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Influence of meteorological parameters on performance of rainfed cropping systems

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सार - इस शोध-पत्र में तापमान के वितरण सहित वर्षा के वितरण, सापेक्षिक आर्द्रता (आर.एच.), तेज धूप के घंटो (एस.एस.एच.) से संभावित फसल बोने के मौसम का तथा निर्दिष्ट क्षेत्र में फसल के निष्पादन का संकेत मिलता है। वर्ष 1989-91 के दौरान पश्चिमी बंगाल के कल्याणी फार्म में पाँच किफायती संभाव्य, पोषणीय, वर्षा पर आधारित फसल के अनुक्रमों अर्थात् परती भूमि (यानि कोई फसल नही) - चावल- मसूर, पटसन-चावल-मसूर, प्रत्यक्ष रूप से बोए गए चावल-चावल-मसूर, मूंगबीन-चावल-मसूर तथा तिल-चावल-मसूर पर क्षेत्रीय परीक्षण किए गए। गांगेय के कछार क्षेत्र में स्थित कल्याणी फार्म के निकटवर्ती क्षेत्र में चुने गए कृषि मौसम विज्ञान वेधशालाओं (अर्थात् चिनसुरा, हरीनघाट, बैरकपुर) से मासिक माध्य मौसम विज्ञान प्राचलों अर्थात् वर्षा, संभाव्य वाष्पन-वाष्पोत्सर्जन (पी.ई.टी.), एस.एस.एच., तापमान (अधिकतम और न्यूनतम) और आर.एच. (0700 और 1400 बजे एल.एम.टी पर) को प्राप्त किया गया। इसमें मौसम विज्ञान प्राचलों से प्रभावित हुए फसलों और उनके अनुक्रमों के सापेक्ष उपज निष्पादन पर अध्ययन किए गए। गांगेय के कछार क्षेत्र में मानसून से पूर्व हुई वर्षा अप्रैल/मई के दौरान उच्च आर. एच. सहित साधारण से अधिक तापमान के कारण बेहतर पूर्व-खरीफ फसल लगाई गई। इससे साधारण तापमान सहित मानसून के महीनों में हुई भारी, समान रूप से वितरित वर्षा तथा अधिक उच्च आर.एच. से फसल चक्र के केन्द्रबिन्दु के रूप में वर्षा पर आधारित प्रतिरोपित खरीफ चावल बोने की गुंजाइश का पता चला है। विशेषकर पटसन अथवा मूंगबीन की फसल के पश्चात् खरीफ चावल की पैदावार अधिक रही है। कम वर्षा सहित प्रोफाईल संग्रहित अवशिष्ट आर्द्रता न्युन तापमान और रबी मौसम के दौरान उच्च आर.एच. के परिणामस्वरूप मसूर की फसल अच्छी हुई है। पाँच अनुक्रमों में किए गए अध्ययन में से पटसन-चावल-मसूर तथा मूंगबीन-चावल-मसूर का पोष्णीय उत्पादन और वास्तविक लाभ सहित निष्पादन सर्वोत्तम पाया गया है।

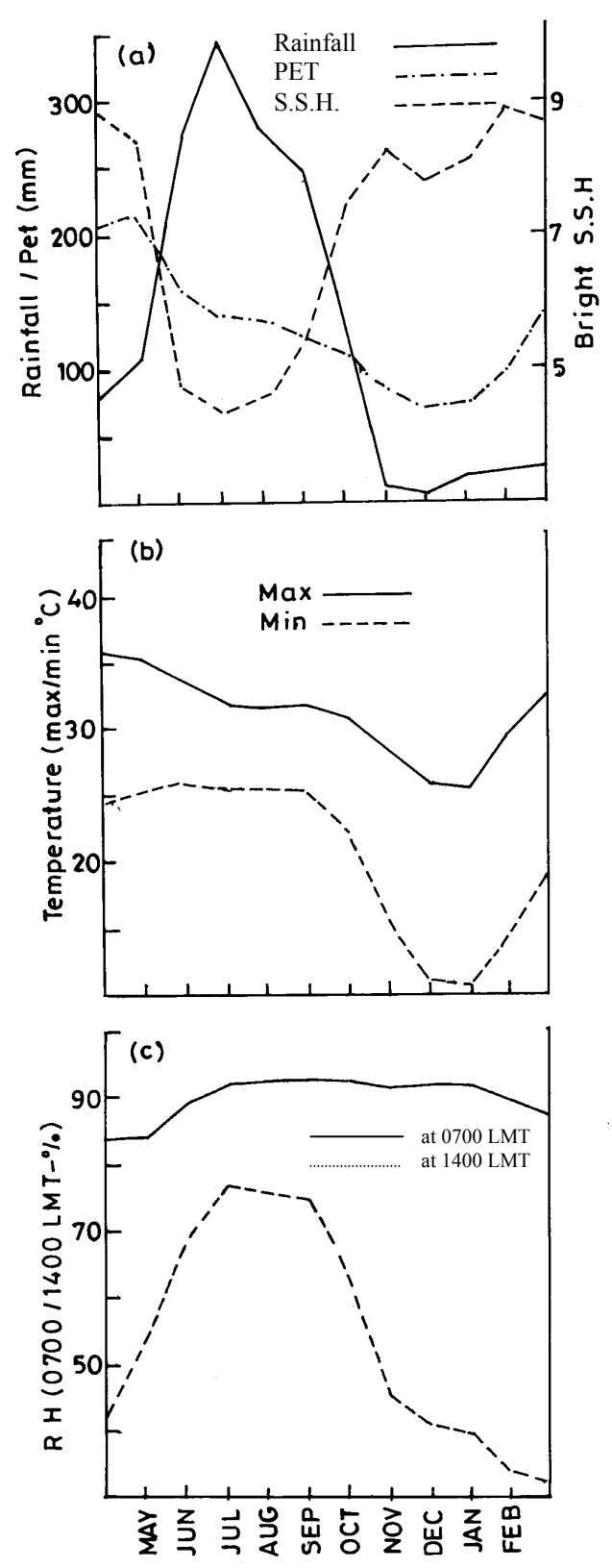
ABSTRACT. Rainfall, its distribution along with distribution of temperature. relative humidity (RH), bright sunshine hours (SSH) suggest the possible growing season and crop performance in a given area. Field experiments on five economically feasible, sustainable, rainfed crop sequences *viz*. fallow (*i.e*. no crop) – rice-lentil, jute-rice-lentil, direct seeded rice-rice-lentil, mungbean-rice-lentil and sesame-rice-lentil were conducted at Kalyani Farm, W.B., during 1989-91. Mean monthly meteorological parameters *viz*. rainfall, potential evapotranspiration (PET), SSH, temperature (max. and min.) and RH (at 0700 and 1400 hrs LMT) were obtained from selected agrometeorological observatories (*viz.* Chinsurah, Haringhata and Barrackpore), adjacent to the Kalyani Farm located in Gangetic alluvial region. The relative yield performance of crops and sequences as influenced by meteorological parameters were studied. In Gangetic alluvial region early rain, moderate to high temperature with high RH during April/May resulted in good pre-*kharif* crop establishment. Heavy, well distributed precipitation during monsoon months along with moderate temperature and very high RH showed scope for rainfed transplanted *kharif* rice as the pivot of crop rotation. *Kharif* rice yields were high especially after jute or mungbean. Profile stored residual moisture along with low rainfall, low temperature and high RH during *rabi* season resulted in good performance of lentil. Among the five sequences studied, performance of' jute-rice-lentil and mungbean-rice-lentil were the best with sustainable production and net return.

Key words – Crop sequences, Fallow, Sustainable production, Net return.

1. Introduction

Rainfall, its distribution along with distribution of temperature, relative humidity (RH), bright sunshine hours (SSH) suggest the possible growing season in given area (Venkateshwarlu 1985) with probable crop performance. Rainfed cropping over most of India (*i.e.* farming with natural precipitation) is a gamble on the monsoon. The problems of rainfed cropping are : (*i*) rainfall, which is concentrated within a short period and is uncertain in its distribution, (*ii*) monsoon rainfall may start late and cease early or *vice-versa*, with short or long dry spells in between, which vary from region to region.

Gangetic alluvial soils (entisol) are new in origin, non-saline in nature, profile characters have not yet fully developed and are highly productive for growing crops in



Figs. 1(a-c). Mean monthly meteorological parameters obtained from Chinsurah, Haringhata and Barrackpore

rotation. In lower Gangetic alluvial region early rain starts by the end of March, due to thundershower activity which is sufficient for raising pre-*kharif* crops *viz.* jute, *aus* rice, mungbean, sesame. Large areas remain submerged during rainy months (June to September) enabling rainfed transplanted *kharif* rice as a pivot of crop rotation. High temperature and high relative humidity during April to September also have influence on growth performance of pre-*kharif* and *kharif* crops. *Kharif* season is succeeded by *rabi* season, when both temperature and relative humidity are low but *rabi* crops like mustard, lentil, barley, safflower, peas, wheat can be raised by using profile stored soil moisture.

Crop growth is the resultant of many physical and physiological processes each of which is affected in various degrees by meteorological parameters. All the crops directly depend on rains, its distribution; the fraction of rainfall is stored as soil moisture, which contributes towards crop water need at its various growth stages, though the demand for rainfall is crop specific as well as region specific. The role of temperature on net photosynthesis varies from crop to crop depending upon their cardinal temperatures need (*i.e*. above and below which crop growth is severely hampered and the optimum temperature range varies from crop to crop as supported by Mavi, 1994). The temperature influences the duration of vegetative period of many plants. Duration of light, its intensity, quality affects crop development in varying degree in different crops. Some crops are sensitive to relative humidity, which is one of the chief factors in controlling evapotranspiration from the crop canopy (Venkataraman 1992). Naturally, in the year-round programme of various rainfed cropping systems their performances varies depending on different crop sequences. In this context five economically feasible, sustainable rainfed crop sequences were studied *viz*. fallow-rice-lentil (F-R-L), Jute-rice-lentil(J-R-L), direct seeded rice-rice-lentil [R (d) - R -L], mungbean-rice-lentil (M-R-L) and sesame-rice-lentil (S-R-L) to judge their performances in Gangetic alluvial region under influence of various meteorological parameters.

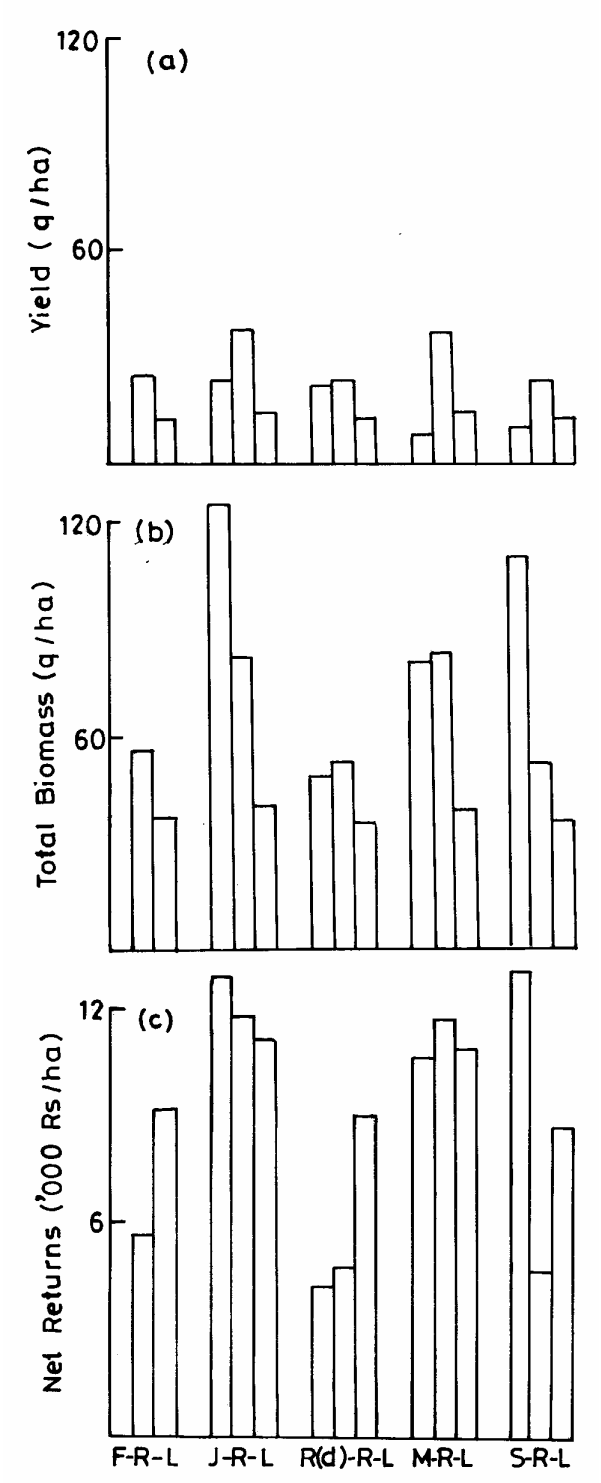
2. Methodology

The meteorological data were collected from three agrometeorological observatories *viz*. Chinsurah (22.87° N, 88.40° E), Haringhata (22.92° N, 88.50° E) and Barrackpore (22.75° N, 88.43° E) which were adjacent to Kalyani Farm (22.39° N, 88.54° E), B.C.K.V., W.B., representing the lower Gangetic alluvial region. Though all the 3 selected agrometeorological observatories were from the same lower Gangetic alluvial region, there were variations in the spatial distribution of the meteorological parameters studied. Hence, pooling of the data from the observatories were done by computing mean. Monthly meteorological parameters *viz*., rainfall, potential evapotranspiration (PET), bright sunshine hours (SSH), temperature (max. and min.) and relative humidity (RH at 0700 and 1400 hrs LMT) were obtained. Modified Penman method as obtained by Khambete and Biswas as published in weekly PET over India (1992) by the Agrimet. Division, IMD has been used in this study and monthly values were computed from the standard weeks. Data period for Chinsurah, Haringhata and Barrackpore were 1972-91, which are presented in Figs.1 (a-c).

The field experiment on rainfed multiple cropping systems was conducted at Kalyani Farm during 1989-91, in all the three crop seasons *viz.* pre-*kharif* (*i.e*. early April to middle of July), *kharif* (*i.e*. end of July to end of October) and *rabi* (*i.e.* end of October to March). The experimental clay loam soil belongs to Gangetic alluvial (entisol) with medium fertility status. The experiment was laid out in an area of 994 m^2 (in which net cropped area was 720m^{2}) with an individual plot size of 48m^2 (8 m × 6m) for each of the 5 crop sequences and were replicated thrice. The croppings during pre-*kharif* season were fallow (*i.e.* no crop), jute (cv. JRO - 7835), direct seeded rice (cv. MW-10), mungbean (cv. Pusa Baisakhi) and sesame (cv. B - 67); succeeding crop during *kharif* season was transplanted rice (cv. IR-36), followed by the crop lentil (cv. B-77) during *rabi* season. General fertilizer doses were @ 50 kg N, 25 kg P_20_5 and 25 kg K_2O per ha for pre-*kharif* crops; @ 50 kg N, 50 kg P_20_5 and 50 kg K_2O per ha for transplanted *kharif* rice and @ 20 kg N, 40 kg P_20_5 and 40 kg K_2O per ha for *rabi* crop (*i.e*. lentil). The pre-*kharif* crops were sown during first week of April; succeeding *kharif* rice was sown during end of July, while the *rabi* lentil was sown during third week of October, as paira crop (*i.e*. lentil seeds were sown just before harvest of *kharif* rice). All the crops were raised under conventional agronomic practices. The final dry yield (q/ha), total biomass (q/ha) of all the crops were determined and the mean values are summarized (sequence-wise) in Figs. 2 (a & b). Based on local market price during the experimental years, net returns (Rs/ha) for each of the crops as well as sequences were computed and the mean for the experimental years are presented in Fig. 2(c).

3. Results and discussion

In the Gangetic alluvial region, performance of the rainfed crops (in all the pre-*kharif, kharif* and *rabi* seasons) as well as sequences, as influenced by different meteorological parameters were critically analysed and discussed.



Figs. 2(a-c). (a) Mean yield, (b) total biomass and (c) net returns obtained under different rainfed crops in sequences in Gangetic alluvial region

3.1. *Pre-kharif season*

During pre-*kharif* season early rain during March to May, moderate to high temperature with high RH, bright SSH resulted in good pre-kharif crop establishment Figs. 1 (a-c). Salient meteorological features during April, May were 7-11 cm/month of rainfall, around 25° C/36° C min/max temperatures; mean RH varied between 40-85% with mean bright SSH more than 8; however, the potential rate of evapotranspiration (PET) was 20-22cm/month. Naturally, with the occurrence of pre-monsoon shower the pre-*kharif* crops were sown making use of residual soil moisture also. During June, July the balance between rainfall and PET was positive. The 4 pre-kharif crops *viz.* jute, direct seeded rice, mungbean and sesame performed well Figs. 2 (a&b). The mean yields (q/ha) were around 23.0, 22.1, 8.6 and 9.9 for jute, direct seeded rice, mungbean and sesame, respectively, while their respective total biomass productions (q/ha) were around 124.7, 49.1, 79.8, 109.7. Considering cost of cultivation and gross return, the net returns obtained [Fig. 2(c)] were very high for sesame and jute (both around Rs. 13000/ha), closely followed by mungbean (around Rs. 10700/ha), while net return from direct seeded rice was very low (around Rs. 4000/ha).

3.2. *Kharif season*

Heavy precipitation during monsoon months with moderate temperature and very high RH [Figs. 1 (a-c)] showed greater scope of rainfed transplanted *kharif* rice as pivot of the crop rotations. Rainfall during June to September varied between 25-35cm/month. Due to heavy precipitation for consecutive four months, large areas were submerged where transplanted rice performed well, as supported by Chatterjee and Maiti (1984). Maximum temperature during June was high which reduced slightly in the succeeding months of the season. The mean minimum and maximum temperatures were ranged between 25-34° C. RH values throughout the season was more than 70 %. During July to September RH values were ranged between 76-93%. Potential evapotranspiration was high during June (around 16 cm) which gradually reduced in the succeeding months. However, mean hours of bright sunshine was low (varied between 4-5 hours) during the season which showed negative influence on yield and total biomass production (as more cloudiness during the season resulted in less photosynthesis and more pests and diseases attack). The combined influence of these meteorological parameters was reflected in *kharif* rice production. The yield/total biomass production [Figs. 2 (a&b)] for the rice crop was very high which followed jute and mungbean (the yield was around 37 q/ha with total biomass around 82 q/ha). Yield and total biomass of the crop after fallowing (in pre-*kharif* season), resulted in moderate production (around 26 q/ha yield with 56 q/ha biomass production), while rice crop after direct seeded rice or sesame resulted in poor yield (around 23 q/ha) and total biomass

production (around 51 q/ha). The results revealed that jute or mungbean has positive influence (enriched the soil by decomposition of the crop residue) in the succeeding *kharif* cropping, while direct seeded rice or sesame has negative influence (depleted the soil) on the transplanted rice crop (Kashyapi 1992). The impact was reflected in the form of net return, also [Fig. 2(c)]. *Kharif* rice after jute or mungbean gave around Rs. 12000/ha net return, while rice crop after direct seeded rice or sesame produced around Rs. 4700/ha net return. Thus, rice cropping after jute or mungbean is around 2.5 times more remunerative as compared to the cropping after direct seeded rice or sesame.

3.3. *Rabi season*

At the commencement of the season, precipitation was high with moderate temperature, high RH and moderate potential evapotranspiration [Figs. 1 (a-c)]. Afterwards, some precipitation (<2.5 cm/month) was received in the succeeding months (because of western disturbances or some other systems, which along with profile stored soil moisture helped in *rabi* crop (lentil) establishment. Temperature during the season varied between 11-30° C, while mean RH level was low (ranged between 40-90%) during the season. Bright hours of sunshine was around 8 with 7-10 cm/month of potential evapotranspiration during November to February. The growth and yield performance of *paira* lentil during the season was very good which was reflected by high yield, total biomass production and high net returns [Figs. 2 (a-c)]. The lentil yield varied from 12.0 to 14.5 q/ha, while total boimass production was ranged between 34.5 to 40.5 q/ha. The crop net returns were between Rs. 9000-11000/ha (approx). However, lentil crop during *rabi* season performed better in which preceding pre-*kharif* crops were jute or mungbean, though the variation was not so marked.

3.4. *Crop sequences*

Among the five sequences studied, performance of jute-rice-lentil was the best with around 75.0 q/ha net yield. 250 q/ha net biomass production and Rs. 36000/ha net return. Mungbean-rice-lentil, sequence also performed very good with around 60.0 q/ha, 200 q/ha and Rs. 33000/ha net yield, net biomass production and net return respectively. Performance of sesame-rice-lentil was moderate with around 45.5 q/ha, 196 q/ha and Rs. 26500/ha net yield, net biomass production and net return, respectively. Performance of fallow-rice-lentil was the worst (around 38.0 q/ha net yield, 93 q/ha net biomass production and Rs. 15000/ha net return), because only two crops were raised in the sequence, which was closely followed by direct seeded rice-rice-lentil (with around 58.0 q/ha net yield, 136 q/ha net biomass production and Rs. 18000/ha net return).

4. Conclusions

The present study on performance of rainfed cropping systems in Gangetic alluvial region revealed the following conclusions :

(*i*) Four pre-*kharif* crops *viz*. jute, direct seeded rice, mungbean, sesame performed well under influence of early rain, moderate to high temperature, high RH, bright sunshine hour during the season. Sesame and jute gave very good net returns, closely followed by mungbean, while net return obtained from direct seeded rice was very poor.

(*ii*) Heavy precipitation during monsoon months with moderate temperature and very high RH showed very good scope for rainfed transplanted *kharif* rice as pivot of crop rotations. The yield, total biomass production as well as net return for the rice crop was very high in which preceding crops were either jute or mungbean.

(*iii*) Performance of *paira* lentil during *rabi* season was very good under influence of profile stored soil moisture (after *kharif* rice), low precipitation, low temperature, moderate RH, low potential evapotranspiration and very high hours of bright sunshine.

(*iv*) Among the five sequences studied performance of jute-rice-lentil, mungbean-rice-lentil were the best with sustainable production and net returns, closely followed by sesame-rice-lentil, while fallow-rice-lentil and direct seeded rice-rice-lentil were the worst in performance.

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References

Chatterjee, B. N. and Maiti, S., 1984, "Cropping System (Theory & Practice)", Oxford & IBH Co., Calcutta, 1-326.

Kashyapi, A., 1992, "Cropping effect on succeeding N-fertilized *kharif* rice and after effect on lentil, under rainfed conditions", Ph.D. Thesis. Awarded from Deptt. of Agronomy, Faculty of Agriculture, B.C.K.V., Mohanpur, W.B., 1-269.

Mavi, H. S., 1994, "Introduction to Agrometeorology", Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, 1-272.

Venkataraman, S., 1992, "Effect of weather on soils, seed materials and crop", Crops and Weather, Publications and Information Division, I.C.A.R., Krishi Anusandhan Bhavan, Pusa, New Delhi - 110 012.

Venkateswarlu, J., 1985, "Crops and cropping systems in dryland agriculture", In Efficient management of dryland crops. Central Research Institute for Dryland Agriculture, I.C.A.R., Hyderabad, A.P., India.