Crop-weather models during the “Kharif Season” under the rainfed conditions of Hissar region

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ABSTRACT

The Kharif crop-weather models have been prepared utilising the water availability periods, the climatic water balance parameters, the accumulated soil moisture, weather parameters and the performance of the Kharif crops under the different climatic situations prevailing during the above normal, normal and sub-normal years of rainfall. Crop production strategy has been suggested for each of these situations.

INTRODUCTION

In order to develop a crop production technology it is necessary to quantify the availability of water and manage it with suitable agronomical practices. Bishnoi (1975) studied the reliability, deficiencies and excesses of rainfall during the S. W. Monsoon season; and the probability charts for the occurrence of rainfall of less than 100, 200, 300, 400 and 500 mm indicated the confidence with which these amounts of rainfall could be expected over different regions of the state. Bishnoi et al. (1972) studying the rainfall pattern at Hissar, observed the wide variation in the amount and distribution of Kharif rainfall. Thus, there is a need for a flexible crop planning for dry land areas closely linking the crop planning, cultural practices and fertilization with the receipt of the rain.

Dastane et al. (1970) while working out cropping pattern under dryland farming presented a model to fit a crop under the given conditions of moisture storage, evapo-transpiration and moisture exploring capacity of the roots; and stressed the importance of soil moisture balances under such situations. Virmani (1973) prepared some models in this direction utilising water availability calender based on soil moisture percentages with respect to wilting stage and hygroscopic coefficient, and the weather parameters. But in these models, the soil moisture status was depleted at the normal values of potential evapotranspiration rate till
The weather elements such as maximum temperature, mean relative humidity, sunshine hours, pan evaporation have been superimposed so as to visualise their influence on water availability periods and crop performance at various growth stages. The performance of Bajra (*Pennisetum typhoides*), Moong (*Phaeolus auritus*), Guar (*Cyamopsis tetragonaloba*) and Cowpea (*Vigna sinensis*) under dryland agriculture conditions have been revealed.

**RESULTS AND DISCUSSION**

The analysis of productive environment parameters such as the water availability periods, climatic water balance parameters have been given in table 2 during the various types of situations during the S.W. Monsoon season at Hissar, whereas their distribution during the various crop growth phases so as to influence the performance of various crops and role of agronomic practices have been graphically depicted in the figs. 1-4. The behaviour of *Kharif* crops Bajra, Moong, Guar and Cowpeas and the role of different agronomic practices are given in table 3.

During the above normal years of rainfall, the water availability periods of 73 days without moisture stress and 18 days with moderate water stress have given sufficient period to tailor the *Kharif* crops successfully, even the long duration varieties like Arhar (As-8). During such years mixed cropping of Bajra with Moong, Cowpea and Castor is also successful. The input facilities of fertilizers and agronomic practices of dry sowing, optimum plant population have shown good results during such situation. Intensity of cropping from 150 to 200 percent is feasible by growing fodder crops of Baira, Guar, Cowpeas; Bajra or Cowpea + Moong, followed by a Taramira or Rava Crop thereafter, depending on the availability of soil moisture status in the late September Monsoon rains. The 53 days of humid and moisture period during the vegetative, flowering and grain filling phases of the crop increased the chemical activity for normal functioning of the cells and maintaining of their turgidity. The higher humidity during the season reduces the saturation deficit but has favoured the plant diseases and pests.

During normal years the water availability periods without stress and with moderate stress are of 62 days and 33 days respectively and thus giving a crop growth period of 95 days where the *Kharif* crops can be tailored successfully. The water availability periods are well distributed without any extended dry spells. During such years inter-row water harvesting technique, dry sowing of crops, and transplanting practices have indicated good results to increase the yield potential. Cropping intensity of 100-150 percent is possible with a fodder crop of Bajra,
KHARIF CROP WEATHER MODEL - ABOVE NORMAL YEAR 1970

CROP PERFORMANCE

GERMINATION FLOWERING MATURITY

FLOWERING

VEGETATIVE PHASE

GRAIN FILLING

MAXIMUM TEMPERATURE

MEAN RELATIVE HUMIDITY

25 SUNSHINE HRS.

PAN EVAPORATION (MM)

ACTUAL EVAPOTRANSPIRATION (863 MM)

WATER DEFICIT (761.7 MM)

WATER SURPLUS (160.7 MM)

SEASONAL HUMIDITY INDEX

ARIDITY = 42.9

MOISTURE = 24.9

WATER AVAILABILITY CALENDAR

HUMID PERIOD = 62 DAYS

MOIST = 12 DAYS

MODERATELY DRY = 18 DAYS

DRY = 9 DAYS

SEVERELY DRY = 4 DAYS

P = PRECIPITATION (228 MM)

PE = POTENTIAL EVAPOTRANSPIRATION (725.5 MM)

P + SMS = SOIL MOISTURE STORAGE

Fig. 1
KHARIF CROP WEATHER MODEL -2 NORMAL YEAR—1971

CROP PERFORMANCE

GERMINATION
FLOWERING
MATURITY

VEGETATIVE PHASE
GRAIN FILLING

23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39

MEAN RELATIVE HUMIDITY
MAXIMUM TEMPERATURE

SUNSHINE HRS.
PAN EVAPORATION

CLIMATIC WATER BALANCE

75
50
25
0

SEASONAL HUMIDITY INDEX
ARIDITY
MOISTURE

HUMIDITY INDEX 12-9
ARIDITY -560
MOISTURE -431

WATER AVAILABILITY CALENDER (DAYS)

28 DAYS HUMID PERIOD
34 MODERATELY DRY
33 MODERATELY DRY
4 DRY
4 SEVERELY DRY

P=PRECIPITATION
P+SMS
P+E=POTENTIAL EVAPOTRANSPIRATION
SMS=SOIL MOISTURE STORAGE

Fig. 2
CROP WEATHER MODEL FOR SIKAR

KNARIF CROP WEATHER MODEL - 3 SUBNORMAL YEAR 1992

CROP PERFORMANCE

GERMINATION

VEGETATIVE PHASE

FLOWERING

GRAIN FILLING

MAXIMUM TEMPERATURE

MEAN RELATIVE HUMIDITY

SUNSHINE HRS.

PAN EVAPORATION (mm)

CLIMATIC WATER BALANCE

WATER DEFICIT (5542MM)

ACTUAL EVAPOTRANSPIRATION (2102MM)

SEASONAL HUMIDITY INDEX 6-2

ARIDITY " 0.725

MOISTURE " 663

WATER SURPLUS (473 MM)

WATER AVAILABILITY CALENDAR (DAYS)

HUMID PERIOD 22 DAYS

MOIST 19 "

MODERATELY DRY 6 "

DRY 10 "

SEVERELY DRY 23 "

P, PRECIPITATION (2245 MM)

PE = POTENTIAL EVAPORATION 7647 MM

SMS, SOIL MOISTURE STORAGE

Fig. 3
Kharif Crop-Weather Model -4 Subnormal Year-1973

Crop: Yields (in kg/ha)

- Bajra (H.3) 84
- Guar (FS-277) 50
- Moong (JAM- 
- Har-43) 7.3
- Cowpeas (FS-68) 4.7

Crop Performance

Germination, Flowering, Grain Filling, Vegetative Phase, Maturity

RH, 100 Maximum Temperature°C, Mean Relative Humidity, Sunshine Hrs., Pan Evaporation (MM)

Climatic Water Balance

Water Surplus (21.6 MM), Water Deficit (58.5 MMI), Actual Evapotranspiration (38.7 MM), Moisture Storage

Water Availability Calendar (Days)

Seasonal Humidity Index, Aridity, Moisture

Humid Period 15 Days
Moist 17
Moderately Dry 11
Dry 10
Severely Dry 20

Precipitation (1936 MM)

P = Potential Evapotranspiration
S = Soil Moisture Storage

Fig. 4
Cowpea; Moong + Bajra or Cowpea + Bajra in the *Kharif* season on ridges and Taramira in the ditches with the late September rains. Also during the years when early cessation of Monsoon takes place with normal rainfall, the water availability periods at maturity are reduced. The crop will show performance similar to the above situation, but at the maturity stage less amount of water will be available to crops and the yield potential of the crops are reduced.

During sub-normal years of monsoon rainfall with normal onset in the early July but early cessation by the end of August, the water availability periods without and with moderate stress are of 41 and 6 days respectively. Thus water availability periods have been curtailed to 47 days and therefore the short duration legumes crops have shown better performance. The 19 days of moisture stress period during the early vegetative phase has given rise to high saturation deficit so as to effect the plant population. The mortality in Bajra, Moong and Cowpea Guar was 30, 20 and 15 percent respectively, thus reducing the plant population. Again at the maturity stage the crops are based on the available stored moisture. Grain size and yields are reduced considerably due to premature drying of the crops caused by the continuous drought during the reproductive phase of the crop. During such years only one crop is possible either *Kharif* on the current rainfall or a *Rabi* crop on the conserved moisture. Short duration and drought tolerant varieties of crops are highly desired during such situations.

Also during the sub-normal years with delayed onset of the S.W. Monsoon rainfall, the water availability periods without and with moderate stress are of 32 and 11 days respectively; thus overall supplying 43 days for successful tailing of *Kharif* crops. During such years the crops can show a good performance on account of light intermittent showers without any extended dry spell as during 1973. The 10 days of water stress period at germination stage and maximum temperature above 40°C has effected the germination of crops. Again during the late vegetative phase and early flowering, the 17 days of water stress period has reduced the number of flowers. During early vegetative phase crops are without stress and floral premordias are formed. These floral premordias during the early flowering stage will decide the number of flowers in the plant and due to the water stress during this period number of flowers in the plant are reduced. During such situations crops under late sown conditions has performed better. Only one crop is possible during such situation either *Kharif* on current rainfall or a *Rabi* crop on the conserved moisture storage. Short duration varieties, fodder crops, highly drought tolerant crops are required during such situations.
<table>
<thead>
<tr>
<th>Parameter</th>
<th>above normal rainfall year with normal onset of monsoon years 1970</th>
<th>normal rainfall year 1971</th>
<th>sub normal rainfall year with normal onset and early cessation year 1972</th>
<th>sub normal rainfall years with delayed onset year 1973</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. Mixed cropping yield (q/ha) Bajra + cowpea + castor</td>
<td>Pure Bajra crop gave better yield otherwise yield was reduced by 2 to 3 q/ha</td>
<td>Not Successful.</td>
<td>Not Successful.</td>
<td></td>
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<tr>
<td>Bajra + Guar.</td>
<td>22.15</td>
<td>—</td>
<td>1.00</td>
<td>—</td>
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<tr>
<td>Bajra + Moong</td>
<td>21.05</td>
<td>—</td>
<td>1.07</td>
<td>—</td>
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<td>4. Long duration varieties performance Arhar (q/ha)</td>
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<td>Did not show any result on Bajra</td>
<td>Inter row water harvesting with 60 cm. ridge and 40 cm. furrow in Bajra gave increase 45% yield</td>
<td>Promising increase 24% in Bajra, 13% in Guar, 39% in Moong</td>
<td>Promising 13% in Bajra, 19% in Guar, 75% in Moong</td>
<td>—</td>
</tr>
<tr>
<td>6. Fertilizer use Nitrogen</td>
<td>100% N/ha gave 21.5% higher yield of Bajra</td>
<td>Linear up to 120 Kg. N h/a in Bajra.</td>
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<td>Phosphorus</td>
<td>100 Kg. P₂O₅/ha gave 39% higher yield.</td>
<td>80 Kg. P₂O₅/ha gave 50% increase in Moong yield.</td>
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<tr>
<td>7. Other feasible agronomic practices</td>
<td>Dry sowing, relay cropping, transplanting</td>
<td>Mulching, Dry sowing, Transplanting.</td>
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<td>8. Intensity of cropping</td>
<td>150 to 200% feasibility.</td>
<td>100 to 100%</td>
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<tr>
<td></td>
<td></td>
<td>150%</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>100%</td>
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