This volume presents the abstracts of the papers submitted to the Third Indian Agrometeorological Congress to be held at Central Institute of Fisheries Technology, Cochin during 28th to 30th April, 1988, on the theme "Agrometeorology in SAARC Countries", organised jointly by Kerala Agricultural University and Indian Agrometeorological Society.

Dr. P. BALAKRISHNA PILLAI
General Convener
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SESSION I

AGROMETEOROLOGY IN SAARC COUNTRIES

THE ROLE OF WMO IN THE DEVELOPMENT OF AGRICULTURAL METEOROLOGY WITH SPECIAL REFERENCE TO SOUTH-ASIAN COUNTRIES

V. KRISHNAMURTHY, WMO, GENEVA

Climate and weather variability play an important role in determining the physical productivity of agricultural crops, livestock and forests, and in the risk of failure of the production. The success and failure of agricultural projects depend on many factors-finance, man and machine power, transport, soils, choice of crops, pest and diseases - most or all of which are weather sensitive. Pre-project Planning, Investment Planning, Project Implementation, Project Management, Project Operation and Project Appraisal/Revision, all require agrometeorological input.

For the last three decades, the world Meteorological Organization has concentrated its efforts to increase the capability of members towards the provision of meteorological and climatological assistance and comprehensive services to agriculture. The paper presents details of such assistance.

AGRO-METEOROLOGICAL RESEARCH REQUIREMENTS FOR IMPROVING CROP PRODUCTIVITY IN SAARC COUNTRIES.

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Vagaries of weather have been mainly responsible for high fluctuations in crop yields in SAARC countries. Effects of recent droughts since 1965 on agricultural production have been discussed. Possible methods to overcome this situation are the

study of agrometeorology of the region and adjust crop production to suit the climate and development of management practices to suit climatic conditions. For this purpose, a better insight into the effects of various environmental factors on crop production and the influence singly as well as in combination of physical processes such as radiation, momentum transport, heat and water are required. These ideas with respect to each process have been elaborated and illustrations of some of the research work carried out by the author have been given. Use of systems analysis approach for assessment of agro-ecological potentials of crop production has been stressed. A review of present status on crop weather modelling in respect of important crops has also been presented.

AGROMETEOROLOGICAL SERVICE IN SAARC COUNTRIES

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SAARC countries are included in developing countries. Agriculture is the main resource of livelihood in these countries. Agriculture mainly depends on monsoon rainfall. Due to the vagaries of monsoon rainfall, floods or droughts disrupt completely the economy of these countries. Establishment of Agrometeorological Observatories, collection of data, their analysis, establishment of crop-weather relations and ultimately advice given to the farmers have a great impact on these developing countries. Survey of these alongwith the services available at the farmer's door-step are presented in this paper.

A PRELIMINARY STUDY OF AGROMETEOROLOGY IN SAARC COUNTRIES.

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Of the seven countries constituting SAARC, five of them-namely India in the middle with Bangla Desh and Pakistan on either side and with Himalayan countries of Nepal and Bhutan to its north, are situated in a contiguous land mass forming the Indian Sub-continent. Among the remaining two, the island of Sri Lanka lies close to the Indian Peninsula separated by Palk Strait, while the group of isles of Maldive is situated in the Indian Ocean about 650 kilometres South-West of Sri Lanka.

The paper deals with the Climate, Agro-Climatic Zones and Land Utilisation in these countries. The status of crop and animal husbandry, forestry and fisheries are broadly indicated. The average area and yield of important crops, their variability and relative performance in various agro-climatic zones have been brought out. From the available information, an attempt has been made to evolve sound stratagies to optimise and stabilise production of these agricultural crops in different agro-ecological zones.

FUTURE CLIMATE CHANGES - A NEW CHALLENGE FOR INDIAN AGROMETEOROLOGISTS

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The variability of the climate, the changing annual weather pattern rules the daily work of the agrometeorologist. The fluctuations have their maxima and minima, the frequencies and their correlations to crop yields, pest performance, flooding catastrophies, drought and so on. Establishment of a well functioning observer network along with the improved utilization of remote sensing techniques, especially with satellite mounted sensors and improved application of computer models help in answering the above challenges.

One improtant point discussed among the climate modellers is the possible climate change caused by anthropogenic changes of the CO2. For agrometeorologists, CO2 is a production controlling growth substance. The temperature increase of about 0.5 to 0.9° C possible caused by increasing CO2 from 285 ppm in 1860 to 340 ppm in 1980 is still not yet clear. The temperature increase, however, is very likely to be shown and the agrometeorologists are to observe changes in plant and pest behaviour which could give clues to the behaviour of the biosphere as a whole and to crops in particular. Since fossil fuel is still the safest energy source, the increase of CO2 may even be accelerated when developing countries raise their energy consumption. India may be one of the hardest hit countries by the directions of the climate changes predicted so far. All the more important is the work of Indian agrometeorologists.

The change in land use patterns are a possible cause for global climate changes in several ways. The change in land use is especially important on a global scale when forest is changed

into cultivated land. Satellite remote sensing may become a major tool in monitoring global changes. The impact of a predicted climate change on crops and husbandry is to be the important future research objective. Computer models have to be developed to descern the influence of different environmental parameters upon the same process of a given plant or animal. The change of CO_2 levels in the atmosphere may also cause a change of chemical reactions within plants, such as change in the uptake of minerals.

Ahead of us lie many changes in atmospheric qualities and climatic components. These changes are significant enough to influence the quantity and quality of agricultural products. we should be alert and report changes that occur and plan for alternative cropping systems to drier and wetter and warmer climates. We should also pay attention to the frequency and extent of maxima and minima to early or late frosts, and to the possible changes in the timing of the monsoon.

SESSION II

CLIMATE AND CROPS

INFLUENCE OF METEOROLOGICAL PARAMETERS ON LOW LAND RICE PRODUCTION

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A field experiment was conducted at the Tamil Nadu Agricultural University, Coimbatore during the South West Monsoon and Summer seasons of 1985-86 to identify the weather parameter responsible for the individual growth or yield parameter of rice as well as to evaluate the climatic influence on the stage of crop growth which contributes to the grain yield during different periods of the year and closeness of their relationship. The variety IR 50 was transplanted at six and five fortnightly intervels in the above seasons. Correlation coefficients worked between growth attribute and meterological parameters revealed positive association of plant height at harvest and leaf area index at flowering with minimum temperature and mean temperature summation, respectively at vegetative phase. Plant height had a negative relation with solar energy sources but LAI was positively correlated. Duration from planting to flowering was positively correlated with air temperature range and max:min temperature ratio at the vegetative phase. The ripening phase duration showed a negative association with minimum temperature of this phase. The yield attributes like panicles m^{-2}, grains m^{-2}, degree of ripening, filled grain percentage, panicle weight and grain yield showed a negative correlation with minimum air temperature at reproductive and ripening stages. However, they had a positive association with solar energy sources at these stages. The mean relative humidity during these stages exerted a negative influence on the above characters. However, the partial correlation coefficients worked indicated that its effect was masked either by solar energy or temperature.

EFFECT OF TEMPERATURE ON THE DURATION OF VEGETATIVE PHASE OF POPULAR LOW-LAND RICE VARIETIES GROWN IN THE KASARAGOD DISTRICT OF KERALA.

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The duration of vegetative phase from transplanting to flowering seems to widely vary from one season to another and from period to period depending upon the planting time in the same season even in photo-insensitive rice varieties. If the soil properties, maintenance of water in the field, fertilizer application and variety are same, the duration of vegetative phase may depend on prevailing air temperature in that particular crop growth period. To understand the influence of air temperature on the duration of vegetative phase, a field experiment was conducted at the Regional Agricultural Research Station, Pilicode under different planting dates in Kharif and Rabi from 1984 to 1987. The rice vaerieties selected for this study were Jaya and Thonnooran which are photo-insensitive and grown in the low-land areas of the Kasaragod district of Kerala.

The mean number of days required for vegetative phase was only 57 days in case of Thonnooran and Jaya took 72.5 days in Kharif 1987, compared previous years 1984, 1985 and 1986 when the duration of vegetative phase of Thonnooran and Jaya around 62 and 82 days, respectively. This was possibly due to relatively high maximum (30.3°C) and minimum (24.4°C) temperatures recorded during the vegetative phase in Kharif 1987. The vegetative phase of Jaya was 78 and 68 days when transplanted on 8-6-87 and 20-7-87, respectively. It was only 58 and 55 days in case of Thonnooran. It was noticed that the duration of

vegetative phase in both the varieties was much less in Rabi when compared to that of Kharif. The number of days required for vegetative phase was significantly less when the maximum temperature was more than 31°C.

A significant negative correlation at 0.001 level existed between the maximum temperature and the duration of vegetative phase in both the varieties. It also indicated that the maximum temperatrue had a higher negative correlation than that of minimum and mean air temparatures with duration of vegetative phase. A simple regression equation ($r = -0.9219$ for Jaya and -0.8211 for Thonnooran) was fitted for estimating the duration of vegetative phase using the maximum temperature for both the varieties. The number of growing degree days or heat units which is dependant on the mean air temperature and base temperature could not explain the duration of vegetative phase as it appeared to be more dependant on the maximum temperature.

SOME ASPECTS OF AGROCLIMATOLOGY AND MANAGEMENT OF WATER RESOURCES AND PESTS FOR SUSTAINED GROWTH OF PADDY IN CAUVERY DELTA, TAMILNADU

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The Cauvery delta covers an area of about 9,000 Km^2 and is located in the Thanjavur district of Tamilnadu. The water balance elements of the delta are studied using Thornthwaite and Mather (1955) water balance book keeping proccdure. The delta receives an average rainfall of about 950 mm per annum. The water loss in the form of evapotranspiration is about 1694 mm per

annum. The average water deficit per annum is about 549 mm. The delta is provided with very good irrigation facilities since from eighteenth century. Paddy is the predominant crop and is cultivated in three periods namely Kuruvai (short duration), Thaladi and Samba (long duration). The average yield is about 5,500 Kgs per hectare during kuruvai period but the yield has reduced to about 3,500 Kg per hectare during Thaladi and Samba periods. Recent water crisis in the delta due to low inflow into the Grand anicut has changed the cropping pattern and farmers have to switch over to turn system in the vennar, vettar and Grand anicut canal systems. The pest is affected during Kuruvai, Thaladi and samba periods. The common pest is the stemborer. There has been an accelerated increase in the consumption of fertilisers and pesticides in the recent decade. Therefore, in the present study an attempt is made to describe the agro-climatic elements, water and pest management for sustained growth of paddy in the cauvery delta.

AGROCLIMATIC DATA BASED PLANNING FOR SUCCESSFUL RAINFED RICE CULTIVATION - A CASE STUDY FOR CHHATTISGARH REGION

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In the Chhattisgarh region of Eastern Madhya Pradesh rice is grown in about 4 million hectares out of which only 20 per cent area is under irrigation and the rest of the area is under rainfed situation. There is a lot of soil variability ranging from lateritic through sandyloam, clay loam and clayet soils within a range of a kilometer or two. Traditionally farmers grow long duration, tall and photo sensitive varieties which flower by mid October and mature by mid to end of November depending upon the

temperatures. Monsoon withdraws by the third week of September and the success of rice crop mainly depend on the October rain due to cyclonic activity in the Bay. As such drought is a recurring feature for rainfed rice crop.

In view of this, based on the stable rainfall periods and rainfall distribution pattern encompassed with the soil characteristics, areas at different block level of each district were identified where rainfed rice crop is highly successful, successful, failure and need immediate crop diversification.

WEATHER PICTURE OF AZOLLA GROWING LOCATIONS OF KERALA

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R. A. R. S. Pattambi

In order to study the influence of weather conditions on the growth and establishment of azolla, a detailed survey was undertaken in Kerala during 1980. Fluctuation in mean-maximum temperature was narrower during the azolla growing and non-growing periods at Kayamkulam, where the coverage under azolla was maximum. Kayamkulam had higher mean relative humidity value and narrower fluctuation than those of Pattambi, where the coverage of azolla was minimum. A higher rainfall during the non-growing season, followed by a well distributed rainfall during the azolla growing season as experienced at Kayamkulam was found to be favourable for the growth of azolla. Soils of azolla growing locations had lower contents of clay compared to non-growing locations. Soils of azolla growing locations had higher pH values and P contents. A similar trend was noticed in the pH and P contents of water also.

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GEOMETRY OF PLANTING RICE TO FAVOUR GROWTH OF AZOLLA AS INTERCROP UNDER TROPICAL CONDITION

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Effect of geometry of planting rice on the growth of azolla was studied during the rabi season of 1980 and kharif and rabi seasons of 1981. Maximum growth of azolla was in the bulk method (equidistant planting) and the line planting methods which were more labour intensive and cumbersome were only either on par or inferior to this method. Planting in bulk method resulted in the higher light interception and lowest water temperature. Under tropical condition as in Pattambi where temperature and solar radiation are high, bulk method of planting rice already adopted by the farmers needs no modification for growing azolla as an intercrop.

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ESTIMATION OF GLOBAL SOLAR RADIATION FROM METEOROLOGICAL DATA OVER WHEAT IN INDIA

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Global solar radiation was estimated using Augstrom formula in prescott's modification and by incorporating factors other than n/N that affect the daily global radiation on a horizontal surface, for 18 meteorological stations over wheat season in India. Analysis showed that in the area responsible for 90% wheat production the n/N factor could account for only 3.2 to 57.2% variation in global solar radiation. Also, emperical coefficients 'a' and 'b' were neither statistically related to n/N nor their sum was constant.

The inclusion of other factors such as temperature range, rainfall rate and solar elevation alone or in combination improved the prediction ability of the relationship and could account for 59.6 to 99.8% variation in global radiation. Emperical models to estimate global radiation in different parts of the country are suggested.

RELATIONSHIP OF NET RADIATION TO GLOBAL RADIATION OVER WHEAT, MUNG AND GRASS IN DELHI

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In the present paper, the regresssion equation between day time hourly net radiation and global radiation have been deduced over wheat, summer mung and grass in Delhi. The relationships were found to be highly co-related with coefficient of determination (r^2 value), 0.979, 0.952 and 0.954 over wheat crop under clear sky boot leaf stage, clear sky anthesis stage and cloudy sky soft, dough stage respectively; 0.927 and 0.940 over summer mung under clear and cloudy sky conditions and over gross the values were 0.939 and 0.954 under clear and cloudy sky respectively.

The day time short wave and longwave components of the net radiation have been computed. Short wave radiation reflected from the wheat canopy was found to be 14 to 21 per cent of the global radiation, 20 to 25 per cent over summer mung and 23 per cent from grass. The net outgoing day time long wave radiation was between 19 to 22 per cent of globel radiation on clear days and 16 per cent on cloudy day over wheat crop whereas it was 23 per cent on clear day and 10 per cent on cloudy day over summer mung. The day time hourly and average values of canopy temperature, air temperature and sky temperature on clear & cloudy days have also been discussed.

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SOME PHYTOMETEOROLOGICAL ASPECTS OF WHEAT (Triticum aestivum L.) AT ANAND (GUJARAT)

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An attempt has been made to study some of the phytometeorological aspects of wheat (Triticum aestivum L. var. HDM-1553). A field experiment was conducted during the years 1981-82, 1982-83 and 1983-84 with two dates and two methods of sowing in winter season at Gujarat Agricultural University, Anand. In the thermal regime the accumulated values of growing degree days (GDD) and photothermal units (PTU) were computed by measuring the daily maximum and minimum air temperatures and evapotranspiration (ET) was measured by gravimetric soil moisture measurements and same was used for computing soil moisture growing degree days (SMGDD). Photosynthetically active radiation (PAR_M) and solar radiation (Rs_M) were measured with the help of integrated solar radiatiometer for a part of the experimental period.

The average ratio between PAR_M/Rs_M was obtained as 0.512. The accumulated values of solar radiation and photosynthetically active radiation served as better indices compared to the thermal and moisture regimes. The meteorological indices of thermal regime viz., ΣGDD, ΣPTU and ΣSMGDD gave negative non-significant correlations with grain yield and biomass production whereas measured ΣET gave significant positive correlations in almost all the phases of the crop growth. The positive significant correlation were also obtained with PAR_E and Rs_E with the grain yield and biomass production.

EVAPOTRANSPIRATION BY WHEAT - COMPARISON OF SOME DIRECT AND INDIRECT METHODS

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Evapotranspiration (ET) from irrigated wheat (var. HD 2329) was measured using weighing lysimeter and profile soil water depletion methods and compared with estimates of potential ET by modified Penman, Papadakis, and Jensen Haise methods as well as evaporation from the open pan. Cumulative estimates of ET by calendar weeks, crop growth stages, and seasonal totals were obtained. A total of 309 mm. seasonal ET was found with the lysimeters, Soil water depletion gave ET of 433mm, thus over estimating it by 124mm. Seasonal potential ET was 328mm by modified Penman method, 314mm. by Papadakis method and 437 mm by the Jensen Haize mathod. The PET estimates by modified Penman and Papadakis methods matched closely with the actual ET. The seasonal crop co-efficients of 0.94, 0.98, 0.82, and 0.71 were obtained with modified Penman, Papadakis, open pan evaporation and Jensen Haise methods, respectively. The time trends in ET by various methods indicated that modified Penman method gave the estimates nearest to actual ET except during early period of crop establishment and later nearing maturity of the wheat crop.

EFFECTS OF SOIL MOISTURE REGIMES ON CROP MICROCLIMATE, WATER USE AND GROWTH OF WHEAT

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Wheat (HD-2329) was sown after a pre-sowing irrigation and was maintained following crown root initiation at four differ-

ent moisture regime treatments, namely: 1_0 with no irrigation (rainfed) throughout the crop season, 1_1 with irrigation scheduled at $\frac{IW}{CPE} = 0.5$, 1_2 with $\frac{IW}{CPE} = 1.0$ upto booting stage and 0.5 thereafter, and 1_3 with $\frac{IW}{CPE} = 1.0$ throughout the crop season. Soil moisture samples were taken before and after each irrigation from the 0-180 cm depth. Micrometeorological observations were recorded at representative crop growth stages and biometric observations were made at regular intervals during the crop season. The energy balance components of net radiation, sensible heat flux, and latent heat flux at different growth stages in 1_3 treatment always exceeded those for the 1_0 treatment. The 1_3 treatment provided the most favourable microclimate for plant growth and yield, as it intercepted maximum solar radiation and experienced lower canopy temperatures, higher leaf water potential, and higher soil moisture status. Water use efficiency of 86 Kg ha^{-1} cm^{-1} was found to be the highest under the 1_3 moisture regime as compared to the lowest value of 68 Kg ha^{-1} cm^{-1} for the rainfed treatment. The 1_3 moisture regime yielded 4.10 t/ha, whereas comparable grain yields in 1_2, 1_1 and 1_0 treatments were 3.80, 3.45, and 2.63 t/ha, respectively.

EFFECT OF MOISTURE REGIMES ON CROP MICROCLIMATE, EVAPOTRANSPIRATION AND GROWTH OF MAIZE

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Field studies with maize (cv. Partap) were conducted at Punjab Agricultural University, Ludhiana during kharif 1986 and 1987. Four soil moisture regime treatments were imposed 30 days after sowing, namely: rainfed (I_0) and three differentially irrigated treatments in which irrigation was scheduled at cumulative pan evaporation of 100 mm (I_1) 75 mm (I_2) and 50 mm (I_3),

respectively. Data were collected on lysimetric evapotranspiration, soil moisture status, canopy temperature, net radiation above canopy, reflection, transmission and interception of solar radiation by the crop canopy. Biometric observations were made for various plant parameters. The I_1, I_2 and I_3 treatments received 2,3 and 4 differential irrigations, respectively in 1986 while 2,3 and 5 irrigations became due in 1987. Seasonal evapotranspiration from I_3 treatment was found to be 344 mm in 1986 and 337 mm in 1987. Net radiation was highest in the I_3 and lowest in the I_0 treatment whereas canopy temperatures followed the reverse trend showing as much as 9 to 10° C difference at mid day. Little differences occurred in solar radiation reflection by the treatments. Radiation interception was highest and transmission to ground the least for the I_3 treatment followed in order by the I_2, I_1 and I_0 treatments. The increasing soil moisture status and solar radiation interception from I_0 to I_3 treatment showed a direct postive influence on growth parameters of plant height, ear length and weight, cob number, 100-grain weight, grain and stover yields of maize. Grain yields were 0.31, 0.70, 0.96 and t/ha in 1986 and 0.35, 0.54, 0.83 and 1.40 t/ha in 1987 for I_0, I_1, I_2 and I_3 treatments, respectively.

INFLUENCE OF CERTAIN ATMOSPHERIC AND SOIL PARAMETERS ON LEAF WATER STATUS OF WINTER WHEAT.

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Winter wheat was grown on the alluvial loam soil of the IARI Farm. Two temperatures and two moisture regimes were maintained by insulating and by weighing pots respectively. It was found that soil temperature influenced leaf water potential and water consumption under non-stressed treatments. Leaf

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water potential was found to be significantly correlated with soil water potential. (69% and 56%) and gravimetric moisture content. Inclusion of relative humidity and average aerial temperature along with gravimetric moisture content improved percentage estimation of leaf water potential, eventhough the most important factor was gravimetric moisture content. (56.4%). Average day soil temperature was found important in determinig the magnitude of leaf water potential. Stomatal resistance measured were significantly correlated with relative humidity and leaf water potential. For wheat there is a gradual decrease in leaf water potential with crop growth.

ASSESSMENT OF CROP WATER STRESS IN WHEAT AND ITS RELATIONSHIP TO YIELD

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Stress Degree Day (SDD) and Crop Water Stress Index (CWSI) in relation to yield of winter wheat during 1985-86 were studied using canopy temperatures measured by an IR thermometer at Anand. The crop was subjected to different stressed conditions under six different irrigation treatments. It was observed that during the growing season, canopy temperatures were always low in non-stressed treatment and high in stressed treatments. The crop with less stressed and non-stressed treatments did not have a single day with canopy—air temperature differential (Tc-Ta) approching zero, whereas, in stressed treatment, positive values of Tc-Ta prevailed for about 12 days between 35th and 49th day after sowing. This was the period of jointing and flowering phase and, therefore, indicated that high Tc-Ta values during this period are not preferable for better yield.

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It was also revealed that both the stress indices SDD and CWSI could be used to characterize crop water stress in wheat. Cumulative SDD and mean CWSI attained a maximum value of -149.76 and 0.4651 respectively for stressed treatment. However, non-stressed treatment has a cumulative SDD of —432.62 and a mean CWSI of 0.1551 which indicated that both the stress indices would increase with increasing crop water stress. Both the stress indices have good correlations with the grain yield.

CROP WEED COMPETITION AS INFLUENCED BY THE INTERCEPTION OF SOLAR RADIATION IN SORGHUM - LEGUME INTERCROPPING SYSTEMS

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A field experiment was conducted at the Indian Agricultural Research Institute, New Delhi during 1980 and '81 to study the distribution of solar radiation through canopies of sorghum grown as sole crop and intercropped with different leguminous crops. Observations on the penetration of solar radiation to the ground level, using a Lux meter showed that raising an intercrop in sorghum increases the interception of solar radiation by crop canopy to a great extent. Maximum light interception was observed when sorghum was intercropped with fodder cowpea, followed by grain cowpea, green gram, soyabean and ground nut, in that order. When sorghum intercepted only 25% of solar radiation, 92-94% of incoming light was intercepted by the crop canopy in sorghum + fodder cowpea system, at 35 day stage of the crop. Soyabean and ground nut showed their role in light interception at later stages only. The interception of solar radiation was closely related to the LAI of the crop. The combined LAI of sorghum and intercrop was much higher than that of sole sorghum.

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Decreased light intensity at lower layers due to the higher interception by crop canopy adversly affected the weed growth and competition. Weed population and dry matter production was much less in intercropped plots, and this effect was most pronounced in sorghum + fodder cowpea system. Problem weeds like Cyperus rotundus, Echinochloa colonum and Dactyloctenium aegyptium were very sensitive to shading by the crop canopy, whereas the tall growing weed Digera arvensis was not much affected.

MICROCLIMATIC MODIFICATION FOR WINTER MAIZE

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An experiment was conducted at Ludhiana to study the growth and yield of winter maize with respect to modified microclimate by row orientations and dates of sowing. The performance of the crop sown on 10th Nov. was better in all respect than that sown on 15th Oct. Among the four row orientations, viz. N—S, E—W, NE—SW and NW—SE best results of crop growth and yield were observed in N—S orientation. The energy utilised in sensible heat, latent heat and soil heat was found to be most appropriate in N—S orientation to create more humid and mild microclimate leading to higher leaf area index, taller plants, more biomass and longer grain filling period. The improved crop characteristics due to modified microclimate in N—S orientation resulted 24.4% more test weight and 4.9% higher grain yield than E—W orientation.

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EFFECT OF DATE AND METHOD OF SOWING ON MICROENVIRONMENT, PHENOLOGY AND PERFORMANCE OF WINTER MAIZE

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Field experiments were conducted with maize sown in winter season during 1985-86 and 1986-87. Maize cv. Partap-1 was sown using ridge and flat methods on three dates each year viz. 1st week of November, 3rd week of November and 1st week of December. Soil temperatures were recorded at 5 cm depth during emergence and solar radiation interception was measured at maximum growth stage of the crop. Crop phenological events and biometric observations were also recorded. Mean daily soil temperatures during crop emergence decreased progressively from 22.8°C for Ist to 18.0°C for second and 14.6°C for thrid sowing in the ridge method. The corresponding values for flat sown crop were 20.6, 16.2 and 12.5°C, respectively. Emergence rate decreased drastically as mean daily soil temperatures dropped below 15°C. Solar radiation interception by crop canopy was highest and transmission to ground the lowest for ridge over flat sowing and for early over the delayed sown crop. Days to emergence increased for both sowing methods as the date of sowing was delayed. For late sowing the ridge sown crop emerged early by 4—7 days than the flat sown crop. In general, the ridge sown crop experienced earliness in tasseling by 6—10 days, silking by 7—8 days, and maturity by 4—5 days compared to the flat sown crop. Plant height, dry matter production, cob length, 100—grain weight, grain and stalk yield decreased progressively from Ist to 3rd date of sowing. Compared to Ist sowing, the mean grain yield for second and third sowings was reduced by 10.0 and 21.3 q/ha in 1985-86 and 3.0 and 18.5 q/ha in 1986-87, respectively. The ridge sowing gave 6.5 q/ha higher grain yield than flat sowing in 1985-86 and 7.3 q/ha in 1986-87.

CANOPY TEMPERATURE STUDIES IN PEARLMILLET AND CLUSTERBEAN UNDER DIFFERENT MOISTURE LEVELS

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Canopy temperature studies were carried out in the pearlmillet and clusterbean crops under two moisture levels (rainfed and irrigated). The crops were sown with the first effective showers of monsoon during 1986 kharif season at Haryana Agricultural Research Farm, Hissar. The irrigated treatment plots were watered twice (post sowing). The observations recorded after frist irrigation indicated that the canopy temperatures (T_c) in pearlmillet were higher than the clustarbean and the magnitude of this difference in irrigated crop was more. The difference between canopy temperature T_c and air temperature T_a in clusterbean was narrow (- 3° C) during morning hours (0900 hrs) and widest (-9.7° C) during afternoon hours (1400 hrs). The values of R^2 obtained by corelating vapour pressure deficit (VPD) and the $\overline{T_c} - T_a$ were low clusterbean (0.52) and very low in pearlmillet (0.17).

MICROCLIMATIC STUDIES IN DIFFERENT INTERCROPPING SYSTEMS OF PEARL MILLET AND GREEN GRAM CROPS

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Nine different intercropping systems of pearl millet and green gram were planted during KHARIF season of 1986, at the research farm of the Department of Agricultural Meteorolgy, Haryana Agricultural University, Hissar. The objective was study the micro-climatic variations Viz., temperature, relative humidity and photosynthetically active radiation (PAR) profiles under various intercropping systems. A change of -6 to 10 percent in relative humidity was observed in various treatments in evening hours (1630 hrs) as compared to pure pearlmillet. The relative humidity deviations were higher in the upper foliage layers when compared to lower layers in both morning and evening hours. The temperature profiles were almost reverse to the humidity profiles. In the morning (0800 hrs) the temperature variations in intercrop treatments were in the range of—3·0°C to + 0·5°C when compared to sole bajra crop, whereas this variation ranged from —1·2°C to + 1·5°C at noon hours (1200 hrs). Transmission of photosynthetically active radiation (PAR) was more (22·0%) in the intercrop of bajra and moong (1:3), whereas the absorption was maximum (78·0%) in pure moong treatment. The albedo of the crop was observed maximum (20·0%) in pure bajra treatment plots.

"ASSESSMENT OF PEARL MILLET YIELDS IN ANANTAPUR REGION ADOPTING SOIL WATER BALANCE MODEL"

YOGESWARA RAO. A., DASTAGIRAIH, P. SARMA, Y. R. B,
KRISHNA RAO. K., R. A.S., Anantpur

Field experiments were carried out for a period of 11 years under All India Co-ordinated Research project on Millets at Anantapur Sub-Centre during 1977-87 with a group of hybrid cultivars of Pearl Millet to assess their relative performance and isolate a suitable hybrid for this arid tract. The productivity of one of the promising hybrids, viz., MBH. 110 over the years varied between 0·1 and 29·9 q. Soil water balance model developed by Food and Agricultural organisation was adopted. A close relationship (r = 0·8002) between water use and productivity of Pearl Millet was established. The utility of this model in prediction of yields is discussed.

EVAPOTRANSPIRATION RATES AS INFLUENCED BY THE ADVECTIVE ENERGY IN SUMMER MOONG (VIGNA RADIATA (L.) WILCZEK)

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A field study was conducted to study the effect of advective energy on evapotranspiration rates and yield of moong crop during pre-monsoon summer season 1985 on loamy sand soil. Moong irrigated at 10-day and 20-day intervals was assumed as the unstressed and stressed treatments, respectively. Under the influence of sensible heat advection, the temperature profiles changed from lapse at leading edge to inversion conditions at downwind stations under unstressed conditions, whereas under stressed conditions these profiles, remained lapse at all the stations. The temperature decreased from leading edge to downwind stations, whereas an increase in the vapour pressure was observed from leading edge to downwind stations under both the treatments. However, unstressed treatment kept an edge over stressed one. The ratios of ET/(Rn+S) exceeded unity (>1) under unstressed conditions, showing that the sensible heat advection was towards crop canopy, whereas these ratios were lesser than unity (<1) under stressed conditions where only two-third of the Rn was utilised in ET process. The remaining Rn was changed to sensible heat and the flux was away from the canopy. In addition to the Rn available at the crop surface, the sensible heat contributed 61 per cent of Rn under unstressed and 13 per cent of Rn under stressed treatments towards the ET process.

MACRO ENVIRONMENTAL IMPACT ON GROWTH, REPRODUCTIVE EFFICIENCY AND YIELD IN CHICK PEA (CICER ARIENNUM. L)

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A study on the influence of temperature on four sowing dates at fortnightly intervals from first week of October on three chickpea cultivars, raised in the fields of Indian Agricultural Research Institute, New Delhi, revealed that date of sowings beyond third week of October reduced flower number, flower duration, crop duration, biomass production as well as morphological and yield attributes. The temperature minima and maxima of 12°C and 20°C, 12.5° C and 25°C were conducive for flower production and pod development respectively. The vegetative phase was most sensitive to temperature. A fixed percentage of temperature indices of total crop duration is proportioned at vegetative phase and this remained unaffected by temperature; however, in case of reproductive phase marginal variations occured at extreme temperatures. Heavy shedding of flowers caused low reproductive efficiency in early sown crop.

"PREDICTION OF GROUNDNUT PRODUCTIVITY IN ARID REGION OF ANANTAPUR USING SOIL WATER BALANCE MODEL"

YOGESWARA RAO. A., KRISHNA RAO. K., SARMA. Y. R. B.
R. A. S., ANANTPUR

Field experiments were carried out for 12 years during 1971-82 under All India Co-ordinated Research Project on Dryland Agriculture at the Anantapur main centre to assess the relative performance of a group of promising, long duration, spreading cultivars of Groundnut and isolate a suitable variety to this scarce and highly variable rainfall condition of the tract. Over the years, the productivity of one of the promising varieties viz. Kadiri. 1, varied between 0·9 and 26·7q. Soil water balance model developed by Food and Agriculture Organisation was adopted to derive "water requirement satisfaction Indices (Index-I) over the years. A close relationship (r = 0·8991) was observed between the Groundnut pod yields variation over the years. The utility of this model in forecasting the crop productivity in the arid tract is also discussed.

STUDIES ON SOLAR RADIATION UTILISATION BY SAFFLOWER

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Solar radiation studies at different phenophases of safflower (Carthanus tinctorius) were conducted at Dharwad. The percentage of solar radiation utilisation gradually increases from the early stages of growth reaching a maximum at the seed setting stage and decreasing rapidly later. The percentage of solar radiation transmitted below the canopy decreases steeply right from the initial stage upto the maturity stage and increases rapidly till the flowering stage and increases upto the seed setting stage and thereafter remains practically constant.

STUDIES ON SOLAR RADIATION UTILISATION BY COTTON

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Solar radiation studies at different phenophases of cotton (Gossypium hirsutum) were conducted at Dharwad. The percentage of solar radiation utilisation is maximum during flowering. The percentage of solar radiation transmitted below the canopy decreases upto the boll development stage and then gradually increases till the harvesting. The albedo is constant till the flowering stage and gradually increases reaching a maximum at the boll development stage and later decreases gradually.

A HEAT - TOLERANT TOMATO LINE FOR TROPICS

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Night temperature is critical for fruit set in tomato. Villareal' 1980, reported a night temperature of 59-68°F as optimum for fruit set. Many of the tomato varieties fail to sef fruits under hot dry season when temperature rises to 104°F or more during the day and falls not lesser than 77°F at night. Many areas in the tropics have extremely high night temperature unfavourable for normal fruit set. Tomotoes for the warm humid tropics should be moisture as well as heat tolerant. A reasonable fruit set (54.55%) was obtained at a night temperature as high as 72.1°F in the line LE-79. The fruit setting per cent ranged from 39.13 to 54.55, mean being 48.01 with a night temperature range of 72.1 to 75.4°F. The line LE 79 is hence suited for warm humid tropics.

AIR TEMPERATURE MODIFICATION TO ENHANCE THE EMERGENCE OF MUSKMELON (CUCUMIS MELO) SEEDLINGS UNDER LOW TEMPERATURE CONDITIONS

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An experiment was conducted during winter season to study the feasibility of various weather modification techniques to accelerate the emergence of muskmelon (Cucumis melo) seedlings. The effect of white and black wall backgrounds and polyhouse was compared with open conditions for different dates of sowing. Maximum, minimum and mean air temperatures were recorded under all the conditions. The temperature under all modified conditions remained considerably higher than the open conditions. The average mean temperature under white background remained higher by 4.5 to 5.3°C as compared to open conditions in all the dates of sowing. The first emergence of plants in all the dates of sowing was observed between 8 to 13 days of sowing whereas complete emergence was achieved after 17 to 21 days. In case of open conditions, emergence was very low ranging from 0 to 1.1 per cent at first emergenoe. Even at final stage, emergence ranged between 34.4 to 60 per cent under various dates of sowing. Under white background conditions, first emergence was observed to be 35 to 71 per cent and final emergence in the range of 73 to 84 per cent.

PHYTOCLIMATIC STUDIES IN TURMERIC STANDS RAISED AS A MONOCULTURE AND AS AN INTERCROP IN COCONUT GARDEN

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Microclimatic parameters like solar radiation, air temperature, evaporation, humidity, vapour pressure, Soil temperature and Soil moisture were monitored in turmeric stands raised as a monoculture and as an intercrop in coconut garden. The only environmental variable found markedly different between these two cropping systems was the solar radiation. The rate of evaporation was higher from the pure stand throughout the crop growth period. There was no consistent difference between the pure and intercropped stands for the other environmental variables studied.

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INFLUENCE OF CLIMATIC FACTORS ON TUBER CROPS

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Climatic factors such as rainfall, temperature, sunlight etc. have an unique role on the yield of tropical tuber crops such as cassava, sweet potato etc which are cultivated in many parts of India. Among the climatic factors, rainfall is the most important one, which decide the planting season of these tuber crops. Seasonal influence was also observed on tuberisation, tuber development, flowering and fruit set it tropical tuber crops.

SOLAR RADIATION INTERCEPTION IN SOME CASSAVA - BASED INTERCROPPING SYSTEMS UNDER DIFFERENT GEOMETRY OF PLANTING

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The light interception in some cassava (*Manihot esculenta*, Crantz) - based intercropping systems in relation to planting geometries were evaluated in a field experiment at the College of Horticulture, Vellanikkara. Cassava was planted under three geometries viz., paired row planting, square clustered planting and normal method of planting. The intercrops grown were colocasia (*Colocasia esculenta* Schott), banana (*Musa* AAB 'Mysore') and elephant foot yam *(Amorphophallus campanulatus* Blume). The experiments were laid in RBD with three replications. Light transmission on and into the crop canopies were measured periodically by using an 'Aplab' lux meter.

The relative light transmission to the interspace of cassava during the initial three months were upto 80 per cent which reduced to 10 to 50 per cent during the fifth to eighth month period. Cassava intercepted maximum solar radiation during the fifth and sixth month and the interspaces remained maximum shaded during this period.

Under normal method of planting the canopy closed in faster and the light transmission to the interspace was insufficient to support full yield of the intercrops. The paired row and square-clustered planting resulted in higher light infiltration to the interspace, this difference being very prominent during the period from fourth to seventh month period.

The light transmission to interspaces upto 30 cm from cassava was low. Beyond 45 cm from the cassava plant, the light transmitted to the interspace were substantial.

The performance of the intercrops were better in square clustered planting. The extinction coefficients of the cassava and intercrop canopies were worked out. The light interception was maximum by cassava followed by colocasia, banana and elephant foot yam.

INFLUENCE OF CLIMATIC FACTORS ON CASSAVA PRODUCTIVITY - A REVIEW

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Eventhough, cassava is considered to be a crop of wide adaptability, the prevailing climatic conditions in a locality shows great influence on the crop yield. Cassava is sensitive to shade. The LAI, specific leaf weight, NAR, and total biomass production were less in shaded cassava and the partitioning of dry matter was in favour of the shoot. Shade delayed the onset of tuberisation, reduced the number of tubers, and length of fibrous roots. Multiple regression models showed that variation in drymatter production and distribution can be explained by mean air temperature, photoperiod and LAI. Air temperature influenced dry matter production by its direct effect on photosynthetic rate and indirect effect through leaf area increase and retention. The optimum temperature for photosynthesis in cassava varied from 25-35°C. The leaf pro-

duction rate, leaf area index, crop growth rate and storage organ growth rate is influenced by temperature. Leaf area increases, whereas leaf life decreases with increase in temperature. Higher temperature induces prefenential shoot growth. The relative humidity may influence the leaf area index because of the peculiar drought tolerance mechanism of cassava. Photoperiod influences the storage root number and dry matter partitioning. Moisture stress reduces leaf production rate and leaf size.

SEASONAL VARIATIONS IN YIELD OF THE OYSTER MUSHROOM *PLEUROTUS SAJOR-CAJU*

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Mushroom beds were raised during different months of the year following standard procedures with P. *sajor-caju* the Oyster mushroom. The Climatological parameters like temperature and relative humidity were also noted besides the yield of mushroom. The relationship of climatological parameters-temperature and relative humidity with yield was investigated. The path analysis of yield on these parameters revealed that relative humidity in the afternoon is the major climatological parameter influencing the yield of Oyster mushroom. The multiple linear regression of yield on the above parameters was found to be significant. It was found that 44.38 per cent of the variation in yield during the different months of the year may be attributed to the temperature (Maximum and Minimum) and relative humidity (F. N. and A. N.).

AGROCLIMATIC ZONING IN AGRICULTURAL RESEARCH

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Producution in agriculture depends on several controllable and uncontrollable factors. The controllable factors, such as high quality seed, fertilizers, pesticides etc. can be easily managed to favour high productivity. However, there are many factors like temperature, rainfall, relative humidity, wind velocity etc. which are uncontrollable and thus make the agricultural production a risky affair. In order to minimize this risk and ensure high productivity, there is a need to develop technology suited to well defined agro-ecological situations. To meet this objective, the country has been divided tnto several agro-climatic zones and the zone-wise research centres are being set up under the National Agricultural Research Project - an I C A R sponsored and world bank supported programme. However, the experiences have shown that a zone is a too big and agro-ecologically variable unit to be considered as a specific agro-ecological situation. Therefore, a further sub-grouping within the zone based on specific factors like soil type, rainfall, temperature, flood/waterlogging, cropping pattern and topography etc. is essential. Once these sub-groups on agro-ecological situations are identified, then one can study the gaps in adoption of already available technology and identify constraints of productivity existing in the specific agro-ecological situation which will, in turn,

help in formulating the research strategies relevant to the problems of the specific situation. The technology, thus developed, will be less risky, and favourable to stabilize agricultural production.

In the process of delineation of the zone into specific agro-ecological situations, the staff of the State Department of Agriculture, Animal Husbandry, Fisheries, Horticulture and Statistics can be of great help. The field experiences of these staff will be helpful in correct assessment and identification of the problems in each situation. Their association in the whole excercise, is essential for another important reason too. Since they also became an active participants in the development of the technology right from the conception of the problem, the transfer of technology will become an easier task. Lack of such association is the cause of indifference in the transfer of technology at the present moment.

The issues related to the identification of specific agro-ecological situations are discussed in this paper.

ABNORMAL WEATHER OF 1987 AND ITS FALL OUT IN PUNJAB

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In this study, the effect of abnormal weather on crop production has been highlighted. The Punjab experienced one of the worst abnormal weather of this century during the year 1987. During the rabi season, the night temperature remained above normal by 2° to 3°C which coincided with the reproductive and

grain filling period of wheat crop and thereby affected wheat grain development to a considerable extent. The weather conditions further showed its worst effect in the beginning of May, when the state experienced widespread heavy to very heavy rainfall associated with hail storms and strong surface winds which hindered the harvesting and threshing operations. This wet spell resulted in high moisture content in the unthreshed crops causing loss more than 70 percent in the central and submontaneous regions of the Punjab. Thus, there was a substantial decline in the wheat production.

Later on, the premonsoon showers during the month of June were completely missing. The transplantation of paddy was done by irrigating the fields. The water requirements of pady are higher than any other kharif crop. The situation further deteriorated with the late arrival of monsoon in the month of July. The activities of the monsoon remained at low ebb during the months of August and September. As a result of weak monsoon the state experienced one of the worst drought of this century. To meet the water requirements of paddy crop and other kharif crops, more and more underground water was exploited through tubewells. Excessive running of the tubewells exhausted underground water reservoir to such an extent that the water table fell down significantly which indicates that the rapid fall in water table may be a major threat to the agricultural production in the near future

Consequently, the area and production of different crops declined during 1987 and the paddy crop was raised at the cost of other kharif crops. Thus, the severe water stress resulted in low yield of kharif crops.

SUITABILITY OF CROPS TO THE AGROCLIMATIC ZONES OF PALGHAT DISTRICT OF KERALA

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Monthly meteorological data for the period 1901–80 was collected for all the available stations in the Palghat district, Kerala. A map delineating the Moisture Availability Regimes (MAR) of the district was prepared following Hargreaves (1971 and 1975) and Kesva Rao etal (1986). Soil types (laterite, alluvium Forest loam and black soil) were superimposed over the MAR map and six agroclimatic Zones of the district are identified. They are Semidry-Laterite (B_{LA}), Semidry–Alluvium (B_{AL}), Semidry–Black soil (B_{BS}), Subhumid–Laterite (C_{LA}), Subhumid–Alluvium (C_{AL}) and Subhumid–Forest loam (C_{FL}), Suitability of crops to these agroclimatic zones was examined. To arrive at the following conclusions.

1. Coconut is not very suitable for the zones B_{BS} and in the eastern part of B_{LA}.

2. Tapioca should not be grown in the high water table areas of the C_{AL} zone.

3. Weather data available for the C_{FL} zone is not adequate for a meaningful examination of the suitability of the crops in that zone.

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EROSIVITY, RUNOFF AND RAINFALL ACCEPTANCE AS INFLUENCED BY DIFFERENT AGROFORESTRY PRACTICES

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An experiment is being conducted with various agroforestry practices in a Eucalyptus plantation since May, 1984 at the instructional Farm, College of Horticuture, Vellanikkara, Trichur, Kerala, India. The experiment is mainly to establish the exact relationship of various erosivity indices with runoff and soil loss and also to evolve situation specific agroforestry measures to enhance maximum rainfall acceptance in hill-slopes. The slope of the experimental area is 25% and the soil, moderately acidic oxisol. In comparison to the usually grown taungya crops of cassava and rice, the efficiency of cassava planting on ridges, grass farming alone, interstripping of cassava with grass and pineapple, cowpea live mulching etc. were investigated.

Among the various rainfall characteristics viz. amount, duration, average and maximum intensity, total kinetic engery, EI_{15}, EI_{30} and AI_m, runoff was positively and linearly correlated with the amount of rainfall ($r = 0.930^{**}$) closely followed by total kinetic energy ($r = 0.912^{**}$) and AI_m ($r = 0.848^{**}$). EI_{15} showed the maximum correlation ($r = 0.977^{**}$) with soil loss. EI_{30} and AI_m closely followed it with 'r' values of 0.941^{**} and 0.931^{**},

respectively. Splash erosion, a direct measure of the erosive power of rainfall was also seen positvely and highly correlated with AI_m ($r = 0.932^{**}$) and EI_{15} ($r = 0.923^{**}$).

MICROCLIMATE MANIPULATION AND MANAGEMENT THROUGH MULCHES FOR INCREASED CROP PRODUCTION

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In three separate field experiments, mulches were used for manipulating and managing the microclimate of three different crops viz, winter maize, potato and onion. Thermal and water regimes within the root zone were favourably modified by the application of mulches which maintained higher soil matric potentials within the root zone resulting in reduced irrigation requirments. Woodsavings mulch spread as 3 cm thick layer was more effective in reducing evaporation losses from within the root zone of onions compared with 10 cm thick mulch of dry weed grasses. For all the three crops, yields were significantly ($p<0.05$) higher under mulching. Thus mulches can be effectively used for increasing crop production under adverse conditions of soil temperature and water stress. Under irrigated conditions, mulches could be used for reducing the level of vital but costly input of irrigation water without any adverse effect on the crop yield.

MICROLEVEL METEOROLOGICAL OBSERVATIONS FOR THE IMPLEMENTATION OF AGRICULTURAL PROGRAMMES.

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An intensive microlevel research progrgmme is being implemented by the Kerala Agricultural University to evolve viable models of whole farm development in the tribal hamlets situated on the foot hills of the Agasthyamudi peak and on the banks of Neyyar Dam reservoir near Amboori, South Kerala. The success of massive planting programme of various tree and plantation crops undertaken since 1983 by the Tribal Area Research Centre, Amboori in the highly undulating terrain coupled with quick run-off necessitates a fairly well distributed rainfall data for the last 10 years, collected from the observatory at Neyyar Dam reservoir prior to the implementation of the programme and afterwards from its own meteorological observatory ot Amboori indicate that considerable fluctuation in the pattern, distribution, frequency and amount of rainfall has resulted in successes and failures in various planting programmes initiated from 1983-84. In the studies on the survival and successfull establishment of crops such as cloves, arecanut, cashew and rubber it has been observed that cashew layers are the most difficult to establish among performance studies on different types of planting materials of rubber such as polybagged plants aged 6 months, 1 year and budded stumps indicate the superiority of 1 year old polybagged seedlings in the survival and establishment of the crop.

The results further bring out the need for a well distributed net work of nurseries to produce the required polypag rubber

seedling of age 1 year for planting in difficult and remote areas such as Kanikkar hamlets where erratic monsoon is experienced.

The experience from the Tribal Area Research Centre, Amboori favour the need for microlevel meteorologjcal observations to make predictive models for future years in the planning of various planting programmes of tree crops.

AGROCLIMATIC RESOURCE — AN EXAMPLE OF EVOLVING CROPPING SYSTEM

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Climate plays a major role in crop productivity and it decides the type of crops to be grown as well as the cropping system of a region. Hence, to evolve a suitable cropping system of a region for maximum productivity it is necessary to analyse the climatic resource of a region. By this it is implied that the weather factors like rainfall, temperature, solar radiation, wind and relative humidity should be analysed for the suitability of the crop To illustrate the importance of climate in crop production, a few examples are discussed in this paper.

IMPACT OF CEMENT KILN DUST OF AGRICULTURE

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A study conducted in Walayar area of Palghat district shows the quantity of foliar deposits (Mg. / Cm^2 of leaf) at a distance of 2-6.5 km (W) from the factory, for a fortnight in different plants are; Teak 0.34 - 1.96, coconut - 0.36 - 0.73, Banana- 0.30 - 1.14, Cucumber 1.08 - 1.98, Brinjal - 0.7 - 2.85, Tomato- 1.76 - 3.0, Ground nut 6.8 - 1.59 and Mango 0.7 - 2.0.

In the study area easterly winds bring and spread the pollutants and easterlies constitute 52% of winds in November, 77% in December, 78.5% inJanuary, 63% in February and the corresponding mean wind velocities are (in km ph) 7.6, 10.9, 11.3 and 9.3 respectively. Therefore, during November to February, cement kiln dusts flow towards Palghat, lying south west of Walayar. The economic repercussions of crop loss due to cement kiln dust are under investigation.

YIELD AND FLOWERING RESPONSE OF AMARANTHUS SPECIES TO WEATHER

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An exiperiment was conducted at the College of Horticulture Vellanikkara from April, 1981 to March, 1982, to study the effect of various weather elements on the yield of four Amaranthus species, namely A. dubius, A. tricolor, A. Uiridis and A. spinosus. The crop was grown in 11 consecutive months and the vegetable

yield was correlated with weekly maximum temperature, minimum temperature, average temperature, range of temperature and relative humidity. Among these, the minimum temperature and the average temperature of the first three weeks after sowing had significant influence on the first yield. In all the Amaranthus species tried, minimum temperature had more positive correlation than average temperature, except for A. spinosus, which had a maximum correlation with the average temperature. With respect to flowering, the total heat units from the date of sowing to the date of flowering had high positive correlations among all the spices except for A. spinosus.

EFFECT OF HEAT UNITS AND SOLAR RADIATION ON THE PRODUCTIVITY OF IRRIGATED COTTON

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The results of the experiments conducted at the Tamil Nadu Agricultural University, Coimbatore on date of sowing to quantify the effect of heat units in terms of "Growing Degree Days" (GDD) and "Accumulated Solar Radiation" (ASR) on the productivity of "Varalakshmi" hybrid cotton are reported. There was a progressive decrease in GDD and ASR when the sowings were delayed at fortnightly interval from mid August to mid September causing reduction in growth, yield components and seed cotton yield. The GDD and ASR did not appreciably influence the period from sowing to flowering. On the other hand, the boll maturity period was reduced by about 10 days and the harvesting period 15 days and totally 25 days in the crop duration of the mid September sown crops as compared to the crop sown in mid August.

The mean reduction in seed cotton yield was by 9.1 g/ha when the sowing was shifted from mid August to mid September. The GDD and ASR accounted for 30 and 50 per cent variation, respectively. It was predicted that about 2,500 GDD and 84,800 $cal.cm^{-2}$ of ASR would be required to produce about 3,000 kg of seed cotton. The energy conversion efficiency was the highest (1.47%) with mid August sowings.

ENVIRONMENTAL EFFECT ON COTTON GROWTH

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To find out the effect of environment on cotton, field experiments were conducted at the Tamil Nadu Agricultural Uni-

versity, Coimbatore during the winter combodia seasons of 1983-84 and 1984-85. In the winter combodia season, the cotton crop is sown during August (South West monsoon) and harvested by January/February. The cotton raised during this period coincides with the North East monsoon period with seasonal rain during the months of October and November, which encourages high vegetative growth resulting in mutual—shading. Non dehisceence of bolls and reduction in yield is the rule, if the environmental behaviour is erratic.

The meteorological parameter which modify the environment has been studied in this experiment and correlation was worked out between the yield and the weather parameters. The correlation values were highly significant for all the parameters studied. The multiple regression analysis reveals the highly significant effect of the soil temperature both in the morning and evening and the significant effect of evening relative humidity on the yield of seed cotton. All these three parameter exhibited positive values indicating that every increase of one degree centigrade in soil temperature could increase the yield by 56 kg/ha and a degree rise in morning soil temperature by 6.7 kg/ha.

INFLUENCE OF DIFFERENT TEMPERATURE ON THE GROWTH OF THE OYSTER MUSHROOM SPECIES OF PLEUROTUS

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Three common species of Pleurotus generally known as Oyster mushroom viz., Pleurotus sajor-caju, P. flabellatus and P. ostreatus were grown on potato dextrose broth and incubated under different temperatures ranging from 15°C to 25°C. The comparative growth was assayed by considering the final dry weights of the mycelium.

It was observed that there was a steady increase in dry weight with increase in temperature from 15°C to 25°C and then

the growth declined in the case of P. ostreatus and P. sajor-caju But in the case of P. flabellatus, maximum weight was recorded at 30°C and minimum at 35°C. A rise in temperature beyond of 25°C resulted in reduced mycelial growth in the case of P. ostreatus and P. sajor-caju while in the case of P. flabellatus the maximum growth was at 30°C. The results showed that P. ostreatus and P. sajor-caju preferred an optimum temperature 25°C and that in the case of P. flabellatus it was 30°C. P. ostreatus is generally considered to be a temperate mushroom and usually it fails to develop under tropical conditions.

LEAF WATER STATUS OF COWPEA IN RELATION TO SOIL AND AERIAL TEMPERATURE AND RELATIVE HUMIDITY.

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Investigations on cowpea (Vigna sinensis.L) grown in laterite soils of Kerala, in monsoon and summer seasons, as pot culture experiments at IARI., New Delhi. In both the seasons, water consumption increased steeply after initial flowering around 30 to 33 days after sowing in case of monsoon and 55 days in in case of summer. There is significant differences in water consumptions and dry matter production for the two irrigation treatments. Under lower water regimes, high temperature reduced the yield and water consumption.

The lowest leaf water potentials of - 8. 5. and - 7.0 bars were recorded in summer under lower moisture regimes at later stages of crop growth. At low soil tempereture, the leaf water potentials were higher in both the seasons. From regressions it has been found that inclusion of average aerial tempereture inst-

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ead of relative humidity along with gtavimetric moisture content improved the percentage of estimation of leaf water potential from 48 to 67. Relative humidity and leaf water potential were strongly related to stomatal resistance with coefficient of estimation as high as 98%

There was gradual decrease in leaf water potential from sunrise to about 14-30 hours and there after increased till sunset, With very low diffusive resistance values the transpiration was high and variable. Leaf tempereture decreases relative to cuvette temperature giving a range of -ve to +ve values in leaf and cuvette temperature differences and leaf water potential increases, but reverse in case of diffusive resistance.

SESSION III

CLIMATE AND PESTS AND DISEASES OF CROPS

METEOPATHOLOGICAL FORECASTING OF EPIPHYTOTICS

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Meteorological factors play a significant role in the incidence of plant disease out breaks. Meteopathological forecasting is mainly based on the relationship between weather and disease. The knowledge on the spread of spores provides the geography of danger about a focus of infection. Since most spores arise from leaves and since foliage is the most extensive receiver that the plant extends into the spore-laden air, the leaf temperature and the humidity at the leaf surface are studied by plant pathologists. The frequency of favourable and unfavourable temperatures is the most important factor in the development of diseases. Therefore, the development of a pathogen and hence the disease, may be predicted by adding the periods of favourable temperature. This may give the farmer, necessary time to revise his plans so as to avoid or reduce losses.

Models help us to predict the occurrence of epiphytotics. A model can be a verbal statement, a hypothesis, a theory or law. It is a simplified approximation to reality. Prediction models prepared by monitoring the relevant weather parameters and relating them to disease development are known as bioclimatic models. The 'Dutch rules' developed for forecasting the appearance of late blight of potato caused by Phytophthora infestans is such a bioclimatic model. Based on the synoptic weather charts and the correlations drawn on the occurrence of diseases,

warning systems can be developed and they are known as synoptic models. The 'Indian Stem Rust Rules' is a synoptic model. Solutions for many compiex problems in plant disease forecasting can be arrived at by computer analysis of the meteorological data. BLITECAST, EPIDEM, EPIMAY, EPICORN, EPIVEN, MYCOS and EPIDEMIC are such computerised forecasting models.

EPIDEMIOLOGICAL FACTORS AND THE DEVELOPMENT OF RICE DISEASES.

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The development of plant diseases into epidemic proportions is the result of a series of interactions between the host, pathogen and the environment. The enviromental factors vary depending upon the crop. Relative humidity and temperature are the most important parameters which determine infection, development and spread of the diseases. Besides these, infection is also influenced by other factors like intensity of light, nutrition, age of the host, crop sequence, soil type and host susceptibility.

The major diseases of rice and the effect of epidemiolog cal factors on their development are as follows. A relative humidity of above 90 per cent and a temparature range of 23-26° C is favourable for blast disease. For blight and stackburn the requirements are 60-80 per cent relative humidity and a temperature range of 29-35° C. High humidity coupled with close planting and heavy nitrogen doses favours sheath blight while a continuous rainy weather with strong winds and a temperature of 22-26° C is favourable for the rapid spread of bacterial leaf blight.

SHEATH BLIGHT AND SHEATH ROT INCIDENCE IN KUTTANAD AS INFLUENCED BY WEATHER PARAMETERS

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Epidemiological studies on major diseases of rice in Kuttanad conducted during 1982-83 and 1983-84 revealed that sheath dlight and sheath rot are the two serious diseases affecting rice both in the Kharif (Additional Crop) and Rabi (Punja) seasons. Correlation studies of weather parameters with these diseases indicated that high temperature significantly influences the incidence of both sheath blight and sheath rot. Occurrence of sheath blight was inversely correlated with rainfall. Correlation of sheath rot disease incidence with other weather parameters like relative humidity, rainfall and number of rainy days were not significant. Incidence of both the diseases was high for the October—November sowings.

INFLUENCE OF WEATHES PARAMETERS AND SOIL REACTION ON THE SURVIVAL OF THE SHEATH BLIGHT PATHOGEN, RHIZOCTONIA SOLANI

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The competitive saprophytic colonization of paddy straw bits by R. solani was studied in relation to environmental factors. The maximum survival of 98.1 per cent was observed at a temperature of 20± 2° C and 96 4 per cent survival at 28±2 °C. It was observed that at high temperature (40±2 °C) the substrate units were colonized by Aspergillus nidulans, and papulospora Sp. and even at higher doses of inoculum the survival of R. solani was poor.

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When the influence of pH was studied, maximum survival of R. solani, viz., 96.70 per cent was observed at pH 7. The survival of the pathogen was very low at pH 4 (14.2 per cent), but with an increase in pH the survival was also found to increase up to PH 7. At low pH the colonization by Aspergillus nidulans. A flavus and A. terreus was more pronounced.

The effect of soil moisture on the survival of R. solani was also studied, and it was found that maximum survival of R. solani, viz , 94 4 per cent was noted at 15 per cent moisture level. Increase in the moisture level above 15 per cent was found to decrease the saprophytic survival of the pathogen.

EFFECT OF HIGH RAINFALL AND RELATIVE HUMIDITY ON THE INCIDENCE OF BACTERIAL LEAF BLIGHT OF RICE

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Leaf blight caused by Xanthomonas campestris pv. oryzae is an important bacterial disease of rice in Kerala. In Kuttanad, it is generally found to occur during the additional crop season from June to September almost every year. Certain enviornmental conditions such rainfall, relative humidity and a low maximum temperature prevailing during this period appear to influence the incidence of this disease. In the present investigation, an attempt is made to elaborate the above observation by correlating the recorded incidence of BLB of rice at Mancompu during the two major crop seasons, additional and Punja for five years from 1979 to 1983 with the weather data available for this period.

A regular incidence of BLB was observed only during the additional crop season. There was no incidence of this disease during the punja season. A study of the weather data on rainfall, relative humidity, maximum and minimum temperature for both the cropping seasons at Mancompu from 1979 to 1983 showed that the extent of rainfall and relative humidity during the additional crop season were consistently higher than that of the punja season. The average rainfall and relative humidity for this period were 477.9 mm and 75 8 percent respectively while these were only 118 2 mm and 59.2 percent for the punja season. The average maximum temperature for both the cropping seasons was 31.3 and 34.0°C respectively. However, there was not much difference in the minimum temperature recorded for this period. It therefore appears that some of these environmental factors especially the high rainfall, relative humidity and a low maximum temperature as occuring during the additional crop season have got a favourable influence in the out break of BLB of rice in Kuttanad. At the same time, the lack of this disease during the punja season may be due to the fact that the environmental conditions are probably not conducive for leaf infection by the pathogen. These asaumptions were found to be true in the following year, 1984, when there was a severe incidence of BLB in Kuttanad when the environmental conditions were suitable for the same

EFFECT OF APPLICATION OF COMMON BIOCIDES IN RICE FIELDS ON THE INCIDENCE OF SHEATH BLIGHT DISEASE

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Sheath blight of rice caused by Rhizoctonia solani Kuhn is now considered to be one of the major limiting factors in enhancing rice production in Kerala. A number of environmental factors influence the incidence of this disease. For intensive

culture of rice, currently a number of biocides are recommended to be regularly applied in rice fields and many of them are known to have their action on non-target organisms also. An attempt was made to evaluate critically the role of these biosides on the incidence of sheath blight of rice. For this purpose, eight fungicides, twelve insecticides and eight weedicides were tested for their influence on the survival of the causal organism of sheath blight viz R. solani in soil, effect on the soil microflora including the antagonistic organisms and finally on the incidence of sheath blight disease.

Mancozeb, quintozene and carboxin were found to be most effective in checking the survival of the organism in soil. Of the insecticides, sevidol was the most effective followed by methyl parathion, carbofuran, phorate, monocrotophos and fenetrothion. Among the herbicides, nitrofen was the most effective with respect to maximum inhibition of soil propagules followed by propanil. Some of the fungicides like. captafol, ediphenphos and carboxin and insecticides like carbofuran, sevidol, carbaryl and enthion enhanced the fungal population. Herbicides in general decreased the soil microflora. Ediphenphos among the fungicides and carbaryl among the insecticides minimised the incidence of sehath blight. Of the herbicides propanil was superior in reducing the incidence of sheath blight.

INFLUENCE OF SOIL MOISTURE ON VA. MYCORRHIZAL INFECTION IN RICE

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Although VA. mycorrhizal association has been reported in most of the crop plants, its occurrence in aquatic plants is very rare. Rice plants grown in the up land conditions are normally mycorrhizal but in the wet land condition it is non-mycorrhizal. An attempt was made to achieve mycorrhizal

infection in rice plants at nurssery level by inoculation with specific VAM fungus by adjusting soil moisture level. The mycorrhizal inoculation was given at the time of sowing. The nurssery was maintained under three different levels of mositure, flooded, just wet and partially dry conditions. After 25 days of growth root samples were collected and examined for mycorrhizal infection. The seedlings raised partially dry and just wet conditions were positive for mycorrhizal colonisation indicating that moisture level of soil has got a definite influence on mycorrhizal infection in rice plants. This shows that it is possible to induce VAM infection in rice under wet land conditions,

INFLUENCE OF PRE-MONSOON SHOWERS AND DATE OF PLANTING ON THE INCIDENCE OF GALL MIDGE ORSEOLIA ORYZAE (WOOD-MASON) (CECIDOMYIIDAE DIPTERA) IN RICE DURING KHARIF

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Based on a field experiment on crop-weather studies in rice conducted at the Regional Agricultural Research Station, Pilicode during Kharif from 1983 to 1987, an attempt has been made to find out the influence of pre-monsoon showers and date of planting on the incidence of gall midge. It was observed that the incidence of gall midge was low (4.9%) in 1983, followed by 8.9% in 1986 during which the pre-monsoon (March-May) rainfall was also low and recorded 9 2 mm and 31.9 mm, respectively. While the incidence was high (15 4%) in 1984 during which the pre-monsoon rainfall was also high (393 9mm). Gall midge infestation was high in the varieties Jaya and Allikkannan transplantedduring the third week of (20 - 7 - 87) and was low when transplanted during the July second week of June (8 — 6— 1987). However,

the traditional cultivar Allikkannan recorded low percentage (0.8 to 2.9) of silver shoots compared to that of Jaya (1.8 to 8.3). The weekly incidence of gall midge showed a gradual increase till the maximum tillering stage, whereas the weekly rainfall was high prior to the maximum tillering period. The continuous high rainfall received prior to the maximum tillering stage might have influenced favourably the multiplication and development of the pest which resulted in high percentage of silver shoots.

SEASONAL VARIATION AND EFFECT OF CLIMATIC FACTORS ON THE INCIDENCE OF DOWNY MILDEW OF SORGHUM

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Late Kharif sown sorghum crop was found to bemore liable for downy mildew infection compard to Rabi and summer sown crop. Statistical correlation between the disease incidence and the climatical factors showed that maximum and minimum relative humidity, total rain fall and number of rainy days were having positive and maximum temperature was having negative correlation with the disease. The partial regression analysis revealed that 45.45 percent of variation in the incidence of sorghum downy mildew could be explained with the six climatical factors included in this study.

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METEOROLOGICAL FACTORS IN DEVELOPMENT AND SPREAD OF MAIZE DISEASES

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Brown stripe downy mildew (Sclerophthora rayssiae var. zeae), Erwinia stalk rot (Erwinia chrysanthemi pv zeae) and Fusarium stalk rot (Fusarium moniliforme) are important diseases causing extensive damage to maize crop during Kharif season in tarai region of Uttar Pradesh Chemical control measures have been developed and recommended to farmers in the locality which can effectively reduce the disease intensity during the crop season. However, these can only be undertaken when the disease starts taking its toll on to the crop. In order to apprise farmers well in time, efforts were made to correlate the meteorological factors like, temperature, relative humidity, frequency and total precipitation, wind velocity and duration of bright sunshine with the disease intensity and severity of above diseases in different years on some commonly grown cultivars.

Cloudy and dull weather coupled with moderate temperatures and high relative humidity found favouring the brown stripe downy mildew. Frequent rainfall with high temperatures $> 30^{\circ}$ C and high relative humidity $> 90\%$ coupled with longer duration of bright sunshine favoured the development and spread of Erwinia stalk rot whereas high rainfall at flowering stage of the crop followed by high temperature and prolonged drought during post-flowering period increased the Fusarium stalk rot in field conditions.

These studies were utelized to device regression models to predict the downy mildew and stalk rots well in advance to apprise the growers well in time to follow recommended control measures in the crop These simulation models also help in assessing yield losses depending upon the final disease severity on the crop.

ROLE OF SEASONS AND CLIMATIC FACTORS ON THE OCCURRENCE OF DIFFERENT POD ROTS OF COCOA

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Cocoa black pod caused by Phytophthora Palmivora was found only during the monsoon months while Colletotrichum and charcoal pod rots were seen throughout the year. Maximum and minimum relative humidity, number of rainy days and total rain fall were positively correlated to the black pod incidence while the maximum and minimum temperature had a negative effect. The Colletotrichum pod rot was favoured by increased maximum and minimum relative humidity coupled with increased number of rainy days while the charcoal pod rot was significantly influenced by the maximum temperature and minimum relative humidity.

ENVIRONMENTAL IMACT ON VESICULAR ARBUSCULAR MYCORRHIZAL INFECTION IN KOKKAN AFFECTED NENDRAN VARIETY OF BANANA

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Pestiside application to soil usually changes the micro environment of plants influencing thereby the growth and activity of many soil microgamisms. (Domsch, 1974). The use of pesticide is also reported to effect the V A mycorrhizal association in crop plants (Neisheim and Linn, 1969, Mosse, 1963, 1973). In this connection, a study was con ducted to assess the impact of certain pestisides on the natural incidence of V A mycorrhizan in some 'Kokkan' affected Nendran variety

of banana under chemical control for this disease at Banana Reserch Station, Kannara. The different treatment were the application of terramycin (100 ppm), penicillin (100ppm), calixin 1000 ppm) and furadan (30 g/plant), Root samples form such plants were examined for the presence of VAM by standard staining technique of Phillips and Hayman (1970) The study revealed that the use of the above antibiotics and pesticides, in general, had no significant effect on the natural colonisation of VA mycorrhiza in the Nendran variety of banana. Therefore, if any one of the above chemotherapic methods is found suitable for the control of Kokkan disease in banana it can be safely recomended without affecting the VAM infection. This will be beneficial the disease affected plants in that it will enable it to absorb more water and some of the important plant nutrients like P, Zn and S from the soil.

INFLUENCE OF WEATHER ON THE INCIDENCE OF FROG-EYE LEAF SPOT DISEASE OF TOBACCO (NICOTIANA TABACCUM)

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Frog-eye leaf spot disease of tobacco caused by Cercospora nicotianae is one of the dreaded diseases in tobacco growing tracts of the Kasaragode district of Kerala. Though the disease incidence primarily depends upon its inoculum potential and crop growth stage under uniform management conditions, seasonal variations are not uncommon. This is because the inoculum is activated depending upon favourable weather conditions prevailing during the maximum crop growth period. Keeping this in view, an attempt has been made at the Regional Agricultural Research Station, Pilicode during the Rabi sesson from 1985-86 to 1987-88 to study the influence of different weather elements such as maximum and minimum temperatures, relative humidity and dewfall on the incidence of frog-eye leaf spot disease of tobacco.

It was noticed that the disease incidence was maximum (62%) during the first week of January 1986 compared to that of the same period of 1986-87 and 1987-88. This was possibly due to the occurence of lowest minimum temperature (18,3° C) coupled with relatively high dewfall (1.5m m) in 1986. Among the different weather parameters, the minimum temperature had a significant negative correlation with the disease incidence. It also indicated that under high humid environment which is conducive for the development of spores, the disease spread was high when the minimum temperaature was low coupled with relatively high dewfall.

WEATHER PARAMETERS IN RELATION TO OUTBREAK OF DOWNY MILDEW AND WHITE RUST OF MUSTARD

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Weather plays a key role in the outbreak of diseases. In the absence of congenial weather condition outbreak of disease may not be expected inspite of the presence of virulent pathogen and vulnerable host. White rust and downy mildew are to most important diseases which have been affecting fhe mustard crop in varying degrees for the last few years in Haryana State.

Haryana State witnessed epiphytotics of white rust with low to moderate severity of downy mildew in 1985-86 and again that of downy mildew with low to moderate incidence of white rust during 1987-88 An introspection of weather data of the two years during disease appearance and flare-up phase has revealed that cool and humid weather with intermittent rains, mist, fog during second half of December when the crop has attained an age of 40-45 days helped in epiphytotic outbreak of white rust and higher relative humidity (>90%) during January for further flare-up. Similar weather parameters with slightly higher temp probably induces more of downy mildew than white rust. Thus weather parameters would be important base for prediction of these disease awhich infact has been used as an important tool in prediction of the disease and consequently issuing Plant Disease Warning by Haryana Agricultural University (HAU) for greater awareness amongst field functionaries and famers. Details will be discussed.

MITE-CAUSED CITRUS RIND DISORDER IN RELATION TO DROUGHT CONDITIONS IN PUNJAB

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During Nov-Dec., 1987 and Jan. Feb, 1988, severe fruit-rind disorder in kinnow orange was noticed at V Chohal in Hoshiarpur District. False spider mite, Brevipalpus phoenicis (Geijsk). (Acari, Tenuipalpidae) was found associated with the rind disorder symptoms. A typical circular band brownish to black in appearance was found around the inner part of the damaged fruit. In advanced stages of infestation, corky skin appeared on most of the fruit surface. From 15.25 pinkish to red-coloured mites were found per damaged fruit. However, deeper layers of rind and of fruit were not affected. Taste of fruit was also not affected in mite-damaged fruits This type of damage igsnificantly reduced the market value of the fruits. Mite damage was significantly more this season because of prevailing drought conditions in Punjab. Mite seemed to inject some toxic material from their saliva while feeding which might cause rind disorder symptoms of kinnow fruits.

RECURRENCE OF LATE BLIGHT OF POTATO IN HARYANA

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Late blight of potato makes an epiphytotic appearance in plains of northern part of India once in 4-6 years In Haryana state disease was noticed in epiphytotic proportion in 1977-78 in intensive potato growing belt comprising of districts Ambala, Kurukshetra and Karnal. Since then disease was observed in low proportion in subsequent years until it broke in epiphytotic form again in 1985-86. This clearly indicates that lack of emphasis

on late blight in certification programme as well as ignorance on thepart of seed growers resulted in passing of inoculum from one season to another through tubers kept in cold storage and consequently epiphytotic appearance in 1985-86. However, role of congenial enviroment can not be ruled out in the outbreak of late blight during 1977-78 and 1985-86 in fact scaning of meteorological data clearly revealed that build up of cool and humid weather coupled with fog and mist (Max. temp 18-24° C, Min. temp 5-12° C, Rainfall 14 mm) in the second fortnight of Dec. 1977 helped in the appearance and spread of the disease. Similarly in 1986 also cool and humid weather with intermittent rains, mis, fog, haze etc. in later part of second week and 3rd week of December backed by thunderstorn and hail on 11/12 (Table-1) helped in the appearance and spread of late blight and subsequently heavy rains in the later part of the month (26/12-26mm. and 27/12-45mm) favoured the disease to spread like wild fire.

STUDIES ON THE EFFECT OF CLIMATIC CONDITIONS ON THE POPULATION THRESHOLD OF PATHOGENIC FUNGI IN KONKAN REGION

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Spores ef 15 fungi were traped during 38 weeks of aerobiological study conducted at the Central Experiment Station, Konkan Krishi Vidyapeeth, Wakawali. Most of the fungi are known to cause diseases in mango, forest trees and other crops. The variations in spores traped were observed. The possible correlation of weather parameters is investigated.

WET SEASON POPULATION OF RICE WHITE BACKED PLANT HOPPER, SOGATELLA FURCIFERA (HORVATH) AS INFLUENCED BY WEATHER FACTORS

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During wet season of 1985 to 1987, influence of weather factors namely maximum temperature, rainfall, relative humidity and sunshine hours was studied on the seasonal population of rice white backed planthopper (WBPH), Sogatella furcifera (Harvath). The results of three year studies indicated that maximum and minimum temperatures had no significant correlation on the population of WBPH. Positive significant correlation for the population density of this hopper was observed with R. H. ($r=0.8017$); and sunshine hours ($r=0.8736$). However, rainfall negatively affected its population ($r= -0.6758$).

EFFECT OF SEASONAL CHANGE TO FRUIT FLY INCIDENCE ACTIVITY IN GUAVA ORCHARD AT LUDHIANA (PUNJAB)

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In Punjab, guava bears twice i.e. in rainy season and winter. In rainy season, fruiting takes place from July to September and rarely extends to first week of October. The fruit fly (Dacus dorsalis Hendel) incidence in fallen fruits was above 80% in August and 100% in September, while it was 30 to 98% in plucked fruits. In July to September, the mean temperature ranged from 28-32°C. In winter, incidence of fruit fly was nil in December to February, however, its incidence starts in second fortnight of March when winter fruiting was almost over. During December to February, the mean temperature varied from 12 to 16°C.

POPULATION BUILD UP OF SPITTLE BUG, POOPHILUS COSTALIS WALKER A PEST OF SACRED BASIL IN THE PUNJAB

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Sacred Basil commonly known as tulsi is a wild as well as cultivated crop. The spittle bug, Poophilus costalis walker was for the first time recorded as a pest on the tulsi (Ocimum sanctnm Linn). The appearance of pest is directly related with the monson rains. The pest reached its peak on 11th and 20th August, 1986 and it lasted until the harvest af the crop. The population dynamics of fhe pest at 10-days intervals is discussed in the paper.

WEATHER AND POPULATION CYCLES OF THE TEAK DEFOLIATOR

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In about 1.5 million ha of teak plantations in India, outbreaks of the teak defoliator, Hyblaea puera (Insecta Lepidoptera) is almost a regular annual feature that precedes the onset of the southwest monsoon. Detailed studies in Kerala indicate a close link between the monsoon and the insect population cycles, but the exact cause-effect relationships remain unknown. Population cycles may be caused by the operation of density-dependent positive feedback in response to (a) increased food availability due to flushing of teak, and density-dependent negative feedback in response to (b) natural enemy abundance, where both (b) and (h) are weather-related. However, the temporal and spatial sequence of outbreak development suggests a

more direct of weather, in addition-possibly, concentration and passive transportation of dispersed low-density moth populations by pre-monsoon wind systems. On site collaboration between meteorologists and entomologists is necessary to test the hypotheses.

EFFECT OF SUNLIGHT ON THE PERSISTENCE OF INSECTICIDE RESIDUES ON GLASS SURFACE

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Studies were undertaken to ascertain the effect of sunlight on the dissipation of the residues of insecticides on glass surface by laying down residue films of insecticides within glass tubes and exposing them tosun light for varying periods. The loss of residues was assessed in terms of mortality response of Drosophile melonogaster M. exposed to the residue films which had weathered under sun light in comparison with the mortality response of the test insect exposing to the residue films kept in the shade. The loss of residues was at a very fast rate under sun light than under shade. Results show that the residues of the insecticides, quinalphos, fenitrothion, methyl parathion and phosalone were dissipated at a much higher rate under sunlight as compared to dissipation under shade. Though residues of malathion, endosulfan and fenvalerate also showed reduction under sunlight its magnitude as compared to dessipation under shade was not very significant.

SESSION IV

DROUGHTS AND WATER REQUIREMENTS OF CROPS

ADVANCES IN ESTIMATING CROP WATER REQUIREMENTS FOR SEMI-ARID REGIONS.

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Estimation of water requirements for crops grown in semi-arid conditions is important to assess the impact of changing management practices and germplasm. Crops grown under dryland conditions are subjected to greater atmospheric demands and higher wind speeds than irrigated conditions. The environment in which dryland cotton is grown has been quantified and it was found that air temperature and vapor pressure deficit gradients are extremely large from the soil surface to the top of the canopy, 70°C/m and 25 kpa/m, respectively, during midday. Methods wnich estimate crop water requirements are the penman-Monteith method with actual canopy resistance or the surface energy balance. The methods perform well compared to soil water balace. The development and evaluation of procedures which accurately estimate crop water requirements have provided an advance in evaluating management practices which improve water use efficiency in semi-arid agriculture.

WATER AVAILABILITY DURING DROUGHT YEARS IN KERALA

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Droughts set in as a result of a sequence of meteorolical processes culminating in subnormal rainfall resulting in severe water shortages. In this paper, drought years in Kerala during the period 1901 to 1987 have been identified employing the water balance method introduced by Thornthwaite (1948). Values of soil moisture, water surplus, runoff and water detention have been computed to assess the water available for exploition during the drought years.

PRONENESS TO DIFFERENT CATEGORIES OF DROUGHTS IN ASSAM AND THE VICINITY

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The investigation has been undertaken aiming at finding out the numbers of different categories of droughts for each of the 15 well distributed stations over the region and showing the distribution of the values of proneness to these droughts through maps. For this purpose, the employed methods based on the bookeeping procedure and climatic indices of Thornthwaite and Mather are universally acclaimed as the most effective ones.

The interesting aspects of the investigation are that even the lavishly rainfed areas like Meghalaya and Arunachal Pradesh have shown proneness to large and severe droughts, moderate drought occur quite frequently and disastrous droughts are rare and restricted in extent.

CLIMATE AND CROPPING PATTERN IN THE DROUGHT PRONE AREA OF ANANTAPUR DISTRICT, ANDHRA PRADESH.

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The present paper deals with the climate and cropping pattern in the drought prone area of Anantapur district. An endeavour is made to compute the annual and seasonal thermal efficiencies of the disrict on the basis of Thornth waite concept (1948). The spatial distribution of annual, seasonal and monthly rainfall and its coefficient of variation are analysed based on the average rainfall data for a period of 35 years (1951-85) recorded in eleven rainguage

stations of the district. The climatic water balance of Anantapur district has been studied on the basis of Thornth waite's method and the water surplus and water deficit in dry, wet and normal years have been worked out. The aridithy index is also measured on the basis of Thornthwaite and Mather (1955) method.

In the study an another attempt is also made to correlate the annual rainfall with the changing trend of cropped area. The existing cropping pattern, crop diver sification and the distribution of primary crop regions in Kharif and Rabi seasons are delineated and described in relation to rainfall distribution and water balance studies. A new approach of rainfall analysis to fix up cropping strategies in dry farming areas carried out by Agricultural Research Station of Anantapur is also dealt with. The present study of agro-climatology of the drought prone area of Anantapur district indicates what changes are ought to be taken to modify the existing cropping pattern for the protective and productive agriculture in the district.

APPLICATION OF WATER BALANCE CENCEPT TO THE STUDY OF DROUGHT AT CUTTACK IN ORISSA''

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Water balance approach put forth by Thornthwaite and Mather in 1955 has applied successfully (Subrahmanyam, 1967) for clearer understanding and better appreciation of the problem According to water balance cencept drought is a situation in which the amount of water needed for maximum evapotranspiration exceeds the amount obtainable by precipitation. and from the soil.

Considering the departure of aridity index from the median value and using the standard deviation, Categorization of drought can be done and thus. the drought years can be indentified

A case study of the station cuttack in Orissa has been undertaken to demonstrate the utility of water balance concept to understand drought in its proper persepective.

A CLIMATIC STUDY OF SEVERE DROUHT CONDITIONS AT VELLANIKARA DURING 1986-87

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Rainfall in Kerala has been erratic for the last two decades. During (1982-83), Severe drought conditions prevailed all over Kerala and during 1986-87, the State experienced a disastrous drought.

Weekly PET values of Vellanikkara for the climatic, wet (1980-81) and drought (1986-87) years, were computed following modified Perman method. Adopting the modified water budgetting technique of Thornwaite and Mather weekly soil moisture content water surplus and water deficit were computed.

The period from 47th standard week of 1986 to 20th week of 1987, received a meagre rainfall of 44 m. m. From the cumulative water deficit deviation chart, it was observed that the 'Cove' period of drought started from as early as 8th week of 1987. The water surplus was less by about 22% and water deficit more by about 68% of the climatic normal value.

EFFECT OF WATER STRESS ON THE GROWTH OF BANANA

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The rate of leaf emergence in banana (Musa Spp. (AAA) cv. Williams) was followed in relation to the change in its water potential. The emergence of leaves stopped when the water

potential was approximately-0.25 MPa. At the same time the stomatal conductance and net photosynthesis also were drastically reduced. Although bananas stopped growth at such a high water potential, they were able to survive without water for many days. The detailed studies on the latex of the plant indicated that the high solute concentration in the latex could be playing a significant role in its adaptation to dry conditions. The latex has been also found to be a good indicator of the water potential and turgor potential of the plant which are difficult paramenters to measure otherwise in banana.

DROUGHTS AND WATER REQUIREMENTS OF CROPS IN TOBACCO - BASED SYSTEM

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The main theme of the paper includes (i) crop productivity in relation to rainfall pattern in semi arid regions (ii) selection of crops and varieties for semi - arid areas (iii) influence of dates of planting in relation to rainfall distribution and crop productivity, (iv) planting density, crop nutrition and nutrient uptake in relation to stored rain water and/or extractable soil moisture, (v) conservation and efficient utilization of rainwater vis-a - vis VFC tobacco based cropping systems. Integrated crop production technology is suggested for different VFC tobacco growing regions mainly for rainfed and dry conditions to increase the productivity and over all returns from the crops raised in tobacco based system by making most efficient utilization of available rain water / resources.

IRRIGATION SCHEDULING METHODS USING CLIMATIC DATA-AN ASSESSMENT

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In the study, two climatological methods viz. (i climatic water balance (Thornthwaite & Mather, 1955) and ii) moisture balance (Tripathi, 1986) methods have been compared with net cumulative pan evaporation (CPE) method, which was used to irrigate the wheat crop grown in semi reclaimed soil, classified as *aquic natrustalf* of the order *alfisol* with loam texture in the surface and silty clay loam in the sub surface, at Karnal (Haryana). The study. was aimed to arrive at a workable method suitable for proper distribution and regulating the water courses on a regional basis.

The study revealed that in a dry period, all the three methods estimated similar dates of irrigation. The applicability of water balance procedure and CEP methods appear to be simpler for scheduling irrigation and regulation of water delivery system.

IMPACT OF IRRIGATION ON AGROCLIMATIC CHANGES IN THE ARID DISTRICT OF GANGANAGAR

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The arid desert ecosystem of western Rajasthan in India is subjected to highly variable and sparse rainfall, extreme-temperatures, strong winds leading to high evaporative demand, soil erosion and frequent droughts threatening the limited productivity from this arid region. The recurring type of climatic hazards necessiated for irrigation to bring out stability and improve agricultural productivity in the

region. The impact of canal irrigation on the agroclimatology of Ganganagar district has been indirecly assessed from the agricultural productivity in the region.

The low and erratic rainfall of the region causes droughts under rainfed crops in every 3 out of 5 years causing failure of crops. Irrigation given in this region of Ganganagar mainly from the Rajasthan Canal since 1960's has broughout vast trasformation of arid region by improving the microclimate and substituting the rainfall deficiency. It has enhanced the cultivation of irrigated crops like rice, wheat, cotton, sugarcane, pulses and oil seeds at the cost of reduction in the net sown area of certain rainfed crops like bajra. The analysis on the crop productivity (1956-85) of of rice, bajra, wheat, cotton, sugarcane. pulses and oil seeds generally established increasing linear trends rating 4.6-7.4 per cent per year.

CONSUMPTIVE USE AND IRRIGATION REQUIREMENTS OF RICE AND BANANA IN SOUTH KERALA - CLIMATOLOGICAL APPROACH.

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Based on 70 year mean weather data available at the meteorological observatory Trivandrum, the Consumptive Use (CU) of rice and banana were estimated following the Blanney Criddle method. In south Kerala, the reference Crop Evaeapo Transpiratia (ETO) from January to December ranged from 6+1 to 7.4 m.m/day, the lowest being in November and the highest in March. The CU of medium duration rice (125 d) during kharif (May-Septemper) and Rabi (Septemeber - January) was estimated to be 881 and 357 m m

respectively. The corresponding irrigation requirements were 256 and 451 m.m. During summer (February - May) a short duration rice needs 751 m.m of water for CU of which 577 m.m has to reach through irrigation. Among seasons, the per day CU of rice was more during summer.

The CU of August planted Nendran Banana (13 months) was estimated to be 2032 m.m while the irrigation requirement was 860 m m

CROP WATER AND IRRIGATION WATER REQUIREMENTS OF EKSALI SUGARCANE IN THE SOUTHERN PARTS OF KERALA CLIMATOLGICAL APPROACH

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The crop water and Irrigation water Requirements of sugarcane (12 months) were estimated emperically for the sourthern parts of Kerala, using the Blanney Criddle formula. 70 year mean data on weather available at the meteorological observatory, Trivandrum were used for this purpose. It was found that sugarcane planted in october requires. 2621 m.m of water for Consumptive Use (CU). Of this 1200 m.m is contributed from rainfall. The irrigation requirement water of eksali sugarcane is estimated to be 1421 m.m.

IRRIGATION REQUIREMENT OF SUMMER GREEN GRAM SCHEDULED THROUGH PAN EVAPORTION AND DEFFERENT STAGES

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An experiment to evaluate the water requirement of summer green gram Vigna radiata was conducted at the Rajendra Agricultural University farm, Pusa, Bihar during 1985 to 1987 wiih eight,

irrigation treatments in randomized block design with four replications. The treatments consisted of three IW: CPE rations of 0.8, 0. 6, and 0. 4, with 6cm irrigation depth, four combinations of stages and days after sowing comprising of presowing, presowing plus 30 days, presowing plus 30 and 45 days, 30 days without presowing and a rainfed control. The results of pooled analysis showed that pre-sowing· irrigation is most essential and had increased grain yield from 3. 67 q/ha with no irrigation to 6.65 q/ha. The maximum grain yield (9. 26 q/ha) was recorded with IW: CKPE ratio of 0. 6 which resulted in two irrigations each of 6 cm. The total water requirement at this level varied from 25. 8 to 29. 8 cm depending upon the rainfall intensities. Growth characters like height, number of branches and green matter yield were favourably influenced with two irrigations scheduled either through IW: CPE ratio of 0. 6 or combinations of stages.

STUDIES ON EVAPOTRANSPIRATION OF IRRIGATION JOWAR AND GROUNDNUT AS DETERMINED BY VARIOUS METHODS IN POST - MONSOON CLIMATE OF KONKAN

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The stndies revealed that the evapotranspiration of sorghum determined by lysimetric method was positively and significantly correlated with that computed by pan evaporation method (r=0.70), modified penman method (r=0.68) and Blaney Criddle method (r=0.64). Pan evaporation method showed its significant positive association with Blaney Criddle (r=0.91), Radiation (r=0.98) and modified Penman method (r=0.98). Similarly, in case of groundnut it was evident that evapotranspiration from lysimetric method revealed significant positive relationship with that from Pan evaporation

method (r=0.69), modified penman method (r=0.57), Blaney Criddle method (r=0.55) and Radiation method (r=0.54). The positive and significant relationship of pan evaporation method with the other empirical methods suggested that the former could be taken as an index to represent the empirical methods precisely in integrating the effects of weather parameters on evapotranspiration of both sorghum and groundnut in warm humid climate of Konkan.

CONSUMPTIVE USE AND IRRIGATION REQUIREMENTS OF SUMMER GROWN GROUNDNUT-A CLIMATOLOGICAL APPROACH.

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The consumptive use and irrigation requirements of summer grown groundunt in the southern parts of Kerala are worked out based on the weather data collected from meteorological observatory Trivandrum, Summer grown ground nut (Jan-April) requires 573 mm of water for consumptive use of which 147 mm is contributed from rainfall (effective rainfall). The irrigation requirement of groundnut is estimated to be 426 mm.

WATER REQUREMENT OF CROPS IN THREE RICE-BASED CROPPING SYSTEMS

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Field trials on rice-rice,rice-ragi and rice-groundnut cropping systems were carried out in the tank irrigated wetlands of the University of Agricultural Sciences, Bangalore in the wet and dry seasons during the period from 1982 to 1984. Four levels

of irrigation were tried. In the wet season, continuous submergence was found to be the best for rice and the water requirement worked out to 110. 77 cm. For the sequence crop in the rice-rice system, partial submergence was best for rice (84.96 cm) whereas giving irrigation at critical stages gave the best water economy for ragi (15. 4 cm) and groundnut (17.03cm.)

IRRIGATION REQUIREMENT OF PEPPER
(Piper nigrum Linn.)

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A pioneer irrigation experiment on Panniyur 1 variety of pepper was started at Pepper Research Station, Panniyur, during 1981-82. Based on the active root zoue of the plant and the soil charactertstics of the experimental plot, the depth of irrigation was determined to be 10 mm. (100 lit. of water per irrigation).

Four levels of irrigation viz. IW/CPE ratio of 1.00 0.75 0.50, and 0.25 were tried. Based upon the common belief of the farmers that a short moisture stress just before flowering is good for better productivity of the plant, two types of irrigation too were tried. In one set of plants the the aforementioned irrigation levels were administered from November-December to onset of South west monsoon (June next year) In an equal set of plants, the irrigation was stopped by the end of March so to provide the short stress period for the plant. An absolute control without any irrigation too was maintained.

Yield data from the experimental plot for the past 6 years has brought out the following results:

1. In a rainfed crop of pepper, a short period of moisture stress just before the flushing and flowering season is advantageous.

2. But the plant can adjust itself to soil moisture regimes in terms of productivity when it is irrigated continously over a number of years. Under such conditions, the period of moisture stress just before flowering seems to be not necessary.
3. In the present day rainfall pattern of Cannanore District, it is advantageous to irrigate the pepper plants at IW/CPE ratio of 0,25.

WATER REQUIREMENT OF BANANA CV, NENDRAN CROWN IN CLAY LOAM SOILS

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An experiment was conducted during 1985-86 and 1986-87 at Regional Agrlcultural Research Station' Pilicode to fix up the optimum water requirement of banana cv. Nendran grown in clay loam soils. irrigation was given at the rate of 20 mm water per irrigation at IW/CPE ratios of 1.00, 0.75 and 0. 50. There was no significant defference between these treatments for plant height, girth of pseudostem, bunch weight and yield/ha.

The consumptive use of water by the crop was worked out using soil moisture depletion method. Irrigation at IW/CPE ratio of 1. 00 recorded the maximum consumptive use followed by irrigation at IW/CPE ratio of 0.75 and 0.50. Irrigation at IW/CPE ratio of 0. 50 recorded the maximum water use efficiency The crop coefficient for computing the water requirement was found to be 0. 67.

EFFECT OF LEVELS OF IRRIGATION AND TIME OF SOWING ON THE GROWTH AND YIELD OF SNAKEGOURD

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An experiment was conducted at the Main Campus of Kerala Agricultural University, Vellanikkara during summer of 1985-86 to study the effect of time of sowing and levels of irrigation on the growth and yield of Snakegourd.

The irrigation treatment IW/CPE ratio, influenced the vine length, female flower production, picking maturity fruit weight, fruit length, girth of fruit, flesh thickness' dry matter production and total yield of fruits.

The November 16 th sown plants recorded highest vine length, more number of female flowers, higher number of fruits, highest fruit weight, fruit length, maximum dry matter. production and maximum water use efficiency.

SESSION V

ENVIRONMENT IMPACT ON AGRICULTURE

AGROCLIMATOLOGY OF PRAKASAM AND NELLORE DISTRICTS OF ANDHRA PRADESH

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The agroclimatic aspects of the Prakasam and Nellore districts of coastal Andhra Pradesh, have been attempted. The region represents the tropical dry climates of monsoon Asia and is also influenced by the weather disturbances formed in the Bay of Bengal. It covers an area of 30, 678 Km^2 with a population of 43.44 lakhs, accounting 11% of the area and 8.14% of the population of Andhra Pradesh. About 61% of the cropped area is under rainfed cultivation. The mean annual rainfall over the region is 908 mm and 75% of the area fall under 'dry farming tract of India'. Both southwest and northeast monsoon rains affect the agricultural potential. Thornthwaite's water balance model is mainly utilised to assess the climatic and water resources of the region for agricultural development.

The distribution of monthly rainfall at different probability levels revealed that one should consider dependable rainfall (75% prob.) or rainfall at some other chosen probability, rather than mean rainfall. The crop growing season is too short to grow two rainfed crops. The commencement of

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humid period has no influence on the onset of monsoon rains. The water requirement of different crops grown in the region indicates that chillies and cotton require more water than maize and groundnut. The weekly water balance diagrams indicate the possibility of mid-season moisture stress, irrespective of their normal climate.

The intensity of climatic drought varies from place to place and also from season. The percentage of occurrence of drought is more for cotton and groundnut compared to other crops grown in the region. The inter-annual variations in mean air temperature indicate the warming of global environment by 0.2°C, and increasing and decreasing trend in rainfall receipt is evidenced. The climatic shifts in the moisture regime indicate that the dry sub-humid climate has more shift toward semi-arid than humid. The semi-arid climate indicates that about 70-90% of the years are under semi-arid conditions. However, the climatic features of northwestern parts are indicating the arid conditions, atleast once in five years. The fluctuations in crop yields are associated with the changes in seasonal moisture index. The study region has been demarcated into nine agro-ecological zones and the possible agronomically relevant cropping patterns are suggested for improving productivity.

SURFACE LAYER MODELLNG AND ITS APPLICIATIONS IN AGROMETEOROLOGY

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In this article, the importance of surface layer, the equations governing the meteorological regime of the surface layer are presented. The linear and non linear models describing the meteo-regime of the surface are discussed. The non linear model of Murthy & Laikhtnev was shown to be in better agreement than linear model.

The important applications of the model in 1. Vertical flux measurement, 2. Water requirements and 3. Drought studies are also discussed.

ESTIMATION OF PENMAN POTENTIAL EVAPOTRANSPIRATION FROM THORNTHWAITE POTENTIAL EVAPOTRANSPIRATION IN PENINSULAR INDIA

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Penman method of computation of PET is more accurate than Thornthwaite's. However the

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former method requires more weather parameters data compared to the latter. Here it was attempted to compute the factor for the conversion of Thornthwaite PET into Penman PET, so that it could be used to convert the former into the latter. A regression equation was also developed to convert Thornthwaite PET into Penman's. Data of 38 stations in peninsular India were used. The regression equation viz., Y=828.44+0.55X gave more accurate estimation compared to the ratio method yielding a multiplicative factor of 1.08.

MODIFICATION AND APPLICATION OF THE PAPADAKIS EMPIRICAL PET FORMULA IN THE CLIMATIC CONDITIONS OF THE PUNJAB.

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Emperical equations are frequently used to predict PET based on climatological data. In many places full array of climatic information is not available. The Papadakis formula can be used where only maximum & minimum temperatures are available. However, the constant, function of other climatic parameter needs modification to suit to differing climatic conditions. Wind speed not considered important by Papadakis for his sitution was observed to significantly affect PET prediction under winter condition of Punjab. The Papadakis equation was, therefore, modified to include a wind function to derive the constant. The inclusion of wind factor improve the PET prediction. The estimates were

significantly correlated with ET_o values with r value ranging from 0.85 to 0.96 for different years at Ludhiana. The variation from actual was less than 10 per cent indicating that modified Papadakis equation can be applied to Punjab conditions.

A PRELIMINARY STUDY ON THE SOIL HEAT FLUX AT PATTAMBI

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Soil constitutes a major storage location for heat, acting as a sink for energy during the day and as a source to the surface at night. The flux of heat into and out of the soil is a process of conduction and mainly depends on specific heat and thermal diffusivity, which inturn depend on moisture content and bulk density. Heat flux within the soil has a great influence on the temperature conditions in the ground-proximate air layer. The changes in the heat flux in the plant root zone considerably influence seed germination, emergence and establishment of crop.

Data on soil temperatures measured at the Regional Agricultural Research Station, Pattambi, at 5.15 and 30 cm depth was collected twice daily at 0700 hrs. and 1400 hrs. L. M. T., for the period 1977-86. Thermal diffusivity and specific heat of the two soil layers 5-15 cm and 15-30 cm were deter-

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mined for all the twelve months at various soil moisture levels. Monthly soil heat fluxes for the above two soil layers at both the times of the day were computed following Subramaniam and Sasthri (1976). It is observed that maximum heat flux occurred in November at both the depths and times of the day. March of monthly temperatures and heat fluxes are presented and discussed.

RAINFALL PATTERN IN KUTTANADU

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R. R. S. Moncompu

The paddy crop in Kuttanadu is not rainfed in nature. But considering the association of rainfall and its distribution on the yield of crop in an area, an attempt has been made to find out distribution of monthly annual and seasonal rainfall pattern in these areas, so as to enable efficient planning of agricultural operations.

Daily rainfall data recorded at R. R. S. Moncompu for a period of 24 years from 1964 to 1987 have been utilised. Normality of the monthly rainfall during the period was examined. The distribution of annual rainfall and the two seasonal rainfalls viz. puncha season (November - April) and additional crop season (May - October) were also studied.

It was observed that the monthy rainfall data did not confirm to normal law. Annual as well as puncha crop season rainfall were found to be in the proportion of 1:1:1 and the additional crop season

rainfall in 1:2:1 for high, medium and low rainfall limits. The mean annual rainfall observed was 2804.75mm. The mean value for Puncha Crop season was 447.12 mm and that for additional crop was 2357.65 mm.

VARIATION TENDENCIES IN RAINFALL PATTERN

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Average rainfall Pattern worked out based on the data for the last 35 years (1953-1987) showed that June to September and October - November periods account for 61 percent and 17 percent respectively of the annual rainfall. Contribution of summer rains and premonsoon rains to the total rainfall is a paltry 3.3 and 1·5 percent respectively.

An indepth micro level analysis of the rainfall behaviour showed emerging trends in total rainfall its pattern and distribution.

A declining trend in annual rainfall and flattening and remodelling trends in the pattern of rainfall is apparent which may warrant subtle changes in crop production systems. In addition, the normal flood and drought situations are likely to get modified in these areas.

A MARKOV CHAIN MODEL FOR THE STUDY OF THE OCCURRENCE OF RAINFALL AT PATTAMBI

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A first order Markov chain model was applied to daily rainfall data of the meteorological observatory at Pattambi with a view to characterise the long term behaviour of fortnightly rainfall of that tract. It was found that the model was adequate in representing the pattern of occurrence of wet and dry days in all fortnights during the entire monsoon and pre monsoon period of the year. Before fitting the model the Morkovian property of the stocastic system was pre tested empirically using the chi-square test.

It was found that during all fortnights the conditional probability for a wet day to be preceded by a wet day was higher than that for a wet day to be preceded by a dry day. It was also found that in all the fortnight the system settled down to a state of equilibrium after a certain period of time and the number of days taken to attain such a state ranged from 6 to 12. The expected lengths of dry and wet spells and that of weather cycle were also worked out. The state occupational probability for equilibrium showed an increasing trend upto the second fortnight of June & thereafter showed a steedy decline. Equilibrium probability for

the occurrence of a wet day in the 2nd fortnight of June was found to be 0.777 but that in the first fortnight of July turned out to be 0.767. Maximum expected length of wet spell was recorded in the first fortnight of July (6.94 days) and this was followed by the second fortnight of June (6.54 days). Expected length of wet spell increased upto the first fortnight of July and thereafter showed a tendency to decline upto the end of November. In most of the fortnights the weather cycles had a length of 6 to 8 days with expected frequency of wetdays ranging from 1 to 7. It was also observed that there had been a significant change in the estimates of rainfall parameters in between the latter fortnight of May and the first fortnight of June. Which indicated that the likely commencement of the South West monsoon at Pattambi could be in the first fortnight of June.

MARKOVIAN CHAIN MODEL TO ARRIVE AGRONOMICALLY RELEVANT RAINFALL DISTRIBUTION

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The rainfall pattern and its probability at Regional Agricultural Research Station, Palem was studied in the present paper. The analysis of precipitation data by the Markov chain probabilities for 5, 10, 20, mm weekly rainfall was carried out. By treating each day of the month as dry or wet

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according as the amount of rainfall during the day is less than/equal to or greater than 1·25 mm respectively. The data was classified into four possible outcomes. Dry day followed by dry day, dry day followed by wet day, wet day followed by dry and wet day followed by wet day. The probabilities of the outcome provided estimates for the parameters of the model the equilibrium probability II_1 II_2 for dry and wet days respectively. Similar results available for Hydrebad, Mahaboobnagar (ICRISAT) are compared with the resultes arrived for palem to charecterise the rainfall climitology that is agronomically relevent in respect to the existing crops and cropping pattern.

STUDIES ON VARIABILITY OF PRIMARY PRODUCTIVITY OF KERALA STATE

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Kerala depends on its agriculture and plantation crops for its economic development. Any fluctuation in the rainfall towards the drier side would upset the delicate moisture regime and water balance of the region and hence would affect crop yields adversely. The present study attempts on appraisal of the primary productivity of Kerala State from temperature and precipitation data using the Thornthwaite memorial model of Leith & BOX (1972). The computed productivity values are compared with the actual crop yield data.

PROBABILITY OF OCCURRENCE OF RAINFALL AT PANTNAGAR

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Analysis of the probability of occurrence of annual and weekly rainfall and length of dry spells from 22 years (1960-1981) of weather record showed that log normal distribution predicts the annual total rainfall fairly accurately. About 861mm of rainfall must occur every year and 1209mm in every alternate year. Two consecutive years should not be a low rainfall year. Rainfall amounts of about 2000mm have a return period of 11 years. Probability of time to the next wet day calculated at 70 per cent level compared best with the observed values (r=0.98) Analysis showed the onset of monsoon period from 24th week and the end of monsoon by 37th week. There is almost no chance of rainfall during the weeks 40 to 51. The possibility of winter rainfall was greatest during the weeks 52, 4 and 10. These rainfall events will coincide with crown root initiation, jointing and flowering to milk stages of wheat at Pantnagar if planting is done in the first week of December.

WEEKLY RAINFALL CHARACTERISTICS OF SOUTH-WEST MONSOON FOR JABALPUR

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The paper gives the short-term rainfall characteristics of South west monsoon (S W M) for Jabalpur on the basis of rainfall data of 35 years (1950 to 1985 excepting 1951). The analysis has been done on weekly basis in terms of the climatic water balance, probabilities for different amount for different weeks, initial and conditional probabilities for different weeks, weekly rainfall statistics, dates of onset, withdrawal & duration of SWM.

From the statistical analysis the main conclusions drawn suggest that in areas around Jabalpur sufficient and dependable rains occur during the Standard Meteorological Week (SMW) 25 to 37 in four years out of every five years. It also suggests that for dry sowing of kharif crop on twenty fourth SWM is possible with probability of about 70% of good harvest. Therefore, it can be inferred that kharif crop in this area is almost assured. It was also observed that dependable soil moisture is available for rabi sowing.

SESSION VI

CROP WEATHER MODELS AND AGROMETEOROLOGICAL FORECASTING AND INSTRUMENTATION

FORECASTING ON AGROMETEOROLOGY

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The importance and impact of forecast on agrometeorological parameters have been felt as early as 1926 by the Indian Agricultural Commission and as a result the first set of forecasts were issued from various Regional Meteorological Centres in the year 1945. The Agricultural Meteorology Division has taken up the Agrometeological Advisory Services (AAS) since 1979 and at present nine AAS units are functioning all over the country to monitor the needs of the farmers for their day to day operational works. Eight more units are likely to come up shortly to cover the entire nation. The bulletins are now being issued once or twice in a week with consultations of Agricultural Experts for telecasting and broadcasting via existing medium for the benefits of the farmers.

This paper highlights the various steps followed in the preparation of such bulletins for subsequent dissemination to the users in addition of telecasting and broadcasting by different media. The different agrometerological elements to be included in the bulletins of forecast during the various phases of the crops have been also presented in this paper. The different weather warning systems detrimental to the crops development and to be included in the forecasting bulletins for taking remedial measures depending on the phases of the crop have been also discussed here.

AGROMETEOROLOGICAL WEATHER FORECASTING FOR FARMERS

O. P. BISHNOI
H. A. U., HISSAR

Weather manifests its influence on agricultuoal operations and farm production through its effects on soil, plant growth as well as every phase of animal growth and development. Weather hazards or abberant weather influence the crops and losses due to conditions affecting harvesting, storage, parasites, crop and animal diseases.

Therefore a specially tailored weather support available to the needs of agriculture can contribute towards short term adjustments in daily agricultural operations which minimize input loses resulting from adverse weather conditions and can maredly improve the yield and quality of agricultural products. Short, medium and long range forecasts in relation to agricultural activities have been main emphasis with particular applications in agricultural operation and planning. Emphasis on crop weather outlook reports preparation from farmer's point of view have been given due emphasis with particular applications on operational, fire weather, crop yield, pests and diseases of crops and animals, frost forecasts so that how farmers productivity can be improved from losses' due to abberant weather conditions in monsoonal climate of India. Present and future status of weather forecasting in India has been also emphasized.

FORCASTING KHARIF SORGHUM YIELDS IN A DRY FARMING REGION OF INDIA

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A systematic methodology using basic and updated models of multiple regression to forcast *Kharif* sorghum yields of Amraoti district in the dry farming region of Maharashtra State State has been presented using data series of 25 years (1956-1980). Periods and weather varieties of phenological significance have been identified. The regression models are able to explain about 90 percent of total variation in yields. All the updated models display progressive improvement. The models display quite satisfactory performance and verifaction during the years outside the model samples except 1985.

The physical cause for high negative departures of forecast yield figures in 1985 are, on investigation, found due to the negative influence of abnormally excess rainfall during flowering period of crop season. Associated synoptic situations have also been discussed. The forecast for 1985 improved significantly when the effect of excesss rainfall was eliminated.

WEATHER ANALYSIS AND MODELLING OF RICE GROWTH AND YIELD-1.

P. H. LATIF-2 K. P. PRADEEP-3

The growth and development of 9 test varieties and a local check variety are analysed in relation to real-time weather data recorded daily at the test site. Some general conclusions that have a practical implication are described. Following an all-possible regression procedure, PROC RSQUARE of the statistical computing package Statistical Analysis System (SAS) with the Cp statistic few selected models are worked out and reviewed. The following five-variable prediction equation is used in predicting yields:

$$Y = 4.800 + 0.5743\ (DNB - 3.1) - 0.1492\ (TDB - 28.1)$$
$$(0.047) \qquad (0.07181) \qquad (0.03142)$$
$$+ 0.06384(RSB - 30.446) + 0.1665\ (RSC - 13.064)$$
$$(0.008818) \qquad (0.01793))$$
$$- 0.1327\ (TNC - 24.0)$$
$$0.02192)$$

where the predictor variable are day-night temperature difference before flowering (DNB) with an average of 3.1, day temperature before flowering (TDB) With an average of 28.1, radiation sum before flowering (RSB) with an average of 30.446 (the RSB variable in the equation is the measured RSB multiplied by 0.001), radiation sum after flowering (RSC) with an average of 13.964, and night temperature after flowering (TNC) with an average of 24.0. The values in the parentheses are standard errors and 4.8 is the average yieldof the ninetest varieties.

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FORECASTING MODEL BASED ON GENERATED VARIABLES TO PREDICT COCONUT YIELD

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In a bid to study the interactive effects of some of the important climatic factors on annual yield of coconut, Correlations were worked out between 44 generated variables using eight climatic factors for four seasons. The model was derived in two stages. In the first stage prediction equations for annual yield with the selected climatic variables (explanatory variables) of each senson were obtained. In the second stage, the prediction equation obtained in the first stage were used as explanatory variables and the final model was obtained by employing step-wise regression.

Sunshine hour (SSH) was observed to be one of the most important climatic factors influencing coconut yield, showing both deletarious and beneficial effects. The fitted model estimates annual yield of coconut with a coefficient of determination of 0.88.

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FORECASTING MODELS FOR CROP YIELDS IN CASHEW

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A sample of 243 trees belonging to 16 varieties of cashew were selected the Cashew Research Station of KAU at Madakkathara, Trichur and their yield for ten years (i. e. from 1976 - 1986) were collected. The monthly data of four meteorological parametres viz: maximum temperature, minimum temperature, rainfall and sunshine hours were collected for eleven years (i. e. from 1975 – 1986) from meteorological observatory, Vellanikkara, Trichur.

A total of six forecasting models were proposed for each of the 16 varieties of cashew of which the first three belong to the square model category, and the last three belonged to the squre root model category. The effective crop season for these models was taken as a period of six months just prior to harvest. Different

combinations of these six months, depending on its influence on the crop yield were considered which gave rise to the four seasons.

Under each season, the six models were introduced. The final crop forecasting models for the yield of each of the 16 cashew varieties were fitted through step up regression. Based on the comparison made using criteria functions the best and most promising forecasting model for each variety for the purpose of future use in predicting the yield were selected.

FORECASTING OF RICE YIELD USING CLIMATOLOGICAL VARIABLES

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A study of foreacasting of rice yield well ahead of harvest using climatological variables was undertaken based on the data related to the co-ordinated crop weather experiments conducted at the Rice Research station, Pattambi for the period from 1949 - 50 to 1973 - 74. Observations on various climatic variables such as total rainfall, number of rainy days, maximum temperature, minimum temperature, maximum relative humidity, minimum relative humidity, number of hours of sunshine, wind velocity were gathered in addition to the seasonal yield. The varieties PTB 1 and PTB 5 were grown as rainfed in the autumn season following more or less uniform cultural or managemental practices during the entire experimental period. Linear regression models were developed to get advance esimates of production on the basis of weekly climatological variables. It was found that yield forecast with sufficiently high degree of accuracy could be made in the fifth fortnight after sowing. Among the different predictor variables, number of rainy days during the 3rd and 5th weeks after sowing, rainfall range during the 4th week after sowing and total rainfall during the 8th week after sowing were decisive in making yield predictions.

Regression models based on generated variables led to more efficient early forecasts than that based on weekly climatic variables. The method also emphasised the importance of considering interaction effects of various weather factors also in developing prediction equations. Two models were used in this study. In the first regression model, weighted averages of weekly weather variables and their interactions using powers of week number as weights were used. The respective simple correlations of weather factor with yield in place of week numbers were taken

as weights in the second model. The generated variables of the latter model were better predictors than that of the first model. The composite regression models were successful in making available yield forecasts with high accuracy for the 2 varieties as early as in the fourth fortnight after sowing.

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INFLUENCE OF RAINFALL AND NUMBER OF MOIST DAYS ON THE YIELD OF PADDY OF SOUTHERN DISTRICTS OF KERALA

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Secondary data for the period 1972—1973 to 1981—1982 gathered from the Directorate of Economics and Statistics on Taluk wise production of grain paddy and these on monthly rainfall and number of rainy days at the nearest reporting station in all the Districts South of Ernakulam in Kerala were utilised for correlation and multiple regression analysis.

Considerable variation was observed between places in different districts with regard to the influence of weather factors. During the Autum season, no. of rainy days during June, gave a significant correlation with the yield of paddy at Attingal, Kottarakkara, Pathanapuram and Mavelikkara. In general the South West monsoon rainfall exerted significant beneficial effects on the yield of paddy at Trivandrum, Quilon and Alleppey Districts. Heavy July rainfall was found to exert significant adverse effects with grain yield of paddy in the Autumn season especially in the Idukki District.

It was also found that number of rainy days was a better predictor variable than rainfall as it would indicate the distribution of rainfall over the period than its intensity.

High rainfall during August and September contributed to better yield in the winter season at Attingal while at Shertallai frequent rains during August resulted in significant yield reduction. At Devicolam high rainfall during October enhanced production.

Prediction equations were evolved to predict the yield of paddy at different centres in each district. Among them the prediction equation for Idukki in the Autumn season gave maximum predictability (R^2 = 81%).

WEATHER INDEX USING PRINCIPAL COMPONENT ANALYSIS

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Based on the linear function that accounts for the maximum variation in the dispersion matrix of the variables, a weather index taking into account the rainfall and temperature was suggested. The index and the index P T suggested by Lange have been computed for the periods July 1 to October 15 and October 1 to January 15 The suggested index has been found to be at least as good as the rainfall index.

Weather indices based on the actual duration of the crop were also computed from 1973 to 1979 when the exact dates of sowing and harvesting were available.

AGRICULTURAL MICROMETEOROLOGY

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The profiles of winds, temperatures and moistures within the crop boundary layer (CBL) depend on the roughness parameter and zero plane displacement of the related fields of meteorology. The introduction of the above CBL parameters improve the model results for accurate assessment of different profiles. Here, different mathematical and statistical steps have been put forward for evaluation of CBL parameters which have been subsequently used for the development of profiles studies. The model results have been compared with the actual observed data for showing the correctness of the model.

This type of model developmeut will help in understanding the prevailing fluxes within the crop fields and environment for

approximate planning and management of the farm suitably. The estimations of model characteristics by different techniques are also discussed in this paper.

INSTRUMENTATION FOR AGROMETEOROLOGICAL AND ENVIRONMENTAL INVESTIGATIONS

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Central Institute of Fisheries Technology had been engaged in the development of instruments for fishery hydrography and related marine environmental investigations. Many of these instruments which were tested and operated under the hostile marine conditions were later modified for applications in a variety of other fields including agro-meteorology, water resources, soil science etc. With noval features and specific operational advantages in comparison with equivalent types, namely, low power requirements, remote measurements, integrated data acquisition which make them suitable for operation at remote sites. The data acquired using independant instruments as well as large data acquisition systems and useful for investigations in agrometeorology are: air temperature, relative humidity, wind, wind direction, solar radiation, average radiation, atmospheric pressure, rainfall, water temperature, water salinity, waves, water flow, water evaporation, water level, soil temperature and soil moisture. Some of the special features of the sensors and systems developed are: remote measurements of all the parameters from distances upto a few hundreds of metres; integration of wind energy, solar energy average solar energy over long required durations of hours, days or months; continuous measurement of soil moisture and soil temperature from different depths and locations. The new instrumentation techniques have shown noval investigation methods and facilities for faster and scientific results.