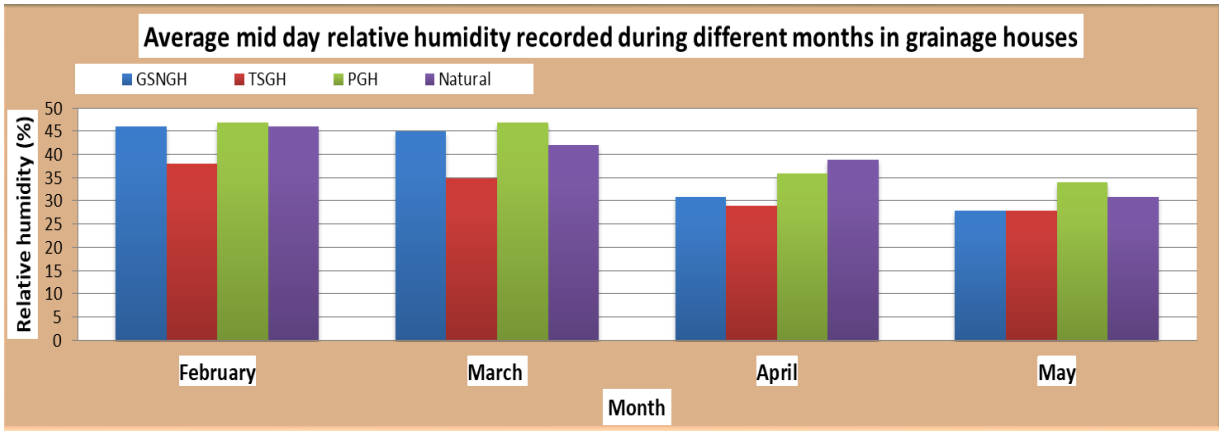
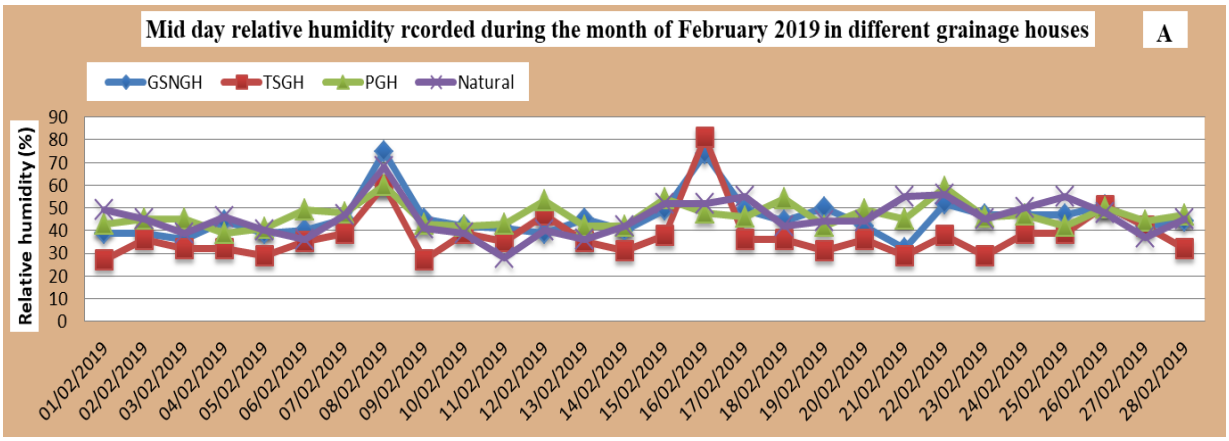
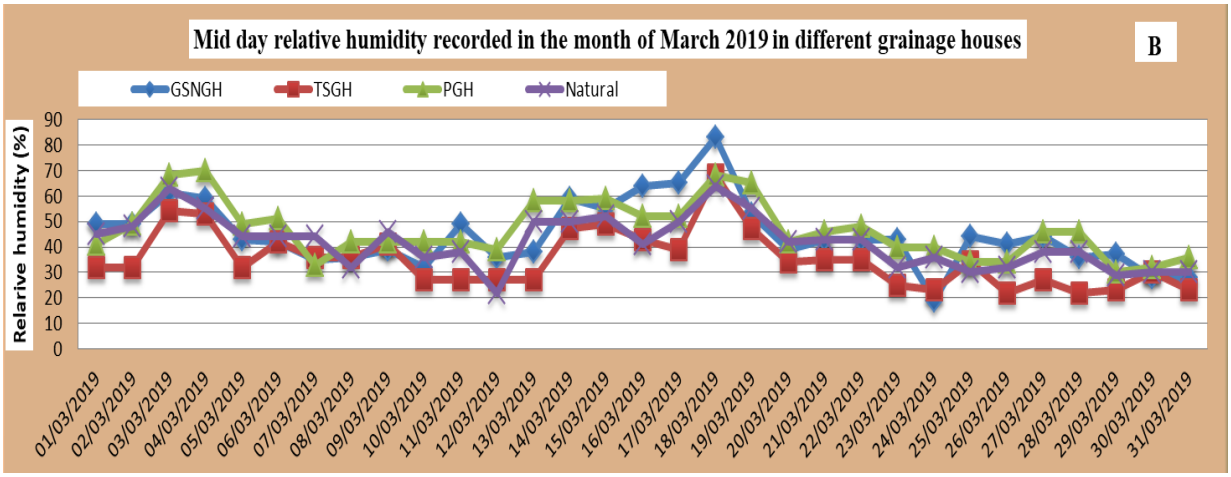


Fig 6: Average mid-day relative humidity recoded during different months ingrainage Houses





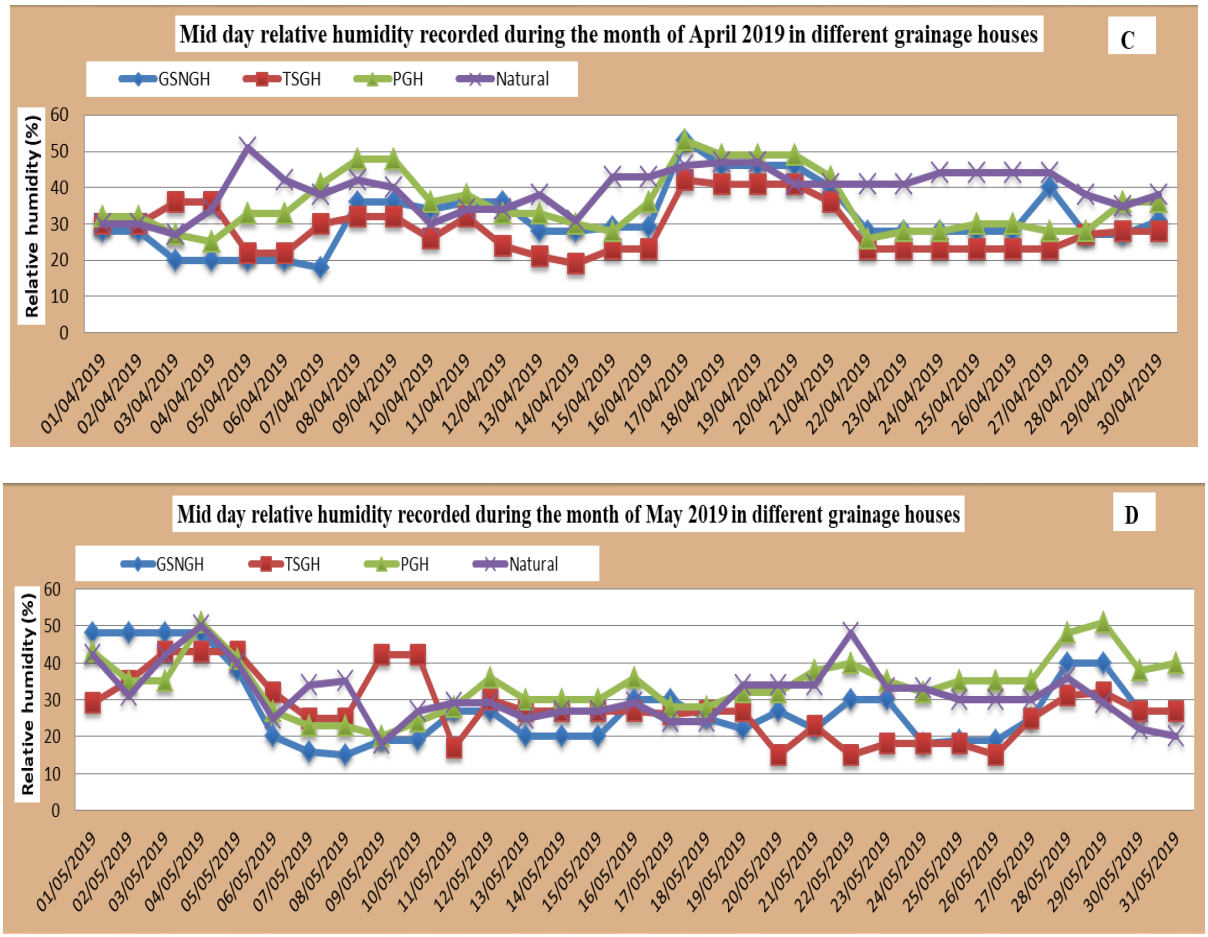


Fig 7: Mid-day relative humidity recorded during the months of February (A), March (B), April (C) and May (D) 2019 in different grainage houses

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