I N T R O D U C T I O N

INTRODUCTION

India has made commendable progress in enhancing agricultural production and productivity during the last few decades by introducing short-duration high yielding strains of cereals. It is desirable that production of oil and pulse crops be also enhanced in order to increase the consumption of energy protein and fat in the cereal-based diet of the common masses. Unfortunately the production of oilseeds and pulses has increased by only 15 per cent, while that of cereals has increased by 105 per cent, during the last three decades (Pushpamma and Chittemma Rao, 1981). The consumption of protein and fat is much below the average requirements due to low availability. In addition to the increased demand, the Indian population is expected to swell to 935 million and the total food grains requirement is anticipated to be about 205 million tonnes by the turn of this century (Swaminathan, 1982). These two factors clearly indicate the urgent need for the balanced increase in agricultural output. The scope for increase in the horizontal production being limited, the situation rightly calls for increasing the vertical production by introducing advanced, viable technology.

The eastern part of India is in the hot humid subtropics and receives about 70 per cent of the annual rainfall (1500 mm) through heavy showers during June to September, while the winter months experience occasional light showers followed by an abrupt rise in temperature beyond mid-February. This climatic condition favours a

rice-based crop rotation which is currently in practice. Hence, cultivation of rice in kharif is a suitable option in this region. At present rice is being cultivated in 87.2 per cent of the total cultivated area under food grains round the year, and out of this about 81 per cent is grown in kharif, 5 per cent in rabi and the rest in summer season. Cultivated area under wheat, mustard and chickpea are only 3.58, 2.73 and 1.08 per cent, respectively, of the total cultivated area under food grains, which indicates the low area under these crops (Anon. 1983). There is considerable scope for increasing the area under crops having low water requirements by utilizing the existing available water and by drawing upon more available ground of surface water resources. Also, the substitution of these crops for rice in rabi season can bring more area under cultivation with the same available water resources and, in turn, increase the total production.

For a fecund crop planning it is imperative to evolve viable package of practices, with suitable fertilizer requirement and timing of irrigation, taking into consideration the soil, crop, climatic and socio-economic structure of a region. Optimum time of sowing, one of the most important factors, primarily depends on the residual moisture retained after the harvest of the preceeding kharif rice, the temperature at the time of sowing and suitability of climatic condition during the growth cycle of the subsequent crop, input resources, and need of the

farmers. Farmers in eastern India invariably grow early, medium and late duration rice varieties because of adequate rainfall, land situation and congenial environment during kharif season. This practice of cultivation vacates the land for subsequent rabi crops at different times. In addition, the water logging due to late rains or low land situation creates an unsuitable soil condition for land preparation before November, which delays the sowing of the subsequent rabi crops. In general, the effects of delayed planting of different crops are different and depends on the climatic conditions of the region. The late sown rabi crops do not perform well, because they experience short duration winter followed by an abrupt rise in temperature beyond mid-February causing low yield of the crops. Farmers are, therefore, reluctant to grow rabi crops and generally keep land fallow or wherever sufficient water is available they grow winter/summer rice. Thus, the adjustment of sowing time to achieve an optimum yield of a crop becomes a vital consideration.

The use of commercial fertilizers is, perhaps, the most important single factor in bringing about increase in production. Even the full benefits of irrigation and the introduction of high yielding varieties of crops cannot be realized without the use of fertilizers. With variation in chemical composition of soil, crops differ markedly in their requirements of different nutrients. Apart from the soil and type of the crop, certain factors, particularly soil moisture, have been found to have a profound influence on

the response of a crop to fertilizers.

Wheat responds favourably to heavy nitrogen application. But nitrogen is a costly input and hence assessment of its profitable level with optimum phosphorus and potassium is desirable. The evaluation of nitrogen requirement of mustard, a crop requiring low nutrients with high profit is also needed. The chickpea, a leguminous crop, fixes atmospheric nitrogen and reduces the need for nitrogenous fertilizers; it also improves structure and fertility of the soil. However, it requires sufficient phosphorus and therefore its optimum phosphorus requirement to achieve maximum yield is an important consideration. Further, the effects of these nutrients on the quality of the crops needs investigation under this Agro-climatic condition.

The broad purpose of irrigation is to minimize yield reduction due to water deficit. To exploit the full yield potential of crops, it is planned to increase irrigated area by about 2.5 - 3.0 million hectares per year with a target of about 105 million hectares total irrigated area by the year 2000 A.D. (Gautam, 1982). The prevalent procedure for scheduling of irrigation involving both time and depth can be separated into those using direct measurement of soil moisture and those employing predictive approach based on estimated crop water use. Of the two, the latter approach based on climatic data appears to be more sound and feasible. Since evaporation from plant and soil is the resultant of all the climatic elements, the climatological

approach may prove to be the most simple, practical and extensive method for timing of irrigation. Further, the acreage under cultivation in rabi season with the same available water resources can also be increased.

The suitable sowing time along with judicious water and fertilizer management can ensure high production and profit of any crop if the limited available water is scheduled to crops having high water use efficiency and economic values. Thus, information regarding the scheduling of irrigation for wheat, mustard and chickpea having varying water requirement will help the farmers and irrigation engineers to use the water for the most productive crops.

Swaminathan (1982) has indicated that the gap between potential and current experimental yield is considerable. Hence, the immediate pay-off will come from an accelerated effort in technology transfer. Therefore, demonstration at farmer's field was required to adjudge the technical viability and economic feasibility in transferring the innovated technologies for their wide adoption after defining the optimum sowing time, irrigation timings and nutrient requirements of the crops.

Under unlimited resources for maximum profit of a farm, the crop which gives maximum profit will be recommended with optimum levels of fertilizers and irrigation along with the suitable time of sowing. However, same may not be true under limited resource conditions and the levels of different inputs along with the distribution of crop may

be different for obtaining maximum profit for a farm.

In general, the farmers of West Bengal are having limited resources specially with respect to availability of land, labour, water, fertilizer and capital. Keeping above facts in view, there is need to develop the resource optimization model for different farm units for optimizing the resources. The use of linear programming technique by simplex method is more common and under the present study the farmers' resources along with the results obtained under the present investigation were utilized for developing the optimization models for different farm units and resources condition for maximizing the profit.

Information on nitrogen requirement for wheat and mustard, and phosphorus requirement for chickpea is available in regions where these crops are commonly cultivated. However, very little is known on the nitrogen and phosphorus requirements for this region where these crops are not common and having short winter periods. The applicability of IW/CPE ratio approach in timing of irrigation for rabi crops has special significance in humid subtropical eastern India where the winter rainfall is uncertain and inadequate, water resources are limited in dry months and the climate experiences an abrupt rise in evaporative demand during the reproductive phase of the crops. The present approach has a great promise in optimising irrigation water and nutrient requirement in this region where the sowing times of rabi crops are not definable.

Keeping these aspects in view, the present investigation was carried out with the following objectives :

i) To find out the effect of sowing time, fertilizers and scheduling of irrigations on growth and yield of wheat, mustard and chickpea,

ii) to find out the effect of sowing time, fertilizer and scheduling of irrigation on N, P and K concentration of the crops at different stages and their uptake,

iii) to study the effect of sowing time, fertilizer and scheduling of irrigation on soil moisture extraction pattern, water requirement and water use-efficiency of the different crops,

iv) to find out and demonstrate the effect of sowing time, fertilizer and scheduling of irrigation on performance of different crops at farmer's field, and

v) to optimize the resources, namely, land, labour, water, fertilizer and capital for obtaining maximum profit for a given resource condition.