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From the Chief Editors Desk…

Dear Readers,

Agriculture has been the very important occupation of human beings. Increasing population, climate change, shrinking the resources and increasing disposable incomes have put agriculture worldwide under tremendous pressure. To face the changes we need the basic knowledge with high research potential in agriculture. So we glad to launch our first issue of **"Agrisakthi Nature Monthly e-Magazine for Innovative Agriculture"**. The main aim of this magazine is to explore the novel innovations, modern technologies, scientific information and latest findings in agriculture and allied sectors for upliftment of farming community. Agrisakthi Nature e-magazine is an open access peer reviewed English journal which will start publishing from January 2022.The Agrisakthi Nature e-magazine will offer a platform to all the undergraduate and post graduate students, scholars, researchers and scientists to share their ideas about latest innovative topics. We invite the popular article, review article and short communication from various disciplines like agriculture, horticulture, forestry, animal science, dairy science, fishery, organic farming, medicinal plants, and sericulture. The following points to be considered before submission, an article must be free of plagiarism, author himself/herself is responsible for plagiarism, article must be within magazine article page limit (within 3-4 pages), article should not be sent for publication and published elsewhere and author agrees to guidelines and terms, conditions of our magazine. Our Email id is : editor@agrisakthi.com, please share your articles to this email id .

We are happy to announce, our team already published **"Agrisakthi"** Magazine for past two years with 53 issues successfully in Tamil language and received huge positive responses from worldwide. We are looking forward for the same responses to this **"Agrisakthi Nature Monthly e-Magazine for Innovative Agriculture".**

Wish you happy New Year 2022

Best wishes

Editorial Board

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1. ABIOTIC (ENVIRONMENTAL) STRESSES AND PHYSIOLOGICAL CHANGES IN PLANTS

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Introduction

The effects of climate change on the general environment have been very significant over the years, most especially in agricultural plants grown in various environments. According to Intergovernmental Panel on Climate Change (IPCC), stresses are incurred on plants as a result of changes in the climatic conditions of the environment, which has been concluded to be the most influencing factor affecting agricultural production.

The individual climate change inducing stressors are abiotic in nature and they impose stress on different plant species: these abiotic plant stressors include drought, high or low temperature (low and high), and waterlogging, the fight against these stress factors are however complex due to how interrelated they are.

Drought (Water stress)

Drought is defined as the deficiency of water severe enough to check the plant growth. Drought has been classified into two broad categories viz., soil drought and atmospheric drought. Soil drought leads to atmospheric drought. Atmospheric drought occurs due to low atmospheric humidity, high wind velocity and high temperature which cause a plant to lose most of its water.

Physiological changes occur due to drought

Functioning of stomata

In general, stomata lose their function and may die, because wilting after certain limit denatures the starch in the guard cells and also in the mesophyll cells.

Carbohydrates metabolism in green leaves

The very first effect of drought on carbohydrates metabolism is that starch disappears from the wilted leaves and sugar accumulates simultaneously.

Photosynthetic activity

CO_2 diffusion into the leaf is prevented due to decrease in stomatal opening and there by reduces photosynthetic activity in green cells.

Osmotic pressure

The reduced amount of water during drought causes an increase in the osmotic pressure of plant cell. This increase in osmotic pressure permits the plant to utilize better soil moisture.

Permeability

The permeability to water and urea increases during drought.

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Biochemical effects

Water shortage alters the chemical composition. For example, starch is converted to sugar, besides this, there is a considerable increase in nitrate nitrogen and protein synthesis is adversely affected.

Methods to overcome drought

- Selection of drought tolerant species
- Adjusting the time of sowing in such a way that the crop completes its lifecycle before the onset of drought
- Seed hardening
- Mulching to minimize the evaporative loss
- Foliar spray of anti-transpirants

Temperature (Heat) Stress

Heat stress is an important environmental stress factor in plant productivity that typically accompanies drought conditions. Intense solar radiations and / or decreased evaporation of water from plant surfaces add to heat stress faced by plants.

Upper Temperature limit for Survival

Although some plants such as *Tidestromiaoblogifolia* (family Amaranthaceae), a native of very hot climate of death valley, California and some desert grasses thrive well at temperatures upto 50°C or even higher, most tissues of higher plants cannot Survive extended exposure to temperatures above 45°C. Among the vascular plants, the highest known temperature tolerance is found among agaves and cacti which can withstand temperature of 60°C or more.

In general, while actively growing plant tissues rarely survive temperature above 45°C, non-growing cells or dehydrated tissues such as pollens and seeds can endure temperature of 70°C and dry seeds of alfalfa are known to survive temperature of even 120°C.

Plants undergo heat – shock stress when suddenly exposed to temperatures 5-15°C above the ambient for brief periods ranging from 15 minutes to few hours. Heat – shock stress is very deleterious to plant growth.

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Physiological changes occur due to High temperature (heat) Injury

Inhibition of Photosynthesis and Respiration

At higher temperatures, photosynthesis and respiration are inhibited. However, the rate of photosynthesis declines first than the rate of respiration.

The reactions in thylakoid membranes of the chloroplasts of higher plants are most sensitive to high temperature which lead to declining photosynthetic rate. The photosystem II complexes located on these membranes are especially susceptible to heat injury. At higher temperature, the fluidity of thylakoid membranes itself is disturbed. In addition to the heat effects on primary photochemical reactions, the activities of Rubisco and other enzymes of carbon fixation may also be adversely affected.

At higher temperatures, the imbalance created between photosynthesis and respiration (rate of photosynthesis lesser relative to rate of respiration) is one of the main causes of harmful effects of high – temperature on plants that leads to decline in carbohydrate reserves. (This is the reason of deterioration of quality of vegetables and fruits at higher temperatures). This is more so in C_3 plants than in C_4 or CAM plants because of the operation of photorespiration in addition to the usual dark respiration in the former.

Cell Membranes Disfunction

At higher temperatures, the stability of the cell membranes is reduced. Their structure and composition are modified because of decrease in strength of H – bonds and electrostatic interactions between polar groups of proteins within the aqueous phase of the membrane. This may also result in loss of permeability and leakage of ions. As mentioned earlier, disruption of membranes causes inhibition of processes like photosynthesis and respiration; the reaction in thylakoid membranes of the chloroplasts being most sensitive to high temperature.

Denaturation of Proteins and Nucleic Acids

At very high temperatures, the proteins begin to denature and the enzymes lose activity. Unfolding of nucleic acids also occurs.

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Chilling Injury –Tolerance and Alleviation

Under natural and agricultural conditions, higher plants are also affected or stressed by cold or very low temperatures in certain parts of the year especially during autumn and winter. There are two types of cold injuries in plants, (i). Chilling injury (ii). Freezing (frost) injury. Injuries to plants caused by low temperatures (chilling temperatures) well above their freezing point are called as chilling injuries while injury caused by freezing temperatures (below the freezing point of water) that results in ice formation in plant tissues is called as freezing or frost injury. There is varying degree of tolerance to cold temperatures among different plants. Some plants may be more sensitive to cold than others, whereas some species may be cold resistant altogether. Chilling and frost damage is an important hazard in crop plants all over the world.

Chilling Injury and Chilling Resistance

Many species of plants especially those native to tropical and subtropical regions are susceptible to chilling injury. For instance, exposure to a temperature of 1^{0}C to 5^{o}C for 24 to 36 hours is fatal or markedly injurious to crop plants such as rice, velvet beans, cotton and peanut, but less injurious to maize, tomatoes, sorghums and pumpkins. Among ornamentals, ***Coleus, Croton, Passiflora, Diffenbachina etc.,***are examples of chill – sensitive plants. ***Arabidopsis***is a chill – tolerant plant.

As a result of chilling injury, the plants invariably show, (i) Reduced growth (ii) Chlorosis and lesions on leaves, (iii) Appearance of foliage as if soaked in water for long and (iv) In extreme cases, wilting of the plant and its death. The causes of such pronounced effects lie in disorders which are induced in the metabolic activities and physiological conditions within the plant cells such as (i) Loss of membrane functions, (ii) Inhibition of photosynthesis and translocation of carbohydrates (iii) Slower respiration (iv) Inhibition of protein synthesis and (v) Increased degradation of existing proteins. In general, larger the exposure of chillsensitive plants to chilling temperatures, the greater is the resulting injury.

Chill – sensitive plants may be acclimated or hardened by prior exposure to low but non – injurious temperatures. Plants are better acclimated to chilling by slow and gradual exposure to prior chilling temperature. Sudden exposure to low temperature around 0^{o}C (which is called as 'cold shock') is markedly injurious to plants. The plants native to temperate regions or those growing at high altitudes, are usually genetically adapted to colder temperatures and are therefore, resistant chilling injuries.

One of the reasons of some plants being chill – sensitive and others chill – resistant lies in the proportion of saturated and unsaturated fatty acids components in the lipid bilayers of their cell membranes. The cell membranes of chill – sensitive species have higher proportion of saturated fatty acids (with higher melting points) while those of chill – resistant species have higher proportion of unsaturated fatty acids in their lipid bilayers. This view is further supported by the findings of Williams et al., (1988) and Palta et al., (1993) who observed increased activities of the enzymes desaturases (the enzymes converting saturated fatty acids into un-saturated fatty acids) and an increase in the level of unsaturated fatty acids during acclimation to low temperatures. Thus, at chilling temperatures, the saturated lipids in the membranes will solidify soon disrupting the membrane activity in chill sensitive species. Higher proportion of unsaturated lipids in chill – resistant or chill – hardened species on the other hand, allows the membrane to remain fluid at low temperatures and function normally.

The importance of membrane lipids in acclimation to low temperatures has also been demonstrated by different workers using mutant and transgenic strains in plants such as *Arabidopsis* and tobacco.

Flooding

Flooding stress is a major environmental threat for plantssince frequency of flooding events increase over the years. Crop damages due to flooding events amount to several croresthrough yield losses. There is significant variation in the plant tolerance to flooding. Plant species adapted to wet areas had evolved specific strategies to face with and even thrive under flooded conditions.

Large variation in survival exists between plants submerged in darkness versus those submerged with little light, hinting at the importance of underwater photosynthesis. This importance is not only related to the production of carbohydrates but also, to the generation of molecular oxygen that accumulates in submerged plants and diffuses to tissues with less oxygen (e.g., roots).

Among cereals, rice has the exclusive ability to germinate and grow robustly in flood-prone areas. Rice adaptive plasticity to different hydrological regimes has allowed the selection and characterization of some genotypes that have been subsequently used to breed high yielding and tolerant modern varieties.

Although plants produce oxygen through photosynthesis, the lack of an efficient system to transport oxygen to nonphotosynthetic organs implies that these organs can be deprived of oxygen if their anatomy limits oxygen diffusion from outside. Additionally, complete submergence of the plant by flooding events may also lead to low oxygen availability in the aboveground organs, especially when water turbidity limits photosynthesis. When oxygen becomes limiting for respiration plants experience hypoxia, whilst the complete absence of oxygen (anoxia) is even more detrimental to plant survival.

Both hypoxia and anoxia trigger extensive reprogramming of gene expression, with induction of the fermentative metabolism, allowing the plant to use glycolysis for ATP production.

Climate changes will lead to extremes in water availability that will cause severe drought in some areas, while flooding due to extreme rainfall events will affect other geographical areas. Unless new crop varieties able to withstand abiotic stresses are developed, productivity will be greatly affected. Flooding in the wild is a natural occurrence in many ecosystems and therefore many wild species are superbly adapted to watery conditions. Here improved gas exchange with the environment is essential to avoid hypoxia within the plant. To this end, plants can induce and/or constitutively develop aerenchyma, longitudinal connected gas spaces, which provide a rapid means of aerial gas exchange over long distances within the plant. This is usually combined with a change in root architecture to minimize the distance (and therefore diffusive resistance) between the aerial surface and the flooded root tips, for instance via adventitious roots, which can create a collection of air conducting snorkels originating from the hypocotyl or stem into the anaerobic substrate. Often aerenchymas are combined with a barrier that prevents oxygen leakage into the surrounding anaerobic soil, which drastically improves flooding tolerance. An extensive aerenchyma system is extremely effective under waterlogged conditions where the shoot remains in aerial contact and can thus funnel air down to the root. During complete submergence, however, the shoot does not make aerial contact oxygen, their effectiveness in funneling air towards the roots is greatly compromised. In such cases, some wetland plant species, in an attempt to regain aerial shoot contact, display rapid vertical elongation of leaves, internodes or petioles to snorkel for air. This escape strategy is observed in some rice varieties, as well as in several other plant species.

In an alternative strategy the plant aims to enter a state of inactivity (quiescence), to be revived once the flood recedes. This is also a difficult tactic as energy and carbon utilisation should be kept to a minimum to make reserves last a long time, whilst they should simultaneously be sufficient to maintain cellular integrity. In submerged plants low oxygen and high ethylene conditions prevail under flooded conditions and thus rapidly accumulates inside the plant. The internal level of these gases is a balance between consumption, production and diffusive resistance. Therefore active, heterotrophic or compact tissue, such as meristems and roots, will rapidly experience low oxygen upon flooding. In photosynthetic tissue the consumption and production of oxygen is dependent on light conditions, and thus also the oxygen availability. Ethylene is the primary signal for most adaptations to flooding. Ethylene modulates a hormonal cascade of ABA, GA and ultimately auxin to induce adventitious rooting in tomato, *Solanum dulcamarum*, and rice. However, root emergence also requires ethylene induce ROS formation in the epidermal cells, leading to their cell death to allow root penetration.

Similarly, lysigenous aerenchyma formation, which is formed by apoptosis of specific cellsin the cortex, involves an ethylene dependent drop in antioxidant activity. The subsequent increase in ROS leads to the required cell death. Interestingly, the important suberin based oxygen barrier is not affected by ethylene, but likely causal genes involved in its formation have been identified. The escape strategy to reach the water surface is also ethylene driven. However, downstream signalling is considered divergent in the plant kingdom, as it was found to act via group VII ERFs in rice (see below), but via genes typical of low light induced elongation in *Rumex palustris*. Remarkably, ethylene pre-treatment induced anoxia tolerance of *Rumex palustris* was associated with enhanced hypoxia related gene expression. A behaviour that was absent in *Rumex acetosa*, a species that experience fewer flooding events and employs a quiescence instead of an escape strategy. This highlights the importance of a link between ethylene and hypoxic signalling pathways. The high levels of ethylene associated with flooding inhibit root elongation, but through the formation of aerenchyma the excessive ethylene is easily removed. However, species that are ineffective in producing aerenchyma therefore experience strong root growth reduction under flooded conditions. The strong dose dependency of ethylene signaling might play an important role in its contrasting developmental roles during flooding. To avoid detrimental effects associated with high levels of ethylene, some of the species that continuously occupy aquatic or flood-prone environments have lost or reduced their capacity to either produce sense or respond to ethylene.

CONCLUSION AND FUTURE PROSPECTS

Abiotic stresses are important restraint limiting the crop output worldwide. Plants show a wide range of responses to drought and heat stresses which are mostly depicted by a variety of alterations in the growth and morphology of plants. Although water and heat stress may affect the overall growth and development of the plants, the major stage being damaged is the reproductive growth. Even a mild stress at flowering or grain filling stage can substantially reduce the crop yield. Other clear effects of these stresses are damaged photosynthetic machinery, oxidative damage, and membrane instability. The genetic and environmental interactions are still poorly studied/understood. Hence, abiotic stress management technologies or tolerant crops should be developed to grow crops under various abiotic stresses with minimal yield loss.

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2. CLIMATIC FACTORS INFLUENCING PLANT DISEASE DEVELOPMENT

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Plant diseases are one of the important factors which have a direct impact on global agricultural productivity and climate change will further aggravate the situation. Plant diseases are estimated to cause yield reduction of almost 20% in the principal food and cash crops worldwide. In the last 40 years, effective management of pests and diseases has played a key role in doubling food production, but pathogens still claim 10–16% of the global harvest. In Asia, 14.2% of the potential production costing about US$ 43.8 billion is lost due to diseases. Environmental factors have traditionally been considered to have the major impact on disease development. Weather conditions have a great impact on disease development and have been intensively studied as predictors of disease outbreaks.

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The environmental conditions such as temperature, relative humidity, rainfall, duration and intensity of light, etc. play very important role in causing epidemics. These are actually the deciding factors and influence almost all the stages of disease cycle. Favourable environmental conditions are needed for sporulation, liberation of spores, dissemination of pathogen, germination, infection and establishment of pathogen in the host. For example, persistent optimum temperature and moisture are needed for spore germination and entry of germ tube in the host. Similarly optimum temperature, moisture, light and specific nutrition is required for the development of the disease and sporulation of pathogen.

Temperature

Temperature plays a very important role in the development and spread of the disease. Powdery mildew is favoured by high temperature. Bean, Greengram and Black gram powdery mildew (*Erysiphe polygoni*) is severe in summer. Root rot caused by *Macrophomina phaseolina* is also severe in high temperature (30-35^{0}C). Rice blast disease caused by *Pyricularia oryzae* is a low temperature disease and when the night temperature falls below 20^0C. *Verticillium* wilt of cotton is severe in low temperature. Loose smut of wheat is severe when temperature is around 19-20^0C, if high (29-30^0C), no disease is noticed. Optimum temperature for growth of bacterial leaf blight of ricecaused by *Xanthomones oryzae* pv.*oryzae* is 25-30^0C. Disease symptoms do not develop at temperature below 20^0C. The yellow rust of wheat, *Puccinia striiformis* does not tolerate high temperature. The disease is practically absent in seasons when temperature is high.

Bacterial wilt of corn caused by *Xanthomonas axinopodis* pv.*stewartii* is severe during mild winter. The bacterium overwinters in flea beetles. If winter is severe, the beetle is killed and so mild winter favours the disease. Apple scab caused by *Venturia inaequalis* overwinters as perithecia in fallen leaves. Ascospores are discharged in the early spring to initiate the disease. If blossom buds are swelling and beginning to open, if the temperature is near 20^0C and if the blossoms remain wet for 18 hours, scab can be expected within a week. In USA, the incidence of blue mould of tobacco is closely related to winter temperature. When temperature is 16.5^0C during January, the disease appears quickly in a severe form. If temperature is low the disease appear late in the season and cause less damage. Cold winter destroy the over wintering phase of the fungus (Oospores).

Relative Humidity:

It is a very important factor for the development of diseases

Sugarcane downy mildew:*Peronosclerospora sacchari* produce more conidia when RH increased from 86 to 90 percent.

Sorghum downy mildew:*Peronoselerospora sorghi* the maximum sporulation takes place at 100 percent RH. At 80 percent RH and below, no conidia are produced.

Late blight of potato:*Phytophthora infestans.* In USA, temperature of about 10^0C and relative humidity of not less than 75 percent for at least two days induce late blight of potato. In Europe, 12 hours of 90 percent relative humidity or more, temperature of 10^0C or more and free moisture on leaves prevailing for 4 hours induce late blight of potato. In

Peru, nocturnal humidity of about 95 percent is essential for outbreak of late blight of potato.

Rainfall:

Frequent rain drizzling favours the bajra ergot caused by *Claviceps fusiformis*. Bacterial leaf blight of paddy caused by *Xanthomonas oryzae*pv. *oryzae,* the disease develops rapidly when there is a combination of rainy weather, strong winds and temperature of 22-26^{0}C. Brown stripe / downy mildew of Maize (*Sclerophthora rayssiae var.zeae*), average rainfall of 100-200 cm or above caused severe disease in India. Brown spot of rice (*Helminthosporium oryzae*), heavy rainfall in September accompanied by a favourable temperature variation of 25-30^{0}C, followed by continuous cloudy weather during October and November and low solar radiation caused epidemic in India during 1942.

Dew

It favours sporulation of many fungal pathogens. Sorghum downy mildew caused by *Peronosporaphilippiensis* produces more conidia when the leaves are wet for 4-5 hours. Length of dew point is very much important in paddy blast. Dew period of 6-8 hours highly favours the disease.

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Moisture:

In order for most fungus spores to germinate and penetrate plant tissue, free water must be available on the plant surface. If the leaf is dry, infection will not occur. A dry spring can reduce disease development for the entire season since the dry weather protects the young tender tissue from fungus infection. If sufficient moisture is available later in the season, the foliage may be tough and spores less numerous. Thus, free moisture especially early in the season favors most diseases. Temperature: Some crops grow at a temperature below which fungi can infect, but most crops grow at temperatures most suitable for fungal reproduction. Most fungi grow well at temperatures between 70^{o} and 90^{o} F and are dormant in winter. Diseases are more common, and more damaging, in tropical climates than the temperate climates.

Wind

The wind dispersal of plant pathogens is known as anemochory. It is one of the most common methods of the dispersal of plant pathogens. It is the most dangerous and potent mode of travel for plant pathogenic fungi. It acts as potent carrier of propagules of fungi, bacteria and viruses. Usually the fungal pathogens are light in weight and are well adapted to wind dispersal. Heavy winds cause severe injury to rice leaves. Wound injury favours the entry of bacterium, *Xanthomonas oryzae* pv. *oryzae*. After heavy wind, the disease becomes severe.

Some pathogenic bacteria are carried along with the infected material to short distances by wind. Damping-off pathogen (*Pythium spp*.), wart disease pathogen of potato (*Synchytrium endobioticum*); root rot pathogens (*Sclerotium* and *Rhizoctonia*) and seeds of phanerogamic parasites witchweed (*Striga*) are efficiently carried by wind. Viruses and phytoplasmas are not directly transmitted by wind, but the insect and mite vectors that carry the viruses move to different directions and distances depending upon the direction and speed of air. The adaptations for wind dispersal in fungal pathogens include, production of numerous spores and conidia, discharge of spores with sufficient force, production of very small and light spores so that they can move to long distances. The duration and periodicity of sporulation and discharge are also important factors for wind dispersal. Some fungal pathogens causing powdery mildews, downy mildews, rusts, smuts, sooty moulds, leaf spots, blast, apple scab etc., produce large number of very light spores and conidia on the surface of the host. Uredial stages of the rust fungi travel long distances through air currents and are thus responsible for destructive epidemics over wide areas. Wind transmission involves the upward air currents, velocity and the downward movements of wind. All are equally responsible for the spread of infection and ultimate outbreak of diseases and have been of special significance in the rust, smut fungi. Uredospores of rust fungi have been carried to long distances, both cross-wise and upwards. Christensen (1942) and Stalkman (1946) determined by exposure of Vaseline slides in the upper air through aeroplane flights, that uredospores and" aeciospores of *Puccinia graminis tritici* could be gathered in a viable condition up to a distance of 4,200 m, above infected fields, *Alternariaspp*. at 2,400 m. and those of *Puccinia triticina* at 3,750 m. The transmission of aecial spores of *Pucciniagraministrewii* from several groups of barberry bushes to the wheat crop showed that these spores travelled successfully over a radius of 3 kms round about these bushes. The blister rust fungus, *Cronartium ribicola* is known to travel to a distance of 500 metres or 3,750 m inside a plantation that the range is probably more in the open. Similar observations have been made in respect of dissemination of chlamydospores of the smut fungi. In long distance dissemination with intervening stages of infection, the retention of viability of spores is an important factor that determines the extent and severity of epidemics, over wide areas.

The outbreaks of cereal rusts and blast of rice are examples of such dissemination. Spores differ widely in their ability to survive long distance travel through air. Uredospores of rusts, chlamydospores or smut fungi and conidia of *Alternaria, Helminthosporium, Pyricularia* and others are well adapted for long distance travel in a viable condition and are known to play a vital role in epidemiology. The conidia of downy mildews, powdery mildews and the aeciospores and basidiospores of the rust fungi are unable to withstand such long distance dissemination when they are exposed to desiccation and direct sunshine and thus are only capable of producing local epiphytotics of limited magnitude. The bacteria causing fire blight of apple and pear (*Erwinia amylovora*) produce fine strands of dried bacterial exudates containing bacteria and these strands may be broken off and they are transmitted by wind. Bacteria and nematodes present in the soil may be shown away along with soil particles. Wind also helps in the dissemination of bacteria, fungal spores and nematodes by blowing away rain splash droplets containing these pathogens. Wind carries insects and mites that may contain or are smeared with viruses, bacteria or fungal spores to short or long distances. Wind also causes adjacent plants or plant parts to rub against each other. The wound created in this manner help the spread by contact of bacteria (citrus canker), fungi, some viruses (Tobacco mosaic virus) and viroids and possibly of some nematodes.

Light

Light is known to influence the infection of fungal pathogens. Increasing light duration increased sporangial production in case of bajra downy mildew (*Sclerospora graminicola*). But sporangial liberation occurs under darkness. Tobacco necrosis virus infection is severe under low light intensity. Under high light intensity, the disease is negligible and only a few lesions occur. Heavy shade increases brown spot of rice (*Helminthosporium oryzae*) and Blister blight of Tea (*Exobasidium vexans*).

The combination of several weather factors contribute to disease incidence. The combination of dew period and low night temperature favour rice blast, while minimum temp and relative humidity favours tikka leaf spot in groundnut. Temperatures are the key factors for late blight of potato.

Forecasting based on weather conditions

Weather conditions *viz*., temperature, relative humidity, rainfall, light, wind velocity etc., during the crop season and during the intercrop season are measured. Weather conditions above the crop and at the soil surface are also recorded. Forecasting based on correlative information Weather data of several years are collected and correlated with the intensity of the diseases. The data are compared and then the forecasting of the disease is done. Forecasting criteria developed from comparisons of disease observation with standard meteorological data have been provided for diseases like *Septoria* leaf blotch of wheat, fire blight of apple and barley powdery mildew.

In some advanced countries forecasting of disease is made by the use of computers. This system gives the results quickly. One such computer based programmes in the USA is known as 'Blitecast' for potato late blight. Examples of well developed forecasting systems are:

Early and late leaf spots of groundnut :

A technique has been developed for forecasting early and late leaf spots of groundnut in the U.S.A. When the groundnut foliage remains wet for a period greater than or equal to 10 h and the minimum temperature is 21°C or higher for two consecutive days or nights, the disease development is forecasted. A computer programme has been developed in the USA. This is accurate and is widely used in the USA. The data on hours for day with relative humidity (RH) of 95% and above and minimum temperature (T) during the RH observations for the period, for the previous 5 days are fed to the computer. Calculations are rounded to whole numbers. The T/RH index for each of the five days is calculated e.g., when hours of the RH 95% equal 10 and the minimum temperature during the period equals 21.1°C the T/RH index is 2.0 .The T/RH indices for days 4 and 5 are summed. If the total index exceeds 4 disease is forecasted. If the index is 3 or less no disease is forecasted.

Late blight of potato:

In USA, a forecasting programme has been developed for late blight of potato (*Phytophthora infestans*). The initial appearance of late blight is forecasted 7 to 14 days after the occurrence of 10 consecutive blight favourable days. A day is considered to be blight favourable when the 5 day average temperature is 25.5°C and the total rainfall for the last 10 days is more than 3.0 cm. A computerized version (Blitecast) has also been developed in the U.S.A for forecasting potato late blight. Blitecast is written in Fortran IV. When a farmer desires blight cast (Blitecast) he telephones the blight cast operator and reports the most recently recorded environmental data. The operator calls for the blight cast programmes in the computer viz., typewriter terminal and feeds the new data into the computer. Within a fraction of second the computer analyses the data and series of a forecast and spray recommendations to the operator who relays it to the farmer. The entire operation can be completed during standard three minutes telephone call. The system makes one of the four recommendations viz., no spray, late blight warning, 7 days spray schedule or 5 days spray schedule. The last 5 days spray schedule is issued only during severe blight weather. In West Germany, 'Phytoprog' is the programme used. It is based on measurements of temperature, relative humidity and rainfall. Phytoprog provides a negative prognose (an indication of when the usual routine spray application should be dispensed with).

Blister blight of Tea

A system for predicting epidemics of blister blight of tea (*Exobasidium vexans*) has been developed based on the number of spores in the air in the tea plantation and the duration of surface wetness on the leaves. The duration of sunshine is negatively correlated with the duration of surface wetness. The following prediction equation has been developed. $Y = 1.8324 + 0.8439\ X1 + 0.9665\ X2 - 0.1031\ X3$where, $X1 = \log$ % infection t2X2 = log % infection t2 – log infection t1Y = log of the number of spores in the air and t1 – t2 three weeks X3 = mean daily sunshine for a 7 days period preceding t2 d. Southern corn leaf blight 'Epimay' is a system for forecasting Southern corn leaf blight (*Bipolaris maydis*) based on conceptual model.

Rice blast:

In India, forecasting rice blast (*Pyricularia ozyzae*) is done by correlative information method. It is predicted on the basis of minimum night temperature 20 to 26°C in association with high relative humidity of 90% or above. Computer based forecasting system has also been developed for rice blast in India.

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Wheat stem rust

Forecasting wheat stem rust epidemic is done by analysing therein samples which give precise data for inoculum present in the air. Moreover several wind trajectors are also prepared to survey the air-borne primary inoculums and its deposition. It has been observed that primary inoculum comes from South India, to the plains of Central and North India.

Brown stripe downy mildew of corn

The forecasting of brown stripe downy mildew of corn (*Sclerophthora raysiae var. zeae*) which is restricted to India is done on the basis of average rainfall 100 to 200 cm or more accompanied by low temperature (25°C or less).

Spore trapping Techniques:

In spore tarpping, the acquisition of biological data for consecutive forecasting models are important. Spore traps have been widely used in to complete disease with weather conditions. Spore trapping is useful for understanding epidemiology of a disease and behaviour of the pathogens. This helps in developing models on dispersal of pathogens or on epidemiology of the disease and to formulate methods of management.

Methodology of spore trapping depends on the biology of the pathogen, infection forecasting, spore dispersal gradients and management of the disease. In epidemics of air-borne plant diseases, the number of spores of the pathogen landing on the plant which depends on the number of spores in the atmosphere above the crop is an important factor for the quantitative sampling of the atmosphere (number of spores per unit volume of air). For trapping and estimating these studies different types of traps are used.

The following spore traps are usually employed in trapping of fungal spores.

Cylindrical rods or microscopic glass slides:

It helps to gather data on the spore arrival in a locality. In this, the surface of microscopic slide is smeared with grease and made sticky. In the method, quantitative estimation is not possible as number of spores collected is very low.

1. Hirst's volumetric spore trap (Hirst 1952): In this instrument, air is sucked into at a controlled rate and impinged on to a glass slide moved by a clockwork mechanism past the orifice. It gives continuous count of spores in 24 h. The number of spores per unit volume of air at any given time can thus be calculated.

2. Rotorod sampler or rotorod spore trap (Sutton and Jones 1976): It comprises of a 'U' shaped rod attached at its mid point to the shaft of a small battery operated electric motor. In this equipment the surface of the rod is covered with a vaseline strip of transparent cellophanes to catch spores which can be taken off and mounted on a glass slide. From the area of the strip and the speed of rotation, the volume of air samples can be calculated.

3. Anderson cascade spore sampler.

It is a device where Petri plates with nutrient agar are used to collect the spores.

4. Bourdillon slit sampler: Air is sucked in a chamber by vacuum pump which strikes the rotating Petri dish containing agar medium. The agar medium retains the spores sucked in the air. Concentration of viable spores is calculated after counting germinated spores in the medium.

5. Burkard's 7 day volumetric spore trap: This device records spores in the air drawn by a pump on 7 days basis on a cellophane strip wrapped on a drum rotating inside a chamber.

6. Jet spore trap: In the above sampling methods, the viability of the spores cannot be determined. To overcome this, living plants have been used as spore traps. A jet spore trap in which spores are impacted in an air jet into a column of still air, through which they fall, to settle on leaf segments exposed at the base of the chamber. In this trap, suitable cultivars of host plants can be employed to determine number of viable spores.

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3. INSECT PESTS OF CROPS AND ITS WEATHER PARAMETERS

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The climatic factors such as temperature, relative humidity, rainfall, and mass air movements may affect the distribution, development, survival, behavior. Migration, reproduction, population dynamics, and outbreaks of insect pests in most of the crop. These factors usually act in a density-independent manner, influencing insects to a greater or lesser extent depending on the situation and the insect species. In this chapter the weather parameters influencing the pests of rice, pulses and cotton are discussed briefly.

I. PESTS OF RICE AND WEATHER PARAMETERS

1. YELLOW STEM BORER (*Scirpophaga incertulas*)

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The YSB (*S. incertulas*) (Pyralidae: Lepidoptera) is a monophagous insect pest of rice causing damage during both vegetative and reproductive crop stages. The pest is most widespread, dominant, destructive, and causing yield losses to the tune of 27-34% every year in rice crop. YSB attacks the rice crop from nursery till maturity. Left over nurseries after transplantation and stubbles after harvest serve as an inoculum source for infestation in the next season. Only larva causes damage to the crop. After hatching, larva bores in to stem and damages it.

Favourable weather condition for YSB

The pest incidence will be more in warm, moist weather with the temperature of < 28^{0}C. The hibernating adults become active with the onset of summer rains. The Relative Humidity of > 70% also plays an important role for YSB incidence.

2. LEAF FOLDER (*Cnaphalocrocis medinalis*)

The rice leaf folder, *Cnaphalocrocis medinalis* (Guenee) (Pyralidae: Lepidoptera) is one of the major pests of rice and causes serious economic loss when its severe infestation coincides with susceptible crop growth stages (maximum tillering to booting). Leaf folder caterpillars fold the rice leaf around themselves and attach the leaf margins together with silk strands. They feed from inside the folded leaf by scraping the green chlorophyll resulting in longitudinal white and transparent streaks of damage on the blade. The general vigour and photosynthetic ability of infested plants gets reduced.

Favourable weather condition for leaf folder

Rice leaf folder occurs in all rice environments and are more abundant during the rainy seasons. They are commonly found in shady areas, and areas where rice is heavily fertilized. In tropical rice areas, they are active year round, whereas in temperate countries they are active from May to October. The high humidity (60-70% during afternoon) with night temperature of $<22.5^{0}$C favours the pest.

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3. BROWN PLANT HOPPER (*Nilaparvata lugens*)

The BPH (*Nilaparvata lugens*) belongs to the family of Delphacidae (Homoptera:Hemiptera). High population of plant hoppers cause leaves to initially turn orange-yellow before becoming brown anddrying. Severe attack causes drying of tillers and hills, resulting in a scorched appearance in the fields called 'hopperburn' wherein complete drying of the plants is observed and can result in 100% crop loss.

Favourable weather condition for BPH

Plant hoppers are a problem in rainfed as well as in irrigated wet land environments. It also occurs in areas with continuous submerged conditions in the field, high shade, and humidity. Dense rice crop under continuously flooded conditions and excess use of nitrogenous fertilizers provides very congenial environment for plant hopper population build up. The continuous rainfall followed by clear sky, longer day with night temperature of 21-23^{0}C and relative humidity of >70% is the conducive climatic conditions for BPH.

The other sucking insects of rice crop *viz*., green leafhopper (*Nephotettix virescens*) and White backed plant hopper (*Sogatella furcifera*) incidence also more with above climatic conditions.

4. RICE EARHEAD BUG (*Leptocorisa acuta*)

The rice earhead bug belongs to the family ofAlydidae: Hemiptera. Both nymphs and adults suck the sap from individual grains at milky stage. Affected grains become chaffy with black spots at the site of feeding puncture. Yield loss may be 10- 40%. Obnoxious odour emanates on disturbing the bugs in the field.

Favourable weather condition for Earhead bug

The drizzling weather favours the high pest incidence but the heavy rain reduces the pest population.

5. GALL MIDGE (*Orseolia oryzae*)

The rice gall midge (*O. oryzae*) (Cecidomyiidae: Diptera) is a major insect pest of rice causing significant economic loss to the crop over space and time. Feeding by the maggots of the gall midge on the growing tip of rice plants results in elongation of the leaf sheath often referred as onion leaf or silver shoot. A hollow cavity or tubular gall of approximately 1 cm wide and 10-30 cm long is formed at the base of tillers. Galls appear within a week after the larvae reach the growing point. In some cases there would be no gall development but necrosis of the growing tip is noticed. Gall midge causes yield losses of 30-40% in some parts of India. Gall midge is more severe, in late planted conditions.

Favourable weather condition for Gall midge

The gall midge is found in irrigated and rainfed wetland environments during the tillering stage of the crop. It is also common in upland and deep-water rice. The optimum temperature for rice gall midge development is 22 to 26°C.

II. PESTS AND PULSES AND WEATHER PARAMETERS

1. BEAN APHID: *Aphis craccivora* (Aphididae: Hemiptera)

Both nymphs and adults of aphid cause the damage by sucking the plant sap. Infested pods become de-shaped, withered and malformed. Severe infestation may result in complete drying of affected pods. They also act as vector of pea virus.

Favourable weather condition for bean aphid

The night temperature of >20^0C and evening RH of >50% is the conducive conditions for aphid activity. The heavy rainfall decreases the population.

2. GREEN LEAFHOPPER: *Empoasca kerri, E. binotata* (Cicadellidae: Hemiptera)

The nymphs and adults feed on tender leaves and other parts of the plant by sucking the plant sap. In cases of severe attack, leaves become brittle and dry. Characteristics hopper burn i.e. cupping of leaves appear. The plant may lose its vigour resulting in poor growth.

Favourable weather condition for Leafhopper

During summer season the leafhopper population is more in pulse crop. The temperature of>30^0 C favours the population buildup of leafhopper.

3. WHITEFLY: *Bemisia tabaci* (Aleyrodidae: Hemiptera)

The damage is caused by both nymphs and adults, which are found in large numbers. They suck plant sap and lower its vitality. Severe infestation results in premature defoliation, development of sooty mould or honey dew and shedding of flowers and pods.

Favourable weather condition for Whitefly

The temperature >33^0C, high RH (85%), dry season favours but the pest will disappear with the onset of monsoon.

4. BORER PESTS OF PULSES

The Gram pod borer (*Helicoverpa armigera*), Spotted pod borer (*Maruca testulalis, M. vitrata*),Spiny pod borer (*Etiella zinckenella*),Blue butterflies (*Lampides boeticus, Euchrysops cnejus*) are the borer pests damaging the pulse crop. The most common symptoms of damage are defoliation in early stages, dropping of flowers and young pods, damaged pods with round holes, older pods marked with a brown spot where a larvae has entered and larval entry hole on the pod is plugged with excreta.

Favourable weather condition for borer pests

The increasing day (>33°C) and night temperature (>20°C), light rainfall with decreasing humidity favours the borers, but continuous rainfall affects the pest population.

III. PESTS AND COTTON AND WEATHER PARAMETERS

1. LEAFHOPPER: *Amrasca devastans* (Cicadellidae: Hemiptera)

Both nymphs and adults of leafhopper suck the sap from the under surface of leaves, tender leaves turn yellow, leaf margins curl downwards and reddening sets in. In the case of severe infestation leaves get a bronze or brick red colour which is typical "hopper burn". Crop growth retarded.

Favourable weather condition for Leafhopper

Clear sky, dry weather, longer day with temperature of 30-36°C favours the population buildup of leafhopper.

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2. COTTON APHID: *Aphis gossypii* (Aphididae: Hemiptera)

It is a potential pest on cotton infesting tender shoots and under surface of the leaves. They occur in large numbers, suck the sap and cause stunted growth, gradual drying resulting in death of the plants. Development of black sooty mould due to the excretion of honey dew gives the plant, a dark appearance.

Favourable weather condition for aphid

The warm weather (>32°C) and humid condition (82% RH) is conducive for outbreak of pest. Heavy and continuous rainfall wash away the colonies.

3. WHITEFLY: *Bemisia tabaci* (Aleyrodidae: Hemiptera)

Nymphs and adults suck the sap from the under surface of leaves. Severe infestation results in premature defoliation, development of sooty mould, shedding of buds and bolls and poor boll opening. It also transmits the leaf curl virus disease of cotton. The insect is highly polyphagous and known to have biotypes.

Favourable weather condition for whitefly

The high temperature> 33°C and RH of 85% favours of buildup of whitefly infestation.

4. STEM WEEVIL: *Pempherulus affinis* (Curculionidae: Coleoptera)

The damage to cotton starts when plants are young and are about three weeks old. The grubs bite into the region between the bark and the main stem, resulting in swellings on the stem just above the ground level. Young plants are invariably killed on account of the attack of the pest and the older plants that survive, lack vigour and strength, and when strong winds blow, these plants break at the nodes.

Favourable weather condition for stem weevil

The pest is abundant during July-September. Decreasing day temperature (<33°C) and increasing night temperature (>23°C) with high RH >80% conducive for multiplication of the pests.

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5. SPOTTED & SPINY BOLLWORMS: *Earias vitella & E. insulana* (Noctuidae: Lepidoptera)

The young caterpillar bores into top tender shoot, the portion of the shoot above the damage withers, droops and dries up. When the squares and bolls begin to develop, these caterpillars move from the shoots and start damaging bolls by making conspicuous holes into them. The squares and small bolls injured by the larvae drop away from the plants.

Favourable weather condition for Spotted and spiny bollworms

The maximum and minimum temperature of 32°C and 23°C are favourable. However continuous rainfall affects the populations.

6. AMERICAN BOLLWORM: *Helicoverpa armigera* (Noctuidae:Lepidoptera)

The caterpillars feed on leaves, squares, flowers and small bolls. When the squares, flowers and bolls are attacked, they feed the internal content completely by thrusting their head inside leaving the rest of the body outside. The damaged squares and young bolls drop away from the plants. The developed bolls and open bolls are not attacked.

Favourable weather condition for American bollworm

Increasing day (>32°C) and night temperature >20°C, light rainfall with decreasing RH <60% favours the pest incidence.

7. PINK BOLLWORM: *Pectinophora gossypiella* (Gelechiidae: Lepidoptera)

The caterpillars feed on flower buds, flowers and bore into bolls. When they bore into flower buds, they feed on developing anther and style and occasionally on ovary. When they are found in flowers, the flowers do not open and give rosette appearance. The young bolls, when attacked, are shed after a few days, but the larger bolls remain on the plant. Locules are damaged and interlocular burrowing can be noticed. Seeds are destroyed and lint gets stained.

Favourable weather condition for pink bollworm

The October – November and January – March are congenial. Maximum and minimum temperature of 35°C and 25°C with RH of 67% favours. Mortality of pest increases >37°C and continuous rainfall and increasing RH.

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4. METEOROLOGICAL SERVICES FOR AGRICULTURE IN INDIA

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In order to provide direct services to the farming community of the country an exclusive Division of Agricultural Meteorology was set up in 1932 under the umbrella of India Meteorological Department (IMD) at Pune with the objective to minimize the impact of adverse weather on crops and to make use of favourable weather to boost agricultural production.

Services of the Division are:

- Gramin Krishi Mausam Seva
- Dissemination of Agromet Advisories
- Feedback & Awareness of Agromet Service
- Training Programme to AMFUs

The prime object of Agricultural Meteorology Division, India Meteorological Department(IMD), Pune is to minimize the impact of adverse weather on crops and to make use of crop-weather relationships to boost agricultural production. The Agricultural Meteorology Division was established at Pune and from its inception the Division supports and participates in multi-disciplinary activities in this field. It is also the centre for research programmes in agricultural meteorology and has field units in various parts of the country. Besides, forecasts and advisories for farmers are issued by IMD's Forecasting Offices located at different State capitals.

- District-wise Advisories for farmers
- State-wise Advisories for farmers
- District level Weather Forecast
- Regional Weather Forecast

- All India Weather Forecast
- SMS Advisory for farmers
- Alerts / warnings

Weather Based Automated Agro Advisories

Agriculture is highly vulnerable to climate change and climate variability. It is very difficult to balance the growing interest on sophistication and climate change mitigation options. Now, we are in the stage of bolstering adaptation process to cope up our production with demand. Automated Agro Advisory Service (AAS) is a response farming tool, which helps the farmers to get timely weather based agro advisories to make necessary decision for the next few days of farm operations. The AAS requires past and forecasted weather data of 6 days from the current date for closer spatial scale, high performance computing server, faster internet service, short messaging service (SMS) and web cum mobile application. Different combinations of temperature, relative humidity, wind speed and rainfall quantity have been numbered as weather scenarios. Weather based agro advisory for multiple crops and different stages of crop growth have been developed with the help of technocrats and incorporated in the database. Farmers have to register their mobile number for advisory to their own crop, specific to crop stage. Every day, weather scenario of each block will be developed separately for past and future weather and the AAS module match the scenario, crop, stage, and advisory and send the selected advisory to the farmers' mobile as SMS. Farmers can change their crops and sowing date through web portal or mobile app. The AAS simplifies the lab to land with ICT tools and helps the farmers to get rid of weather risk and help them to increase productivity of inputs. The AAS empathises the farmers' need and acts weather smart.

TYPES OF WEATHER FORECAST

Forecasting means the process of estimation of the value of some variable at some future time.

- Now casting: A short-time weather forecast issued generally for the next few hours and validity of less than 24 hours.
- Short range forecasts: Forecasts having a lead time period of 1 to 3 days.

- Medium range forecasts: A weather forecast issued for a period from about 4 days to 10 days in advance.
- Long range forecasts: A weather forecast issued for a period greater than 10 days in advance and up to a season of more than three months. The monthly and seasonal forecast comes under long range forecast.

District Agro-Meteorology Unit (DAMU)

The Government of India has entrusted upon the India Meteorological Department (IMD) the task of establishing the task of establishing weather observing system and development of Gramin Krishi Mausam Sewa in the country. In pursuance hereof, IMD has set up in the country a network of about 130 Agro Meteorological Field Units (AMFUs) which are multidisciplinary units responsible for preparation and dissemination of district and sub-district agromet advisories. These AMFUs are located at State Agricultural Universities, ICAR centres and other institutions. Each AMFU utilizes the relevant output products including weather data from conventional/ automatic weather station (AWS) provided by IMD and ICAR to generate specific advisories for agricultural management for the respective districts of Agro-climatic zones identified under the area of its jurisdiction and disseminate the same to the farming community. Under the Gramin Krishi Mausam Sewa, the IMD proposes to establish District AgroMet Units (DAMU) in 530 districts, in addition to already operating 130 AMFUs, in order to meet the said expansion. Among other responsibilities, DAMU will receive weather forecast from IMD to prepare and disseminate sub-district level agromet advisory bulletins.

ICAR through All India Co-ordinate Research Project on Agro-meteorology (AICRPAM) is pursuing Research & Development on Agro-meteorology through a network of 35 centres located with SAUs in the country for improvement in weather based advisory and strengthening outreach of advisory bulletin to the farming community. The central Research Institute for Dry Land Agriculture (CRIDA) and National Innovation on Climate Reselient Agriculture (NICRA) projects of the Indian Council of Agricultural Reasearch aim to enhance resilience of Indian agriculture to climate change and climate variability through strategic research and technology. It also provides agro advisories to the crop weather outlook, website established by CRIDA and guides the Ministry of Agriculture on contingency planning during the crop season.

Agrometeorology is an important multidisciplinary subject. Hence, ICAR maintains Agromet observatories as well as Automated Weather station (AWS) and record Agromet observations at its institutions, National Research Centres, Project Directorates, Krishi Viyan Kendras (KVKs) etc. to generate agrometeorological information for use in studies on crops, pests and diseases, soil, agroforestry, livestock, horticulture, agriculture physics, soil science, etc. Such data will help ICAR institutes to study crop-weather relationship, relationship between crop weather and pest/ disease and develop region/ location specific agromet predictive models.

Objectives

1. To improvise the existing district level Agromet Advisory Services (AAS) so as to deliver crop and location specific AAS to farmers at block level.
2. To design optimum observatory network for issuance of village level advisories for implementation of crop weather insurance.
3. To establish District Agromet Units as nodal centre for catering to needs of agriculture services.
4. To provide customized advisory bulletins through last mile connectivity to farmers with personalized agromet advisory services.
5. To extend the weather based advisory service to the allied areas like livestock, grazing of farm feed etc.
6. To establish appropriate dissemination and support system for weather-based crop insurance in the country.

The main functions of the District Agromet Units (DAMUs) will be as under;

1. Receive weather forecast from IMD and prepare Agromet Advisory bulletins at block levels. For this DAMU will be guided by AMFU.
2. Disseminate Agromet advisory bulletins through print media, radio, Television and other possible mechanisms.

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3. Assess users' requirements and impact of AAS.
4. Participate / operate Agri-clinics or such mechanism (Kisan Call Centers).
5. Participate in farmers fair and organize awareness activities to popularize AAS.
6. Maintain agro-met observatory, record observation, dispatch and store data.
7. Prepare local climatological information & data base. Receive current weather observations and agricultural data from districts.
8. Identify weather sensitivity of crops, animals, pests& diseases and management practices.
9. Prepare annual reports and submit the same to designated authorities.
10. Collect feedback information from Regional and Narrowcasting stations of DD, AIR, and FM channels, KVKs, ATMA, CSCs, NGOs.

Weather based Agro Advisory benefits

The farmer groups have described their perceptions of the usefulness of five day forecasts and the early warning system. Largely, the farmers have appreciated the flow of information in the form of forecast and advisories as they see benefits in the information. As the sourcing ofinformation is at micro level, the accuracy of forecast is much higher compared to other suchforecasts. Further, the span of five days is small which again enhances the quality and accuracyof information. The forecasts obtained through other means such as television, newspapers orradio provides limited information related to rainfall and temperature only. These customized agro advisories are helping the farmers to use the information in making crucial decisions in thecourse of their agricultural activities. Essentially, the farmers described a variety of impacts from the forecast use with an emphasis on the cost savings through better management of agricultural inputs, pest and diseases, irrigation and risk mitigation measures. Some of these are described as below:

Enhanced preparedness and increased adaptive capacity:

The weather agro-advisories have played a crucial role in enhancing preparedness levels of communities along the transboundary villages as they are alerted well in advance of any weather event. The ease of taking decisions at crucial crop stages have helped the farmers in minimizing risks and losses against unprecedented rainfall and floods.

Sowing/ transplanting of Kharif crops based on the onset of monsoon:

Adjusting sowing times to cope with variable monsoon onset dates, in particular when to establish paddy seedling nurseries and transplant seedlings so that planting can be synchronized with the reliable onset of rain.

Irrigation management:

This helps in avoiding either unnecessary irrigation (and therefore irrigation costs) prior to rainfall or damaging a crop with excess moisture if irrigation is followed by heavy rain. The quantity of irrigation required in the crops is also adjusted using the meteorological threshold.

Fertilizer application:

The application of fertilizer in crops is timed to maximize effects on crop growth and yield, e.g. avoiding application prior to heavy rainfall to mitigate fertility loss through soil erosion, or, even prior to heavy winds to avoid blowing off of the fertilizer.

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Timely harvest of crops:

The timely harvesting of crops was one of the essential decisions taken by farmers based on the advisories so as to avoid the spoiling of crops due to sudden rainfall and also to ensure the storage of grains at optimal moisture content e.g. avoiding cloudy weather that will result in higher grain moisture and therefore higher post-harvest losses.

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5. SEED HARDENING: AN IMPORTANT TECHNIQUE FOR DROUGHT TOLERANCE

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In India, nearly 70 % of cultivated land is rainfed and accounts about 42 % of the total quantity of food grains produced. The low productivity under rainfed condition is due to use of poor quality seeds, soil moisture deficit, low and erratic rainfall and improper crop management.

For enhancing productivity, quality seeds play a major role along with improved package of practices. Seed hardening is a practice adopted to alleviate the moisture stress or making the plant resistant to moisture stress. The inorganic salts like NaCI, Na_2S0_4, KCI, KH_2P0_4, $CaCl_2$ and $MgS0_4$; organic acids like succinic acid, CCC and auxins are used as pre-hardening agents.

As early as in 1964, Henckel developed these wetting and drying treatments of seeds for imparting resistance to drought and adverse conditions. The technique for presowing drought hardening used by him is basically as follows: Seeds are allowed to take up a certain amount of water and then they are kept at 10-25°C for several hours before drying in a steam of air. The best results are claimed for seeds subjected to 2 or 3 cycles of wetting and drying although for some species one cycle is sufficient. The timing of the initial imbibition period(s) is critical because as germination and growth proceed, the degree of "hardening" induced is claimed to become greater the more advanced in the embryo at the time of drying. The optimum stage of" germination or early growth for imposing drying treatment must be a compromise between the two conflicting tendencies, As long as dehydration and desiccation have only a purely physical effect on the colloids of the embryo, its vitality is not affected. By contrast, biological dehydration involving the death of the radicle is irreversible.

The temperature of the soaking and drying cycles and the rate of drying may all is important. The responses of plants following wetting and drying cycles at the seed stage are variable. Drought tolerance for 0.5 % KH_2P0_4, was observed in dryland crops (Vananagamudi and Kulandaivelu, 1989). Seed hardening will modify the physiological and biochemical nature of seeds, so as to get the characters that are favourable for drought tolerance. Although it varies from crop to crop, the principle remains same. When dry seeds are soaked in water/chemical. Solutions the quiescent cells get hydrated and germination initiated. It also results in enhanced mitochondrial activity leading to the formation of high energy compounds and vital biomolecules. The latent embryo gets enlarged.

When the imbibed seeds are dried again, triggered germination is halted. When such seeds are sown reimbibition begins and the germination event continues from where it is stopped previously. Beneficial effects of seed hardening includes accelerated rapid germination and growth rate of seedling, hardened plants recover much more quickly from wilting than those from untreated plants, induces resistance of salinity and to drought condition, seeds with stand higher temperature for prolonged period, flowering is slightly accelerated, compete more efficiently with weeds due to early emergence and results in more yield.

Changes in seed

The hardening resulting from presowing treatments is due to a number of physio chemical changes within the cytoplasm including greater hydration of colloids, higher vl'5cosity and E:lasticity of the protoplasm, increase in hydrophilic and decrease in lipophilic colloids, increase in the temperature required for protein coagulation and increase in bound water content. Pre-sowing treatments also initiate the formation of vital biomolecules, stimulate mitochondrial activity and preserve cellular ultrastructures which would allow plants to resist adverse edapho-climate conditions. The consequences of some of these cellular changes are claimed to include a more xerornorphic structure with higher rate of photosynthesis, lower rate of respiration, lower water deficit, the ability to retain a greater quantity of water and a more efficient root system with higher root shoot ratio and less yield reduction when Subjected again to drought compared to non-hardened plants.

Root is the main plant part as far as moisture extraction and nutrient absorption are concerned. Seed hardening with chemicals and simple water were found to increase root growth even at the seedling stage. This will have a favourable influence on dry land and post monsoon season situations. Increase in root dry weight helps in maintaining high moisture status of plant leaf and increase in productivity. The hardened plants develop a more extensive system, thus enabling them to survive better under drought conditions. It is possible that early radicle emergence and seedling treatment on planting in the field following seed hardening treatments simply give the plant a better start than non-hardened plants. By emerging early in the growing season, seedlings will be able to compete more efficiently with weeds. Further, the germination will be more synchronized which might ultimately in a uniform crop population. Thus, a pretreatment or hardened plant might survive adverse environmental stresses more easily because of its advanced state of development. It is quite possible that yield advantages due to seed hardening treatment would be apparent when the drought was not too severe and be obliterated by extreme moisture stress. Differences in response can also be expected in accordance to the phenological stage at which the stress occurred and the stress duration.

Henkel and Kolotova (1934) described seed hardening technique to improve the drought tolerance. Excessive water loss could be prevented by seed hardening. The physiological induction as a cause of seed conditioning towards increased drought resistance in crop (Henkel, 1961). The seeds subjected to a cycle of wetting and drying which increased the resistance of plants to drought and heat. Seed hardening with water recorded high degree of tolerance to drought p3rticularly at the seedling stage. Repeated cycle of soaking the seeds in water of dilute solutions such as 0.25 % calcium chloride and drying induced drought hardiness in plants (Henckel, 1961).

Seed hardening techniques for dry land crops

The success of dry land agriculture depends on seasonal rains. Several management strategies are followed to enhance the production potentiality of the crop under rainfed condition. Seed hardening is one such seed management technique, where seeds are hydrated and then dried to their original moisture content to tide over the stress environmental condition at field. Though simple water acts as a good hardening agent, the efficiency could be enhanced by use of chemicals where selectivity depends on crop.

The seed hardening techniques recommended are as follows:

Crop: Pearl millet
Chemical and concentration: 2 % Potassium chloride
Methodology: Dissolve 20 gm of salt in 1000 ml of water. Soak 1 kg of seed in 650 ml of this solution for 10 hours and dry back to original moisture.

Crop: Sorghum
Chemical and concentration: 2% Potassium dihydrogen phosphate
Methodology: Dissolve 20 g of salt in 1000 ml of water. Soak 1 kg of seed in 650 ml of the solution for 16 hours and dry back to original moisture or weight.

Crop: Cotton
Chemical and concentration: 2 % Potassium chloride
Methodology: Dissolve 20 g of salt in 1000 ml of water. Soak 1 kg of seed in 650 ml of the solution for 10 hours and dry back to original moisture or weight.

Crop: Sunflower
Chemical and concentration: 2 % Potassium chloride
Methodology: Dissolve 20 g of salt in 1000 ml of water. Soak 1 kg of seed in 650 ml of the solution for 12 hours and dry back to original moisture or weight.

Crop: Pulses, black gram, green gram
Chemical and concentration: 100 ppm Zinc sulphate, 100 ppm Manganese sulphate
Methodology: Dissolve 1000 mg of salt in 1000 ml of water. Soak 1 kg of seed in 350 ml of the solution for 3 hours and dry back to original moisture or weight.

6. WEATHER BASED AGRO ADVISORY MOBILE APPS

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Meghdoot App

- The Ministry of Earth Sciences & Agriculture have developed a mobile application named 'Meghdoot', which will provide location & crop and livestock-specific weather-based agro advisories to the farmers in local languages.
- During the launch, Dr. Harsh Vardhan, Minister for Earth Science, Science & Technology said that Meghdoot app will provide prediction to growers related to rainfall, temperature, humidity and wind speed & direction that play important role in agricultural operations.
- It will also tell as to how to take care of the crops & livestock.
- The information will be updated two times a week i.e. on Tuesdays and Fridays.
- At the beginning, the service will be available for 150 districts in various parts of the country. Later, it will be extended to remaining parts of the country in a phased manner.

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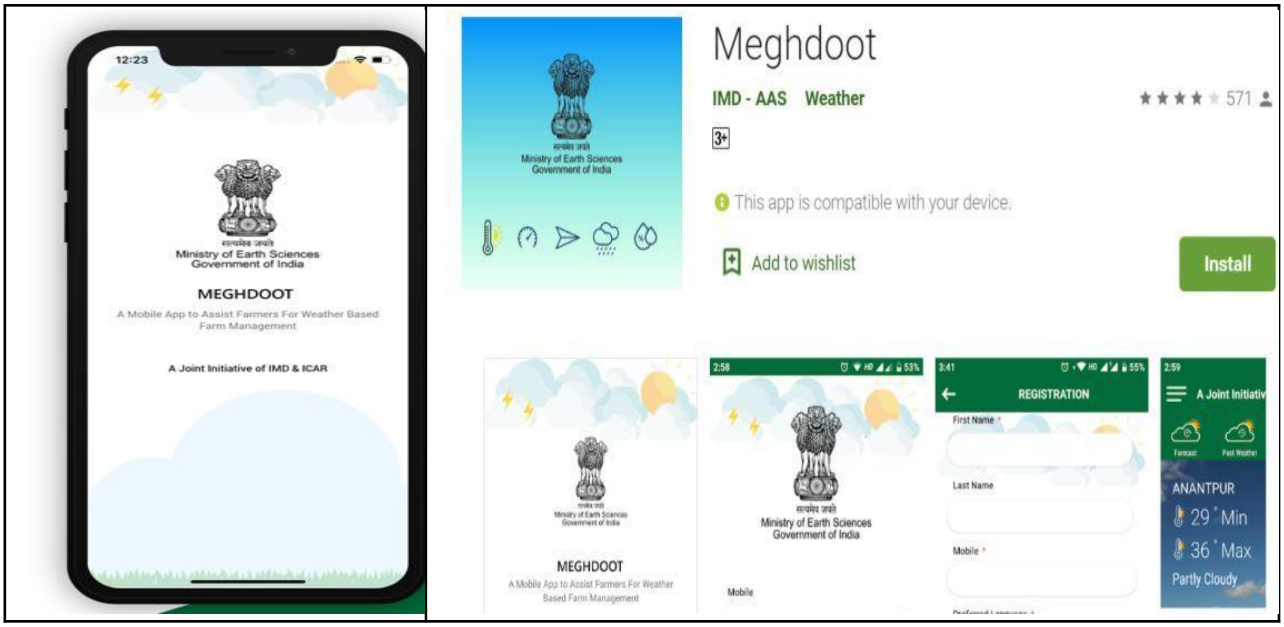
How to use and download Meghdoot App

- Farmers can download the app from either Google Play Store or App Store.
- You will have to register your name as well as location so as to obtain area specific information.
- The app has been developed by the India Meteorological Department (IMD),
- Indian Institute of Tropical meteorology & the Indian Council of Agricultural Research (ICAR).

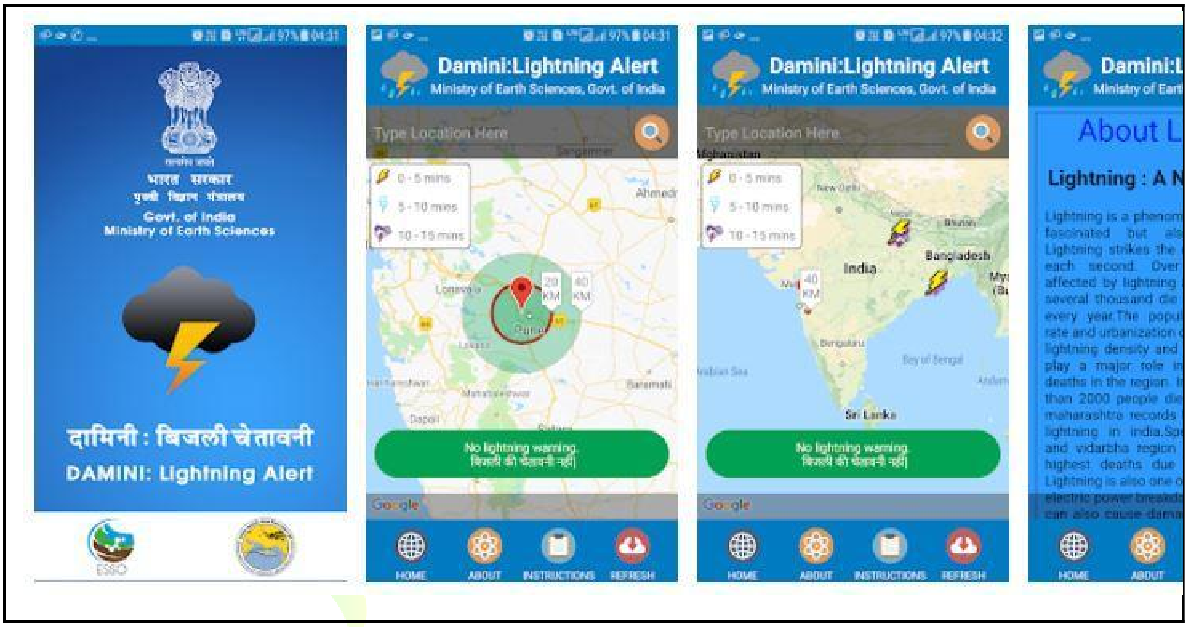


DAMINI-App

- Lightning is a phenomenon that has not only fascinated but also scared mankind. Each second about 50 to 100 lightning strikes occur over the Earth.Over the recent years lightning is identified as the single most killer over India than compared to all other natural disasters.
- There is an increasing trend in death. Recent data suggests, lightning alone account for about 2000 to 2500 deaths every year in India. Thunderstorms and lightning being the quickly evolving meteorological phenomenon, the exact forecast of these events is a challenge. Indian Institute of Tropical Meteorology, Pune an autonomous Institute under the Ministry of Earth Sciences has installed a Lightning Location Network with about 48 sensors over various parts of the country and isconnected to central processing unit at IITM, Pune.
- This network provides exact information about lightning strikes and movement of thunderstorm path. The network is being expanded with addition of more sensors to

increase accuracy and reliability. Using this network, by ESSO-IITM has developed an Mobile App, DAMINILIGHTNING.

- This App gives exact location of currentlightning strikes, probable locations of impending lightning around area of 40 sq.km and movement and direction of thunderstorm. DAMINI also lists precautionary steps to be taken during lightning and some general information on lightning.DAMINI-App would indeed help in getting advance information about impending lightning activity



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7. Solar Irrigation System

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Introduction

Sustainable agriculture also depends on replenishing the soil while minimizing the use of non-renewable resources, such as natural gas, which is used in converting atmospheric nitrogen into synthetic fertilizer, and mineral ores, e.g. phosphate or fossil fuel used in diesel generators for water pumping for irrigation. Hence, there is a need for promoting use of renewable energy systems for sustainable agriculture, e.g. solar photovoltaic water pumps and electricity, greenhouse technologies, solar dryers for post-harvest processing, and solar hot water heaters. In remote agricultural lands, the underground submersible solar photovoltaic water pump is economically viable and also an environmentally-friendly option as compared with a diesel generator set.

Need

There are 2.1 Croreelectrified pumps in India, being used for agriculture and consuming 92.33 Billion units energy every year, contributes approx. 22% of total electricity consumption of India.At present Farmer is getting electricity either free or on very low cost (Flat Rate or Rs. 1 to 1.5/Unit) and that's why farmer is not interested to improve efficiency of Pumps.The agriculture pump market in India is valued at about INR 8600 cr. in 2014-15, and is expected to grow @ 7 to 8 percent annually.

Component

- PV Panel
- Controller
- Pump

PV Panel

A panel is rated in watts of power it can produce. A pump will require a certain amount of power to produce a certain amount of pressure and flow. By using suitable size PV array pump can be operated at economical cost. Most solar pumps actually require about 20% more wattage than specified when wiring the panel directly to the pump. Also, having a larger panel will allow the pump to turn on earlier and later in the day and also in relatively lower light conditions. The solar panels make up almost 80% of the systems cost. The size of the PVsystem is directly dependent on the size of the pump, the amount of water that is required (m^3/d) and the solar irradiance available.

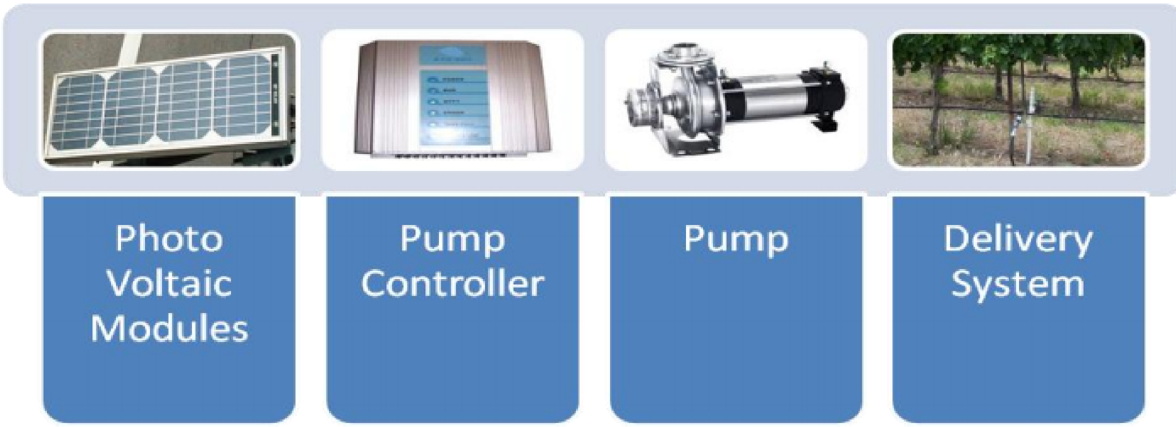
Controller

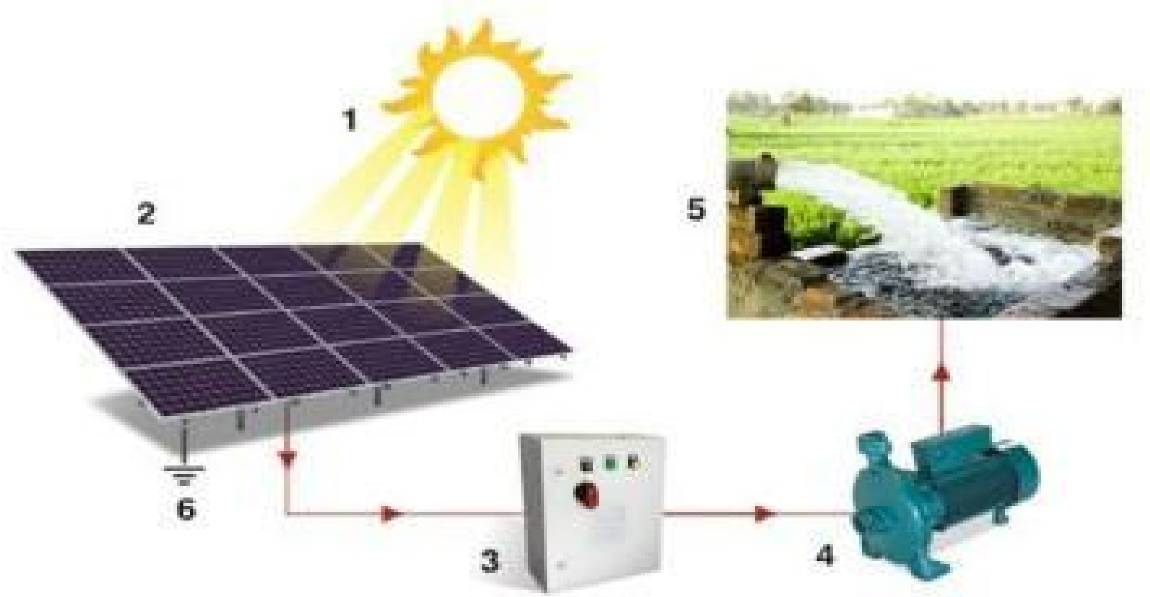
A small device that is installed between the panels and the pump that allows the pump to switch on during low light conditions. The purpose of the controller is twofold. Firstly, it matches the output power that the pump receives with the input power available from the solar panels. Secondly, a controller usually provides a low voltage protection, whereby the system is switched off, if the voltage is too low or too high for the operating voltage range of the pump. This increases the lifetime of the pump thus reducing the need for maintenance.

Voltage of the solar pump motors can be AC (alternating current) or DC (direct current). Direct current motors are used for small to medium applications up to about 3 kW rating, and are suitable for applications such as garden fountains, landscaping, drinking water for livestock, or small irrigation works. Since DC systems tend to have overall higher efficiency than AC pumps of a similar size, the cost is reduced as smaller solar panels can be used.

Pump

This is the heart and soul of the solar water pumping system. For a given power input, the pump produces a unique combination of flow and pressure. These pumps when maintained well, last for more than 15 years of service. An illustrative diagram and an operational pump-set are shown below.





Requirements and specification

Specification of Solar Power pump	
Motor	3000 W
Piston size	1 inch
Motor Speed	1348 - 1353 rpm
Flow rate	888 liters/hour
Working hour of Motor	6.5 hours

Amount of Voltage and current	17 - 20 V and 5.9 – 6.2 A

The SPV water pumping system should be operated with a PV array capacity in the range of 200 Watts peak to 10000 Watts peak, measured under Standard Test Conditions (STC). Sufficient number of modules in series and parallel could be used to obtain the required PV array power output.

The power output of individual PV modules used in the PV array, under STC, should be a minimum of 125 Watts peak, with adequate provision for measurement tolerances. Use of PV modules with higher power output is preferred.

Subsidy from Government

Tamil Nadu has proposed installing 5,000 solar pumps for which 70% subsidy will be provided, according to the states first-ever 'agriculture budget' recently presented to the Legislative Assembly. The program will have an outlay of ₹1.14 billion and utilize state and union government funds in 2021-22.

New technology in Solar Water Pump

In January this year, the Solar Energy Corporation of India (SECI) released a tender for 50 MW of solar photovoltaic (PV) projects, including a 10 MW agro-PV component in Tamil Nadu. Agro PV projects involve developing solar projects and cultivating crops on the same plot. The projects provide the added benefits of shielding plantations from harsh sunlight and controlling weed growth. In cold weather, the ambient temperature drops and to below freezing point in some areas. Since the equipment in a solar PV project, such as solar panels, inverters, data collectors, and batteries, have a certain operating temperature range; the regular operation may be affected when the temperature is lower than the outside area.

Conclusion

Solar water pumps, along with appropriate agricultural technologies and water conservation at the local level, have huge potential in India as they provide water for irrigation to villages at the micro level. Such local level provision for water results in less wastage and doesn't call for electric or diesel pumps thereby reducing farmers' expenditure.

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