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Development of Weather based "Weekly Thumb Rules" for Potential Productivity of Mustard Crop in Punjab

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ABSTRACT

Agriculture is sensitive to short-term changes in weather and to seasonal, annual and longer-term variations in climate. Weather variability is an important abiotic stress, which is most harmful as it affects the growth and productivity of crops, resulting in a yield reduction from 10% to 100%. A study was conducted to evaluate the effect of abiotic stresses on mustard (Brassica campestris L.) yield and to formulate the weather based "Weekly Thumb Rule Models" for potential yield of mustard crop in Punjab, which are based on long term meteorological for the period of 2003-2013. The analysis of meteorological parameters at different locations revealed flowering and pod formation stage of mustard are very critical stages. The range of maximum temperature for the potential productivity of mustard crop during flowering stage in sub-mountainous, central and south western Punjab is 21.3-26.6^{o}C, 20.0-27.3^{o}C and 20.5-22.2^{o}C, respectively. Similarly, the range of maximum temperature for the potential productivity of mustard crop during pod formation stage in sub-mountainous, central and south western Punjab is 11.3-16.7^{o}C, 13.6-20.4^{o}C and 13.2-18.7^{o}C, respectively. The minimum temperature for the potential productivity of mustard crop during flowering stage in sub-mountainous, central and south western Punjab is 4.0-11.0^{o}C, 4.3-11.8^{o}C and 4.6-6.7^{o}C, respectively and during pod formation stage the range of minimum temperature in sub-mountainous, central and south western Punjab is 3.8-4.9^{o}C, 0.9-7.2^{o}C and 4.7-5.6^{o}C, respectively These models can be used for agro-advisory service and for prediction of potential crop yield at 5 locations in Punjab state.

Keywords*: Thumb rules, Mustard crop, Models, Agro-advisory, Weather parameters.*

1. Introduction

Climate change is one of the most important global environmental challenges facing humanity with implications for food production, natural ecosystems, freshwater supply, health, etc. (Sathaye *et al*., 2006). The climate sensitivity of agriculture is uncertain, as there is regional variation in rainfall, temperature, crops and cropping systems, soils and management practices. It has been found that the relative decreases in potential yields associated with abiotic stress factors vary between 54 and 82% [Bray *et al*, 2000 and Khan *et al*, 2008]. Brassica play an important role in global agriculture and horticulture. These crops contribute both to the economy and to the health of populations around the world. Brassica is the third most important source of vegetable oil in the world after palm and soybean oil and is grown as an edible or an industrial oil crop that is used as a source of edible protein, in much the same way as soybean protein [Zhang *et al*, 2003]. About 90% of the total land under oilseed cultivation in India is occupied by *Brassica juncea* [Khan *et al*, 2007].

Agro-meteorological Advisory Service (AAS) is a step to contribute to weather information based crop management strategies and operations dedicated to enhancing crop production and food security. The AAS has

helped to develop and apply operational tools to manage weather-related uncertainties through agro-meteorological applications for efficient agriculture in rapidly changing environments (Singh, 2011). The present study was done to work out the range of weather parameters favourable for the potential productivity of mustard crop in Punjab.

2. Materials and method

The daily weather data (maximum and minimum temperature, rainfall, sunshine hours, relative humidity etc.) for Agroclimatic Zone II (Ballowal Saunkhri from 1984-2013), Agroclimatic Zone III (Amritsar, Ludhiana and Patiala from 1970-2013) and Agroclimatic Zone IV (Bathinda from 1977-2013) were collected as per availability to work out the weekly and monthly climatic normals. The historical data on area, production and productivity of mustard were collected from Statistical Abstract, Punjab from 2003-13 for five representative locations of Punjab to find out the low, medium and high yield crop years. The data on different phenological growth stages (sowing, anthesis, pod formation, pod filling and physiological maturity) for mustard crop were collected from the published reports operational in the Department of Agricultural Meteorology for formulating the thumb rules for 5 locations in the state. The effect of inter and intra seasonal meteorological parameters on different growth stages and the final yield of mustard were established as per the three major categories (high, medium and low crop yield year) of crop years by calculating the deviation of different meteorological parameters. The weekly and monthly deviations from normal meteorological parameters during the mustard season were calculated to identify the influence of meteorological parameters on the mustard crop yield. The data were also used for working out the stage wise "critical limits" of different meteorological parameters, *i.e.*, temperature (maximum and minimum), rainfall, sunshine hours, relative humidity (maximum and minimum) etc. from the actual meteorological data of high yield crop year. On the basis these "Critical Limits" of various meteorological parameters "Thumb Rule models for predicting the potential yield of the mustard crops were worked.

3. Results and discussion

Area, production and productivity of mustard crop of Punjab are given in Fig 1. Area under mustard was maximum (4.5 thousand hectares) in year 2003-04 and minimum (2.0 thousand hectares) in 2008-09. Similarly maximum production (4.1 thousand tonnes) was recorded in 2003-04 and minimum (2.0 thousand tonnes) in 2008-09. Maximum productivity (1261.4 kg/ha) was in year 2010-11 and minimum (955.8 kg/ha) in 2003-04.

Location wise area, production and productivity of mustard of Punjab are given in Table 4.20a. The perusal of the data indicates that during last 10 years the highest area (12.8 thousand hectares) under mustard was in Bathinda in 2003-04 and lowest (0.9 thousand hectares) in Patiala in 2006-07. Highest production (11.3 thousand tonnes) was recorded in Bathinda in 2003-04 and lowest (1.0 thousand tonnes) in Ludhiana in 2008-09. Similarly the productivity was highest (1577 kg/ha) in Ludhiana in 2005-06 and lowest (700 kg/ha) in Ballowal Saunkhri in 2004-05 (Table 1). The weather based "Weekly Thumb Rule Models" for mustard crop for 5 different locations in the Punjab state are shown in Fig. 1 to 5.

3.1 Sub- mountainous Punjab

The range of maximum temperature for the potential productivity of mustard crop during sowing and complete emergence was 25.5-30.4 ^{o}C in sub-mountainous Punjab (Ballowal Saunkhri). The range of minimum temperature, Maximum relative humidity, minimum relative humidity and sunshine hours for sowing and complete emergence was 9.4-13.0 ^{o}C , 84-96%, 40-62 % and 7.6-9.4 hrs, respectively. During flowering stage, the range of maximum and minimum

temperature, maximum and minimum relative humidity and sunshine hours was 21.3-26.6 ^{o}C, 4-11 ^{o}C, 85-98%, 53-58% and 3.9-8.3 hrs, respectively. Similarly range of maximum and minimum temperature, maximum and minimum relative humidity and sunshine hours was 11.3-16.7 ^{o}C, 3.8-4.9 ^{o}C, 93-97%, 59-86% and 3.4-6.5 hrs, respectively. The rainfall in central Punjab in the range of 0.5-16.2mm was required for the potential yield of mustard crop.

3.2 Central Punjab

Amritsar, Ludhiana and Patiala fall under central Punjab. The range of maximum temperature for sowing and emergence, flowering and pod formation stage for central Punjab (Fig. 2, 3 and 4) was 26.9-29.1 ^{o}C, 20.0-27.3 ^{o}C and 13.6-20.4 ^{o}C, respectively. Range of minimum temperature for sowing and emergence, flowering and pod formation stage was 10.1-14.1 ^{o}C, 4.3-11.8 ^{o}C, 0.9-7.2 ^{o}C, respectively. The sunshine hours and rainfall for sowing and emergence, flowering and pod formation stage were in the range of 6.2-8.0 hr & 1.3-14.0mm, 5.4-8.1 hr & 9.2-24.6mm and 3.2-6.1 hr & 3.6-32.3mm, respectively. The range of maximum relative humidity required for sowing and emergence, flowering and pod filling stage for the potential productivity was 91-94%, 92-98% and 97-98%, respectively. Similarly the range of minimum relative humidity required was 32-35%, 44-55% and 57-63% for sowing and emergence, flowering and pod formation stage, respectively.

3.3 South-western Punjab

During the sowing and emergence period the maximum temperature in the range of 26.8-29.3°C, minimum temperature in the range of 10.3-12.6°C, maximum relative humidity in the range of 88-94 %, minimum relative humidity in the range of 28-37 % and rainfall in the range of 3.2-44.6 mm were favorable for potential mustard productivity at Bathinda (Fig 5). The flowering stage of mustard requires maximum temperature in the range of 20.5-22.2^{o}C, minimum temperature in the range of 4.6-6.7^{o}C, maximum relative humidity in the range of 91-98 %, minimum relative humidity in the range of 37-46% and rainfall in the range of 12.4-34.4 mm, for potential productivity. At Bathinda for pod formation stage, the maximum temperature in the range of 13.2-18.7°C, minimum temperature in the range of 4.7-5.6°C, maximum relative humidity in the range of 97-98 %, minimum relative humidity in the range of 57-76 % and rainfall 7 mm are favorable for potential mustard productivity.

4. Conclusions

Thumb rule models were formulated for 5 different district of Punjab representing three agroclimatic zones of Punjab viz. Agroclimatic Zone II (Ballowal Saunkhri), Agroclimatic Zone III (Amritsar, Ludhiana and Patiala) and Agroclimatic Zone IV (Bathinda). These models present the favourable range of different weather parameters required for potential productivity of mustard crop in Punjab. Understanding of climatic conditions and impact of weather on crops help the farmers to take advantage of the favourable weather and reducing the crop losses.

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Table. 1 Location wise area, production and productivity of mustard crop in Punjab

Yield (kg/ha)						Area ('000 ha)					Production ('000 mt)				
Year	Ballowal	Amritsar	Ludhiana	Patiala	Bathinda	Ludhiana	Patiala	Bathinda	Amritsar	Ballowal	Ludhiana	Patiala	Bathinda	Amritsar	Ballowal
2003-04	760	942	1197	994	886	2.2	2.6	12.8	2.1	2.8	2.6	2.6	11.3	2.0	2.1
2004-05	700	1037	1348	972	1170	1.8	1.4	9.4	1.9	2.6	2.4	1.4	11.0	2.0	2
2005-06	963	1139	1577	961	874	2.3	2.4	9.0	1.9	4.4	3.6	2.3	7.9	2.2	4.2
2006-07	1132	1051	1359	1188	1126	2.8	0.9	6.6	1.3	3.1	3.8	1.1	1.4	7.4	3.5
2007-08	1087	884	1199	1003	1235	1.0	1.0	6.0	1.0	4.0	1.0	1.0	8.0	1.0	5
2008-09	990	1109	1182	1121	1242	1.0	2.0	2.0	2.0	3.0	1.0	1.0	3.0	2.0	3
2009-10	1028	1030	1036	1052	1330	1.0	2.0	2.0	2.0	3.0	1.0	1.0	4.0	1.0	3
2010-11	1132	1554	1235	1025	1334	2.0	1.0	2.0	1.0	5.0	2.0	2.0	3.0	2.0	6
2011-12	1225	1054	1395	1137	1376	1.0	2.0	2.0	1.0	6.0	1.0	1.0	3.0	1.0	7
2012-13	1074	1555	1395	1125	1317	1.0	2.0	1.0	1.0	6.0	2.0	3.0	3.0	2.0	6

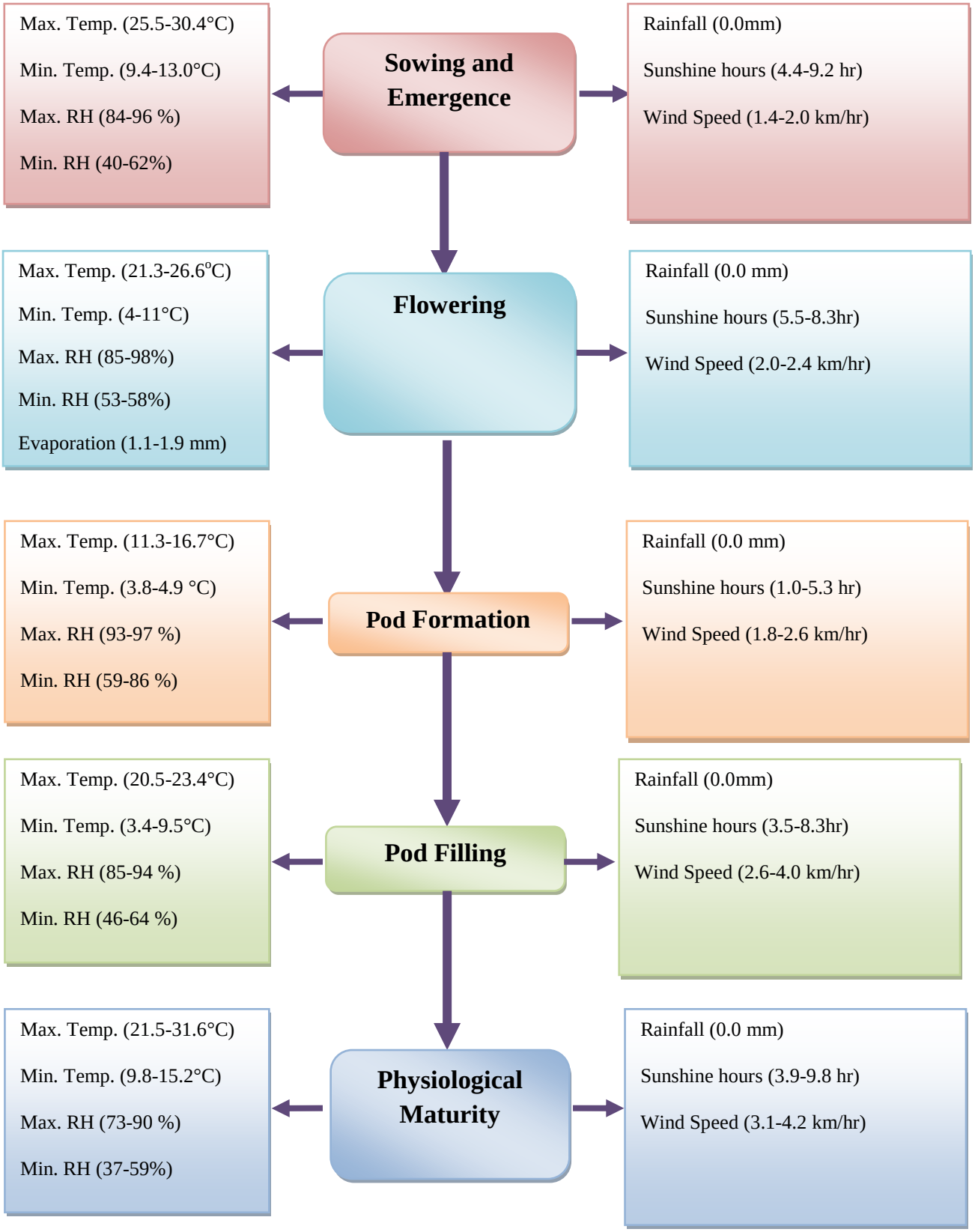

Figure 4.2 Weekly Thumb Rule Model for Ballowal Saunkhri for prediction of potential yield of mustard

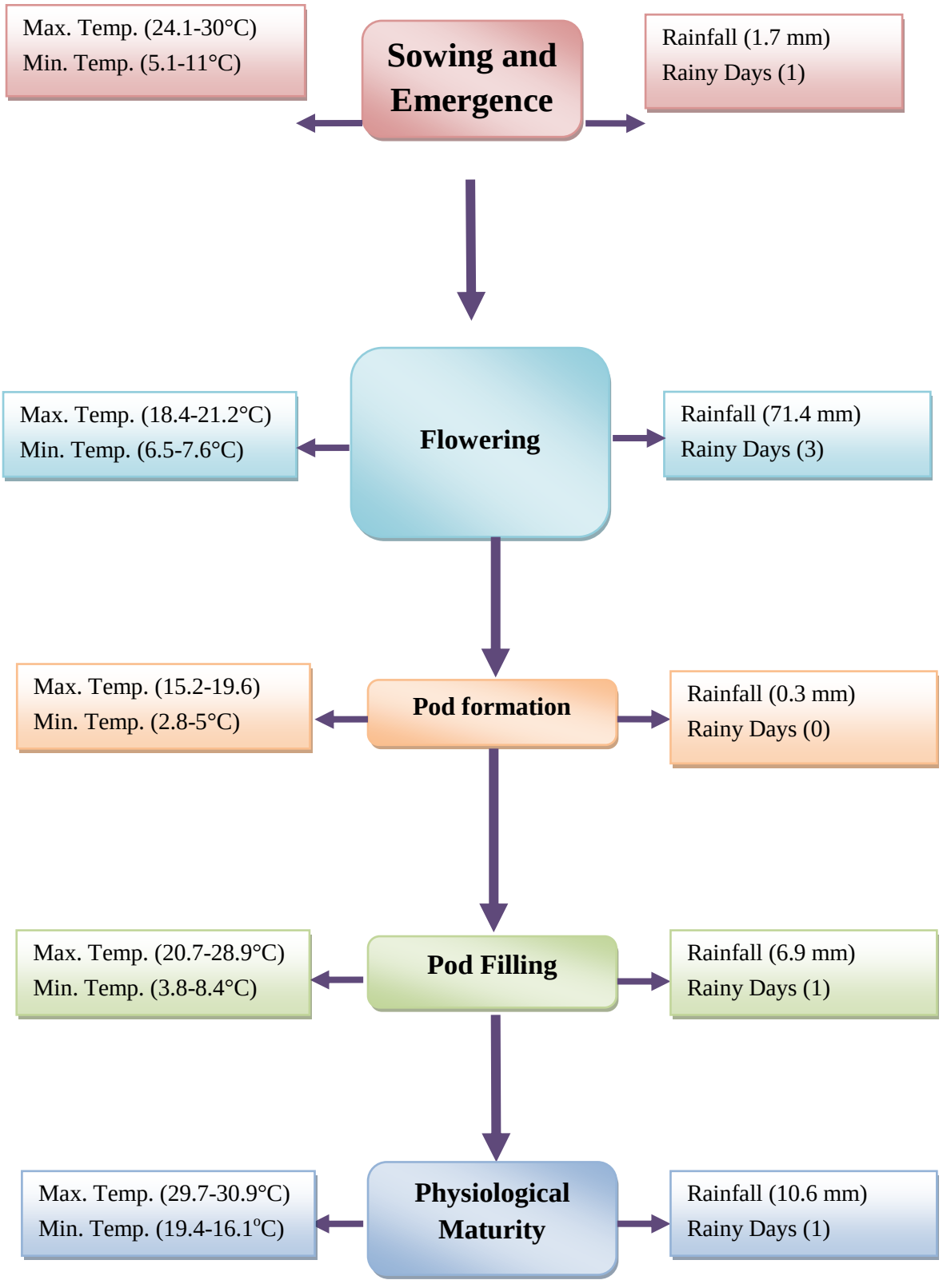

Figure 4.3 Weekly Thumb Rule Model for Amritsar for prediction of potential yield of mustard

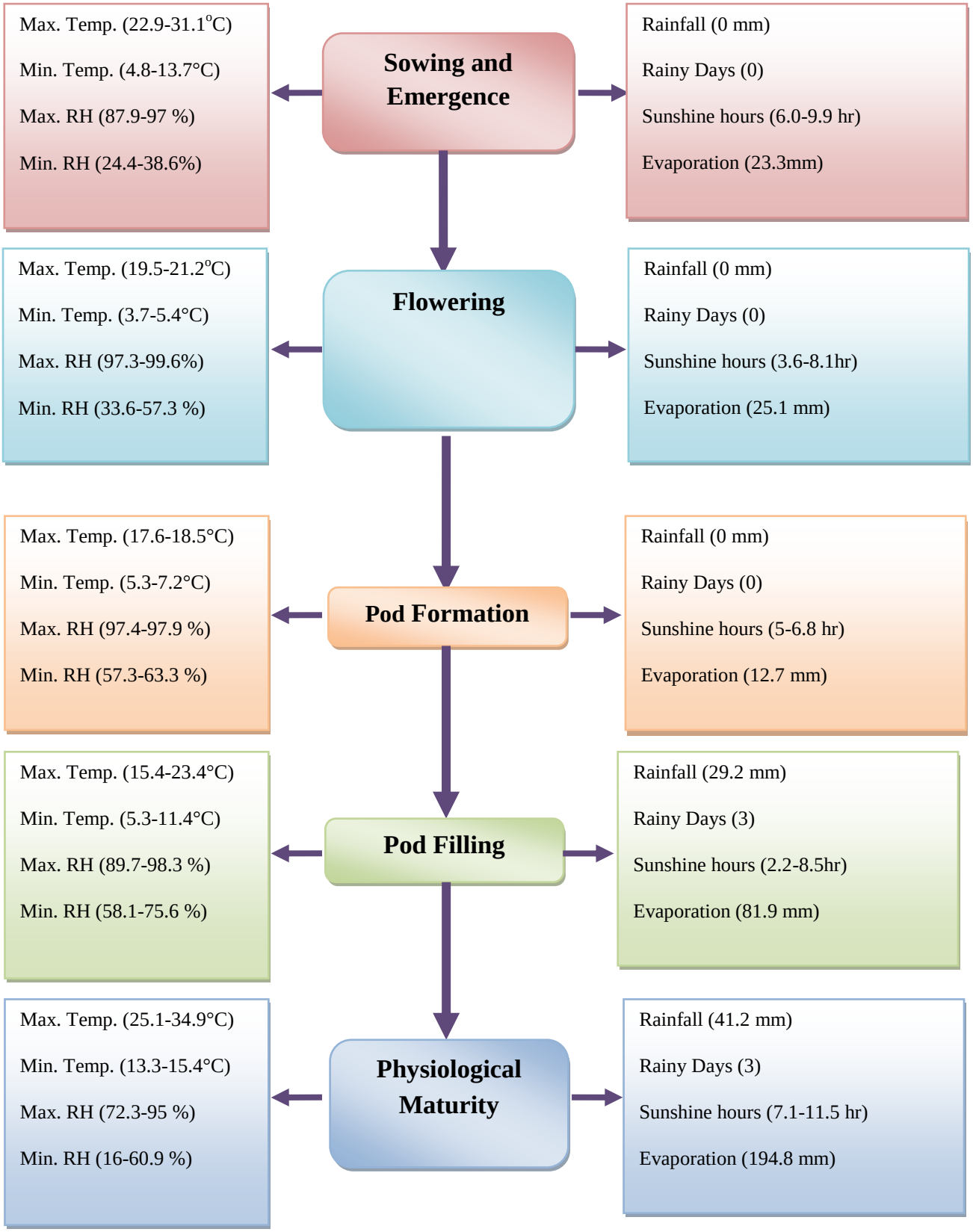

Figure 4.4 Weekly Thumb Rule Model for Ludhiana for prediction of potential yield of mustard

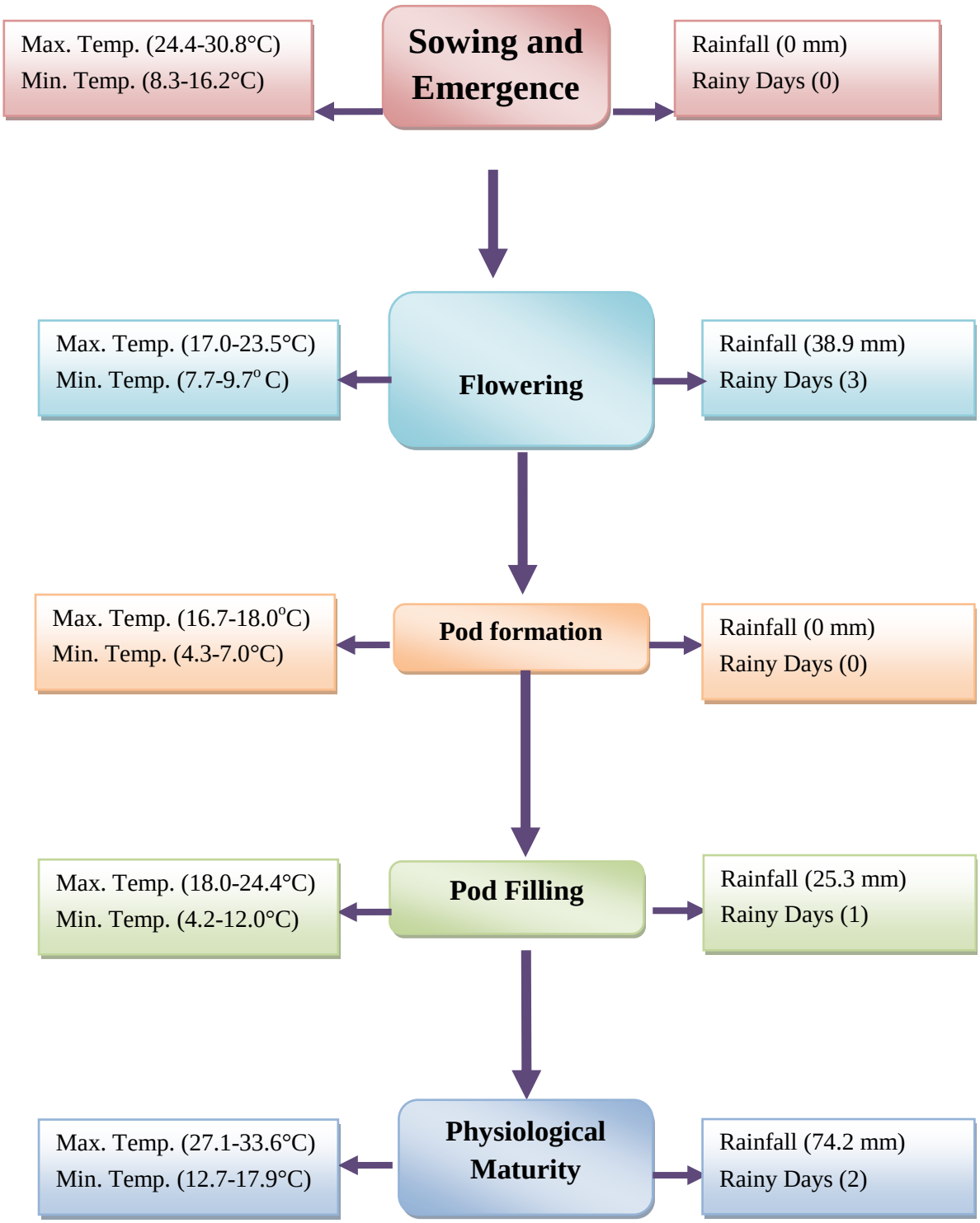

Figure 4.5 Weekly Thumb Rule Model for Patiala for prediction of potential yield of mustard

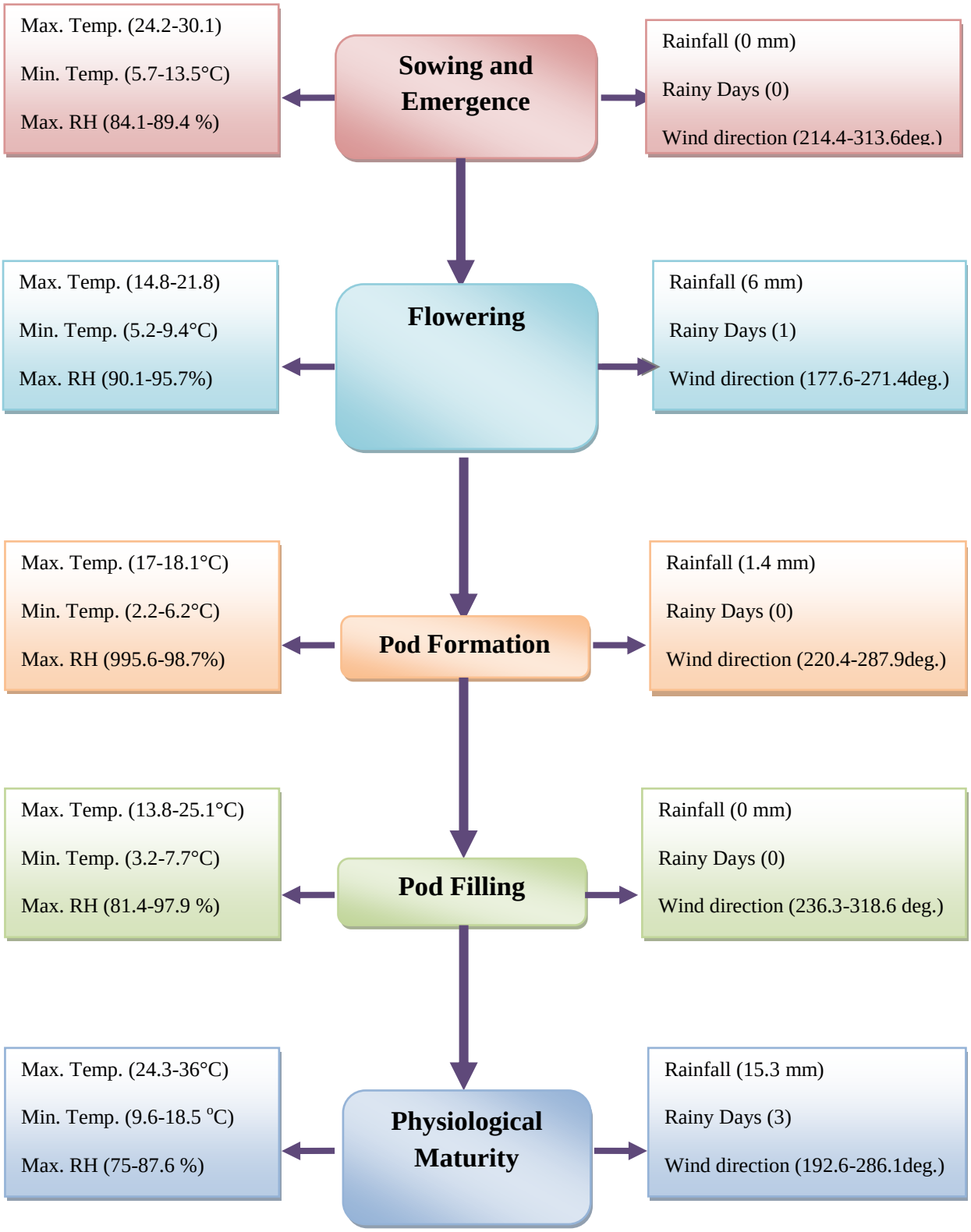

Figure 4.6 Weekly Thumb Rule Model for Bathinda for prediction of potential yield of mustard