FORECASTING OF LEMONGRASS (*Cymbopogon flexuosus* Nees ex. Steud Wats) YIELD BASED ON WEATHER PARAMETERS

By
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THESIS

Submitted in partial fulfilment of the requirement for the degree of

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DECLARATION

I hereby declare that this thesis entitled **"Forecasting of yield of lemongrass (*Cymbopogon flexuosus* Nees ex. Steud Wats) based on weather parameters"** is a bonafide record of research work done by me during the course of research and that this thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other university or society.

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1.INTRODUCTION

Plant growth and development are primarily governed by the environment conditions of the soil and climate. The success or failure of farming is intimately related to the prevailing weather conditions. It is nevertheless possible to optimize farm production by adjusting cropping patterns and agronomic practices to suit the climate of a locality.

Crop forecasts are useful for getting reliable estimates on crop production prior to harvest. This will help planners and policy makers to chalk out an appropriate development plan for increasing crop production. This may also help agriculturists to know the probable production of the crop from its field and their estimates, which are essential for proper planning of distribution of food and their relief measures in areas with impending crop failure. Based on crop yield forecasts, necessary credits can be availed of by farmers.

Weather assumes significance in nearly every phase of agricultural activity from the preparatory tillage to harvesting and storage. As weather is the single major limiting factor in crop production successful farming calls for appropriate decisions in the light of weather conditions in the matter of the time of sowing, transplanting, scheduling of irrigation, timing of fertilizer application, using of pesticides etc.

Thus a sound knowledge of the climatic factors and an understanding of the complex processes of interaction between the climate and the biological processes of the plants are essential to a scientific approach to farming, based on plannėd cropping patterns and improved management practices.

Estimation of most probable production of crop while it is still standing in the field is called its forecast. Forecasts can be formed in many different ways. The method chosen for depends upon the purpose and importance of the forecasts as well as the costs of alternative forecasting methods.

Basically three types of models are used to analyse the influence of weather on crops.

They are:

1) Simulation models
2) Crop weather analysis models (based on the physiology of the crop system)
3) Statistical models employed for prediction.

Among the various statistical models some are univariate models, which would examine the effect of one meteorological factor on crop yield and others are multivariate models, which examine the joint effects of several variables on the crop yield. In simple correlation and regression studies, the final yield of a crop is charted against a single variable, usually the monthly or total rainfall received during the growing season or the temperature during the critical periods. Another statistical approach is that of Fisher's regression integral or response curve technique that deals with the effect of a single meteorological variable on crop yield. It brings out the slow continuous changes in the response of a crop to the weather pattern by fitting a response curve which gives the average change in the yield of a crop associated with an additional unit of the meteorological factor, say temperature at a specific point of time. But it is very seldom that a single weather factor accounts for the majority of variations taking place in the yield of a crop from year to year. During such situations the multiple linear regression analysis is attempted and crop forecasts are made on the basis of the regression function. But such methods make use of the assumption that the various meteorological factors are linearly related to the crop yield, which is not always true.

The Indian sub continent abounds in aromatic vegetation and the essential oils extracted from such plants and attars prepared from them are popular world over. But pride of place among essential oils earning foreign exchange goes to the oil of lemongrass.

Lemongrass is a tropical perennial grass, which yields aromatic oil containing 70-90% citral. The name lemongrass is given to this crop because of typical strong lemon-like odour of the plant, which is predominantly due to high citral content in the essential oil present in the leaves. Lemongrass oil of commerce is popularly known as Cochin oil in the world trade as 90 % of it is coming from Cochin port. Kerala has the monopoly in the production of Lemongrass oil. Three types of Lemongrass are known, viz. East Indian, West Indian and Jammu lemongrass (Thomas 1995). East Indian lemongrass is the genuine and commercial type. It is indigenous to India and is cultivated in the states of Kerala, Assam, Maharashtra and Uttar-Pradesh. West Indian Lemongrass or American lemongrass is believed to have originated either in Malaysia or in Sri Lanka. It is widely distributed throughout the tropics and is grown in West Indies. Jammu lemongrass is mostly confined to North Indian states such as Jammu and Kashmir, Sikkim, Assam, Bengal and Madhya Pradesh.

The crop requires a warm humid climate with plenty of sunshine and rainfall ranging from 2500-3000 mm, uniformly distributed over the year. The grass prefers an average temperature of 23-30 C^0. The plant is hardy and tolerant to drought. This crop is well suited for rainfed agriculture. It grows well at altitudes between 100 and 1200 m above MSL. It is generally grown on poor soils along hill slopes, though it flourishes on a wide variety of soils ranging from rich loam to poor laterite. The grass grows best on well-drained sandy soil.

The lemongrass oil has found variety of uses in various fields. Large quantities are used for extraction of 'citral ' the chief constituent of the oil. Citral is the starting material for the preparation of important ionones. α- ionone is used in flavors, cosmetics and perfumes. β- ionone from the oil is used for the manufacture of synthetic Vitamin A. The oil has found other uses such as bactericidal, as insect repellent and in medicines. The spent grass (residue obtained after extracting the oil) is a good cattle feed and can be converted into silage. It is also used for the manufacture of cardboard and paper.

Thus the lemongrass industry in India is having a vast and expanding business potential in view of the wide internal usage of oil and spent grass and the increased export possibilities of oil and ionone. Since no work has been undertaken till date to forecast the yield of lemongrass with the help of weather parameters, an attempt has been made in this direction in the present study.

The main objectives of this study are:

(1) To develop a suitable and reliable statistical methodology to forecast lemongrass yield (grass and oil) by evolving different empirical – statistical crop-weather models using the original and generated predictor variables.

(2) To perform a comparative study of relative efficiency, adequacy and performance of each of these crop-forecasting models evolved and to select the 'best', most promising and plausible crop forecasting models for the purpose of future use in predicting the grass and oil yield of lemongrass.

(3) To investigate the influence of weather variables on grass and oil yield of lemongrass based on crop forecasting models selected as the 'best' fitted models.

2. REVIEW OF LITERATURE

Several studies have been undertaken so far with regard to crop-weather relationship in various crops, but very little work has been done in medicinal crops like lemongrass. So this study was undertaken to get an idea of the various weather parameters influencing the yield of lemongrass. A brief review of the work done by several workers in the above mentioned crops have been given below under three categories viz.

(2.1) Conventional Regression Models

(2.2) Composite Regression Models

(2.3) Principal Component analysis

2.1. Conventional Regression Analysis

Kalamkar and Satakopan (1941) examined the influence of rainfall on cotton yield at the government experimental farm Akola and Jalgaon by the use of harmonic analysis.

Stacy *et al.* (1957) studied the joint effects of rainfall and maximum daily temperature on the yield of corn crop. They related the maximum daily temperature and rainfall averaged by five-day period for 18 periods during each growing season of a 38-year span to the corn yields using a set of second-degree polynomials as regression integrals. It was inferred that high temperature near the end of growing season were beneficial to crop yields if the rainfall was adequate.

Glovar (1957) studied the effect of weather parameters on the yield of maize crop in Kenyan highlands. It was revealed that the total rainfall in the growing season of the crop had a curvilinear relationship with yield. He also found that total rainfall in the growing season had a curvilinear relationship with yield and so he suggested a prediction equation of the form

$$Y = A X^{b} e^{-ax}$$

where Y was the yield, X was rainfall and A, b, and a were constants.

Gangopadyaya and Sarker (1964) applied the technique of curvilinear regression in studying the effect of meteorological factors on the growth of sugarcane. They found that at Pune the maximum and the minimum temperature influenced elongation most and their optimum values were equal to 87.5 ^{0}F and less than or equal to 68 ^{0}F respectively.

Balasubramaniam (1965) noted that the range of humidity varied between 78 to 86 per cent during years with comparatively very high rice yields.

Ramamurthi and Banerjee (1966) attempted a curvilinear regression study of weather factors on wheat yield at Dharwar by using the successive approximation technique and found that a minimum temperature of about 16 ^{0}C, a maximum temperature of about 29.3 ^{0} C and a mean temperature in the range 22 ^{o} C to 23 ^{0} C were most favorable for wheat production.

Tanaka *et al.* (1966) were of the opinion that in the rainy season growth rate of rice plant was higher at early stages but it became slower and sometimes even negative at later stages. On the other hand in dry season the growth rate was slow at early stages but it was kept constant till the end.

Ghildyal and Jana (1967) found that relative humidity of the atmosphere would influence the rate of transpiration and the increased or decreased transpiration might influence the physiological processes affecting crop yield. They also found that cooler weather; low relative humidity, medium evaporation, sunshine hours and shallow flooding were the most favourable agro meteorological environmental for maximum rice production.

Sreenivasan (1968) noticed that at Pattambi and Chinsurah, rainfall received in the week of transplanting and that in the elongation phase were detrimental to paddy where as that during tillering, flowering and post flowering phase was beneficial. Bright sunshine at very early stages of tillering, panicle emergence and the ripening phases seemed to be conducive for crop growth and yield.

Singh and Kapse (1969) studied the effect of total rainfall and its monthly distribution on cotton yield at Indore and Khandwa. They found that relatively high amount of rainfall received during the months of July, August and September had adversely affected the crop yield, in addition to this; low and medium rainfall years give more cotton yields while high rainfall years record low yields

Das (1970) used regression analysis for the issue of monthly forecasts of the yield of paddy on the basis of weather parameters during *kharif* season for certain homo-climatic regions. In case of Kerala, number of rainy days during the period from 16th April to 15th May and the number of occasions of drought and flood during the period from 16th June to 31st August contributed significantly towards yield.

Joshi and Kabaria (1972) studied the effect of rainfall distribution on the yield of bunch groundnut in Saurashtra and they found that neither the total rainfall nor the distribution of rainfall had any effect on the yield. However, they observed significant correlation between the quantity of rainfall received during the period from full pegging to pod development in favorable seasons, which occurred once in three year.

Sreenivasan (1973) examined the influence of rainfall on the yield of cotton for Khandwa and Indore in Madhya-Pradesh using the Fisherian Technique of regression integral and also by multiple regression analysis. Five out of six and three out of six rainfall distribution constants showed significant correlations with yield for Khandwa and Indore respectively. It was found that for both the stations additional rain during growth and boll formation period's exerted detrimental effects on the crop.

Bhatt and Seshadrinathan (1975) observed that a marginal decrease in light intensity to 75% of the normal sunlight increased plant height, node number, internodal length and leaf length of sorghum but caused a substantial decrease in the width of leaves, dry weight and grain yield.

Bhargava *et al.* (1978) investigated influence of moist days and humid days on the yield of Jowar crop in Jalgaon district pertaining to 1950-1971. It was reported that the yield had linear relationship with the number of moist days and number of humid days. It was found that the span of humid period extended between the third week of June to second week of September while that of the moist period extended between second week of June to the end of September.

Murthy and Murthy (1981) computed simple correlation coefficients between climatic factors and spikelet sterility in rice and found that solar radiation at different periods of reproductive and ripening stages especially on the day of anthesis was significantly and negatively associated with sterility.

Deshpande (1981) presented a bibliography on the crop- weather studies on annual crops.

Shai and Singh (1981) noted that rainfall is the only feature for significant reduction in oil content and that temperature and relative humidity have no effect on yield and quality of lemongrass oil.

Khatri and Patel (1983) attempted pre harvest forecasting of groundnut yield in Gujarat, combining eye estimate and selected rainfall variables through regression analysis. Their results revealed that prediction equation with eye estimate in combination with rainfall variables proved efficient in forecasting groundnut yield compared to regression analysis using both the variables separately.

Bhatia (1983) showed that rainfall in June had significant positive impact on the yield of paddy in the states of Andhra Pradesh, Karnataka, Madhya Pradesh and Orissa. This was because rain in June helped timely raising of the nursery and transplantation of paddy, which in turn had positive effect on yield of the crop. The study also revealed profound influence of October rains on crop yield in the states of Assam, Bihar, Kerala, Orissa and West Bengal.

Jahagirdar and Thote (1983) revealed that instability in the occurrence of rainfall during the period from 4^{th} June to 12^{th} August would affect productivity of rice. They also found that total rainfall received during the *kharif* season had adverse affects on rice yield but frequent occurrence of dry spells during the period from 1^{st} October to 4^{th} November was found to favour crop production.

Sarwade (1983) predicted rice and wheat yield from weather parameters and technology. It was observed technology was largely responsible for the yield increase in preceeding years in wheat whereas for rice it is felt that technology has still much scope. As regards to crop weather relationship, it was concluded that for *kharif* rice, dry spells of more than 8 days during the months of July and August drastically diminished yield. In contrast in case of wheat low minimum temperature during December to February was found helpful in increasing the yield. Also rainfall prior to the sowing period of the wheat crop was found to exert profound influence.

Pathak and Patel (1983) studied the effect of weekly rainfall during the growing period (23rd week to 38th week) of bajra in Kutch district of Gujarat State. The study revealed that about 49.75 % of the total variation in crop yield could be explained by the variables under study.

Vaishnav and Patel (1983) evaluated four different statistical models for pre-harvest forecasting of groundnut (*Arachis hypogaea*, Linn) yield in kharif . The four models attempted in the study were:

Model – I: $Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots \beta_k X_K + \varepsilon$

Model – II: $\text{Log } Y = \beta_0 + \beta_1 \text{Log } X_1 + \beta_2 \text{Log } X_2 + \ldots + \beta_k \text{Log } X_k + \varepsilon$

Model – III: $Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_k X_k + \varepsilon$

Model – IV: $Y = \beta_0 + \beta_1 X_1^{-1} + \beta_2 X_2^{-1} \ldots + \beta_k X_k^{-1} + \varepsilon$

The regression equations were fitted by considering the plant population and the number of mature pods per plant at 30 days and 15 days prior to actual harvesting of the crop, moisture content in the soil at the depth of 0-15 cm after 91 days of sowing. They concluded that Model I accounted for maximum variation and could be adopted for forecasting purpose, 30 days prior to harvest with the above mentioned variables. However the variation accounted by the model was low ($R^2 = 48$).

Huda *et al.* (1983) studied the effect of environmental factors on sorghum growth and development. The independent variables comprised of data on soil water at critical growth stages and daily climatic variables. Regression models that included one or more of the independent variables namely soil water at planting (SW), rainfall, mean temperature, solar radiation, evapo-transpiration (ET) for the whole growing season and for three growth stages were developed for 48 data sets. They concluded that no single environmental factor explained sufficient variability in yield. Rainfall, mean temperature and their product for three growth stages together explained 67 % yield variation.

Appa Rao and Dudhane (1984) studied the weather factors associated with abnormal wheat yields of Himachal Pradesh. Their study concluded that rainfall, cloud and minimum temperature during sowing, elongation, tillering and flowering stages were the important weather parameters that affected the final wheat yield over Himachal Pradesh. Lowest wheat yields were associated with poor rainfall, low cloud amount and appreciable fall of minimum temperatures over the state.

Swe (1985) estimated yield-forecasting models for coconut from weather parameters of quarterly as well as half yearly periods of the effective crop season, which extended from the month just before harvest to 36 months before harvest. He used stepwise regression to estimate the final model with generated variables as predictor variable.

Nair (1985) reported the influence of eighteen climatic factors for a period ranging from 10 to 45 months prior to harvest on monthly and annual yields of coconut. Month-wise and season wise climate and their influence on monthly and annual yield were also studied. He found that seasonal grouping of climate showed stronger relationship on annual yield than month-wise climate.

Rao and Vijayalakshmi (1986) studied rainfall - yield relationship in rain-fed Sorghum in India, to identify the important periods during which rainfall affect the yield and to develop some suitable agronomic manipulations to stabilize yield. They came to the conclusion that delayed seedling reduced yield of sorghum. Distribution of rainfall rather than total rainfall is important in determining the sorghum yields. The rainfall at grain filling stage is crucial for this crop. By considering the amounts of rainfall during certain crucial stages of crop growth it was possible to explain more than 80 % of variation in sorghum yield.

Ajitha (1986) studied effect of various climatic factors on rice yield for varieties namely PTB1 and PTB 5 during the autumn and PTB 12 and PTB 20 during the winter season. The values of coefficient of determination for the best prediction equations of PTB 1, PTB 5 were 0.94 and 0.78 respectively. Also the optimum time of forecast for PTB 20 in the winter season was found to be the fourth fortnight after sowing and that of PTB 12 was the sixth fortnight after sowing with a predictability of 81 % and 79 % respectively.

Menon (1987) fitted forecasting models for yield in cashew. Six forecasting models were developed by attributing three different weights to the general square and square root forecasting models. With an effective crop season of six months, four seasons were developed by taking combinations of these six months period. Thus for each variety of cashew in a particular season, six forecasting models were developed, using the generated weather prediction variables. The final crop forecasting models were constructed using the techniques of stepwise regression.

Ganesan *et al.* (1987) made an attempt to obtain a relationship between biomass production in ragi by the equation of the form $Y = e^{a + b \log X}$, where Y is the biomass production in quintals/ hectare and X the growing degree days or open pan evaporation or evapotranspiration . The other forms of equation considered for suitability were

$Y = a + bx$, $Y = a + b \log x$ and $Y = e^{a + bx}$

Gupta and Singh (1987) derived a multilinear regression equation for estimating sugarcane yield at Padegaon in Maharashtra, using some of the weather parameters at specific periods of crop growth. The regression equation developed accounted for 76% variation in the estimated yield. The study showed that the rainy days and relative humidity during the respective sensitive periods of mid-elongation phase were significant.

Vijayakumar *et al.* (1989) predicted the yield of coconut by using weather variables. The important variables that they identified as important for yield prediction were: relative humidity, sunshine hours, temperature (minimum) and vapour pressure. The prediction model developed could explain 91 % of the yield variation.

Mabel (1990) studied the influence of weather parameters on the yield of black pepper utilizing the data on yield of 29 varieties of pepper (*Piper nigrum*) and maximum-temperature, minimum-temperature, relative humidity, rainfall and number of rainy days recorded from 1963- 64 to 1979- 80. Forecasting models, based on weekly as well as fortnightly weather elements were estimated for each of the 29 varieties by two-stage linear regression technique. First stage models were estimated by multiple linear regression and the second stage models were estimated with the estimates of yield from first stage models as explanatory variables by stepwise regression. She concluded that the forecasting models utilizing weekly climatic data had higher predictability compared to that utilizing fortnightly data.

Sharma and Kharwara (1990) developed linear regression equations to predict grain yields of rainfed bread wheat (*Triticum aestivum* L. emend. Fiori and Paol.), barley (*Hordeum vulgare* L. sensu lato), chickpea (*Cicer arietinum* L.) and lentil (*Lens culinaris* Medikus). Their study revealed that total water supply accounted for 74 – 99 % of variation in the grass yield of four crops: 99 % in wheat, 95 % in barely, 87 % in chickpea and 74 % in lentil.

Gupta *et. al.* (1994) studied the effect of weather variables on yield of pearl millet (*Pennisetum glaucum*) in Jodhpur district .The weather variables used for the analysis were maximum and minimum temperature, rainfall, number of rainy days, maximum and minimum relative humidity. Their study revealed that rainfall, relative humidity and maximum temperature during the vegetative to grain filling phase were the major determinants of grain yield of rain fed *P.glaucum*.

Dubey *et al.* (1995) estimated cotton yield based on weather parameters in Maharashtra. They developed a multiple regression model using the independent variables as the primary variables like rainfall, maximum temperature, minimum temperature, relative humidity and sunshine hours and the derived variables like mean temperature and rainy days, and the cotton yield as a dependent parameter. Their study concluded that the most controlling weather factor reducing the cotton yield was the number of rainy days during boll development or bursting. During fruiting low mean temperature was found favorable for better yield. Rainfall immediately after germination resulted in stunted growth and was found to have detrimental effect on the yield.

Sastri *et al.*(1996) studied the effect of temperature and sunshine on the productivity of rice crop. They found that the rice crop grown during winter/summer season experienced extremes of minimum temperature at seedling and vegetative stages and extremes of maximum temperature at reproductive and maturity stages. Correlation coefficients between the grain yield and maximum and minimum temperatures, growing degree days and total number of sunshine hours at each of the growth stages viz. seedling, vegetative, reproductive and maturity stages were worked out.

Singh *et al.* (1996) studied the influence of agro climatic elements on the yield of rice, using the weather variables namely total rainfall, maximum and minimum temperatures, relative humidity's, number of rainy days and bright sunshine hours. Their study revealed that the most important parameter for assessing a good yield response was the afternoon relative humidity, which gave the best estimate of rice yield (R^2 = 0.62). Rainfall and number of rainy days in that order are the next important variables to be monitored for the rice yield.

Rai *et al.* (1996) estimated paddy yield on the basis of climatic elements at Raipur. Their study revealed that paddy yield at Raipur could be predicted during the second week of reproductive phase i.e. two and a half months before the harvest. Rainfall, number of rainy days, morning or afternoon relative humidity's during seedling to reproductive phases, helped to increase paddy yield; whereas maximum temperature from seedling to maturity phases reduced the yield.

Chaurasia and Minakshi (1997) predicted wheat yield based on climatic parameters based on 35 years wheat crop yield and climatological data for the period 1961-1995. Annual fluctuations in the yield were discussed and regression equations developed to predict wheat yield in the central part of the Indian Punjab. The multiple correlation equation using maximum and minimum temperature, morning and evening relative humidity, sunshine hours and wind speed resulted in a high coefficient of determination ($R^2 = 0.88$).

Rai and Chandrahas (1999) made an attempt to forecast rice yield using linear discriminant score of weather parameters and input variables. Their results revealed that temperature (maximum and minimum) and sunshine hours were effective at the growing phase whereas sunshine hours found ineffective during early growth phase. During active vegetative phase sunshine hours and temperature (minimum) were the important factors. They also concluded that none of the weather parameters alone were sufficient to explain for the discrimination of crop yield whereas the simultaneous effect of all the weather variables taken together was sufficient. Further all the variables under study at active vegetative phase explained about 87 % of the total variation in rice yield.

2.2. Composite Regression Models

Runge (1968) examined the joint effects of maximum daily temperature and rainfall on corn yield using a second-degree orthogonal polynomial. It was found that the effects were more pronounced one week before anthesis and remained at constant level thereafter.

Agrawal *et al.* (1980) developed two models for forecasting yield of rice in Raipur district. In the first model-weighted averages of weekly weather variables and their interactions using powers of week number as weights were used. The respective correlation coefficients with yield in place of week number were taken in the second model. The stepwise regression technique was followed for obtaining the forecasting equations. The first model was

$$Y = A_0 + \sum_{i=1}^{p} \sum_{j=0}^{2} a_{ij} Z_{ij} + \sum_{i \neq i'=1}^{p} \sum_{j=0}^{2} b_{ii'j} Q_{ii'j} + ct$$

where Y = Crop yield, A_0, a_{ij}, $b_{ii'j}$ ($i \neq i$= 1,2,...,p . j= 0,1,2) and c were constants.

t = Year no. included to correct for the long term upward or downward trend in yield. Z_{ij} and $Q_{ii'j}$ were generated first and second order variables defined as

$$Z_{ij} = \sum_{w=1}^{n} w_j X_{iw} / \sum_{w=1}^{n} w_j$$

$$Q_{ii'j} = \sum_{w=1}^{n} w_j X_{iw} X_{i'w} / \sum_{w=1}^{n} w_j$$

X_{iw} = the value of the i^{th} weather variable in the w^{th} week, i = 1,2…p, w = 1,2…n

Second model was

$$Y = A_0 + \sum_{i=1}^{p} \sum_{j=0}^{2} a_{ij} Z_{ij}' + \sum_{i \neq i'=1}^{p} \sum_{j=0}^{2} b_{ii'j} Q_{ii'j} + ct$$

$$Z_{ij'} = \sum_{w=1}^{n} r^{j}_{iw} X_{iw} / \sum_{w=1}^{n} r^{j}_{iw}$$

$$Q_{ii'j} = \sum_{w=1}^{n} r^{j}_{ii'w} X_{iw} X_{i'w} / \sum_{w=1}^{n} r^{j}_{ii'w}$$

r_{iw} = The correlation coefficient of Y with the i th weather variable in the w th week

$r_{ii'w}$ = The correlation coefficient of Y with the product of the i^{th} and i'^{th} weather variable in the w th week.

Rao (1980) attempted to examine the effects of rainfall and temperature and their interactions on the yield of tossa jute. He used a second-degree orthogonal polynomial of the form

$$Z = A_0 + a_0 (\sum t_i X_i) + b_0 (\sum t_i Y_i) + C_0 (\sum t_i X_i Y_i) + a_1 (\sum t_i' X_i) + b_1 (\sum T_i' Y_i)$$

$$+ C_1 (\sum t_i^{1} X_i Y_i) + a_2 (\sum t_i^{2} X_i) + b_2 (\sum t_i^2 Y_i) + C_2 (\sum t_i^{2} X_i Y_i) + DT$$

where

Z was the fibre yield, X was the average weekly maximum temperature (^{0}C), Y the total weekly rainfall (cm), t the number of the weekly period commencing from germination and T the serial number of the year which was included to correct the trend in yields. The study revealed that about 87 % of the total variation in jute could be explained for the polynomial model.

Agrawal *et al.* (1983) revealed that beneficial effects of above average maximum temperature on rice yield increased with rise in humidity while detrimental effects decreased. Joint effects of maximum temperature and rainfall showed that beneficial effects of above average maximum temperature on yield increased with increase in rainfall while adverse effect decreased in general.

Ajitha (1986) fitted the composite models suggested by Agrawal *et al.* (1980) and obtained significantly higher value of the coefficient of determination for the prediction equations.

2.3. Principal component analysis

Pochop *et al.* (1975) performed principal component analysis using the climatological data, which consisted of 42 variables for eight countries and 45 years. Thirty-one out of the 42 components explained 90 % of the variance in the original data complex and were retained for regression analysis. The regression model accounted for 54 % of the variation in the yield.

Agrawal *et al.* (1980) obtained the principal components of the generated variables and used these in fitting regression models instead of the original weather variables. The regression model could explain 80 per cent of variation in the yield. It was also revealed that forecasting of rice yield was possible by weekly climatic variables, two and a half months after sowing for a crop of five months duration.

Ajitha (1986) performed principal component analysis using the generated variables of the paddy varieties tried in the autumn and winter season and the results indicated that for PTB 1, out of the nine components the first four were able to explain about 86 % of the total variability in the original data. As in the case of PTB 5 the first component alone had explained about 63 % of the total variability. For PTB 12 the first two components had succeeded in explaining 88 % of the total variability.

3.MATERIALS AND METHODS

The data utilized for the present study were collected from the available records of the meteorological observatory of the Aromatic and Medicinal Plants Research Station, Odakkali (10°5' 40" to 10°6' 0" N latitude and 76° 32' 35" to 76° 32' 55" east longitudes located in Ernakulam district of Kerala.

Observations on grass yield and oil yield of the largely cultivated variety OD19 (Sugandhi) were obtained from the comparative yield trials conducted at the station from 1966-1990 each trial lasting for 3-5 years. Daily weather data for the same period were also collected.

The station is situated at an elevation of 60 m above MSL and represents the typical soil and agro climatic features of the mid lands of the state. The mean rainfall is 3318 mm with Southwest monsoon contributing 55.70%, Northeast monsoon 28.8%, summer showers 2.4% and pre-monsoon showers 11.4%. The mean number of rainy days is 166 per annum. The mean maximum and minimum temperature are 32.6° and 20°C respectively. The relative humidity recorded was often as high as 92.2%

Lemongrass is a rain-fed crop, and the grass is harvested at periodic intervals. The first harvest is taken 90 days after transplanting and the subsequent harvest at interval of 45-50 days. The first year of the crop has only three harvests as the sowing is done by the second fortnight of May and the first harvest is taken by September-October and the remaining two harvests in the year at intervals of 45 days. These harvests do not reveal the potential of the crop. Hence harvest data for second year of the crop onwards were only utilized.

The first harvest of the second year of the crop is then taken by first fortnight of May and the subsequent harvests in the interval of 45-50 days. Thus five to six harvests could be obtained for every year. Since sufficient number of observations on yield pertaining to the sixth harvest was not obtained, the yield data for the same was not considered in the present investigation. Prediction models of yield (both grass and oil) using data for five harvests have been attempted.

Age was used as an input variable while fitting the yield prediction models its coefficient was found to be insignificant in all the cases. Hence age did not appear in any of the models estimated.

Daily observations on various climatic variables such as number of rainy days (X_1), total rainfall (mm) (X_2), maximum temperature (°C) (X_3), minimum temperature (°C) (X_4), relative humidity (%) (X_5), were available for the period under report. Averages/Totals of these weather variables pertaining to the standard weeks were used for the investigation.

3.1.Test for the presence of trend

The time series data was first tested for the presence of any upward or downward trend. The bivariate data (t_i, y_i) were plotted graphically and the numbers of peaks or troughs in the series were counted.

A 'peak' is a value, which is greater than the two neighboring values. Likewise a 'trough' is a value, which is lower than its two neighbors. Both peaks and troughs are considered as turning points of the series. The number of turning points is clearly one less than the number of runs up and down in the series. The statistical significance of secular trend is then tested by using the Z statistic given by

$$t = [n-E(n)]/[SE(n)]$$

where n = Observed number of turning points in the data.

$E(n) = 2(N-2)/3$, $S.E.(n) = \sqrt{[(16N-29)/90]}$ where N being total number of observations, t is expected to follow the student's t distribution with (n-1) degrees of freedom. If the value of t is not significant at pre-assigned level of probability then the conclusion is that there is no long-term trend in the series.

3.2. Weekly and Fortnightly Correlations between yield and various weather parameters

Coefficients of correlation of weather variables and their logarithms pertaining to six weeks immediately preceding the harvest with grass yield and oil yield were worked out. Further coefficients of correlation of logarithms of weather variables with logarithms of grass and oil yield were also worked out.

Similarly coefficients of correlation of yield of each harvest with weather variables and their logarithms corresponding to three fortnights immediately preceding the harvests were worked out to assess the influence weather variables at varying growth periods in the grass and oil yields of the crop.

A class of multiple linear regression equations were fitted for making fortnightly yield forecasts based on fortnightly weather data and the adequacy of the fitted models were determined on the basis of the relative values of the adjusted coefficient of determination (R^2).

3.3. Multiple linear regression analysis

The technique of multiple linear regression deals with the problem of predicting a 'dependent variable' Y from a set of p 'independent variables' $x_1, x_2, \ldots x_p$, $p > 1$. The functional form of the multiple linear regression is given by,

$Y_1 = \beta_0 + \beta_1 X_{1i} + \ldots + \beta_p X_{pi} + ct + e_i$ where β_0 is a constant, β_i's are partial regression coefficients of Y on X_i. The error term e_i is assumed to follow a normal distribution with mean '0' and constant variance σ^2. The term 'ct' is the correction for trend if it is present in yield data. 'c' is a constant and 't' is the year number included for the correction. The term 'linear' refers to linearity in the parameters and not in the independent variables. The independent variables x_i need not always be statistically independent but are expected to be measured without error. The parameters $\beta_0, \beta_1 \ldots \beta_p$ are estimated by the principle of ordinary least squares.

Two stage regression models were developed for each harvest for each week pwh. While first stage models were developed using weather variables pertaining to each week. Predicted values of first stage model obtained for each week were further used as explanatory variables to develop two stage regression models. Predicted values of the previous weeks were also used in the current week while obtaining models.

The following models were attempted to obtain two-stage models for various orders of harvest:

(1) Model I: $Y = b_0 + \Sigma\, b_i X_i$, Y = Yield, X_i = Weather variables, i = 1,2,3,4,5

(2) Model II: $Y = \Sigma\, b_i X_i + \Sigma\, b_i' \log X_i$

(3) Model III: $\log Y = b_0 + \Sigma\, b_i \log X_i$

In addition to the above three models, Model IV was also used to develop fortnightly prediction models for various orders of harvest, where Model IV is given as:

(4) Model IV:

$$Y = A_0 + \sum_{i=1}^{p} \sum_{j=0}^{2} a_{ij} Z_{ij}' + \sum_{i \neq i'=1}^{p} \sum_{j=0}^{2} b_{ii'j} Q_{ii'j} + ct$$

where

$$Z_{ij'} = \sum_{w=1}^{n} r_{iw}^{\,j} X_{iw} \Big/ \sum_{w=1}^{n} r_{iw}^{\,j}$$

$$Q_{ii'j} = \sum_{w=1}^{n} r^{j}_{ii'w} X_{iw} X_{i'w} \Big/ \sum_{w=1}^{n} r^{j}_{ii'w}$$

r_{iw} = The correlation coefficient of Y with the i th weather variable in the w th week

$r_{ii'w}$ = The correlation coefficient of Y with the product of the i^{th} and i'^{th} weather variable in the w th week.

Explanatory variables of the models obtained for previous fortnights were also considered while developing models for current fortnight.

Stepwise Regression Procedure

This procedure starts with single explanatory variable in the regression. The first variable included in the equation is the one, which has the highest simple correlation with the dependent variable Y. If the regression coefficient of this variable with Y is significantly different from zero it is retained in the regression, and a search for a second variable is made. The variable that enters the regression as the second variable is the one, which has the highest partial correlation with y, after y has been adjusted for the effect of the first variable, that is, the variable with the highest simple correlation coefficient with the residuals from step1. The significance of the regression coefficient of the second variable is then tested. If regression coefficient is significant, it is retained in the regression and a search for a third variable is made in the same way. The procedure is terminated when no regression coefficient of any of the remaining variables is significant.

In the present study fortnightly prediction models were fitted to predict grass as well as oil yield using stepwise regression procedure.

3.4. Principal component analysis

The problem of multicollinearity is inevitable in multivariate situation i.e. there may be substantial inter-correlations among the original explanatory variables, which make the problem difficult to comprehend. Principal component analysis is a powerful method used in such situations which aims at explaining the relationship among numerous correlated variables in terms of a relatively few uncorrelated generated variables commonly called as components or factors. Hence it is possible to find a dependence structure, which carries approximately the same amount of information expressed by the original variables. In effect principal component analysis consists in transforming a set of observed characters X_1, X_2...X_p into a new set of composite characters Y_1, Y_2, ...Y_p which have certain unique properties.

Principal component analysis was initially described by Pearson (1901) and further developed by Hotelling (1933). Weights are assigned to each variable so that the resulting composite variable as a set may have maximum variance.

In the present study principal component analysis was performed using the dispersion matrix. Further prediction models were fitted to predict both grass and oil yield using those principal components that explained maximum variation.

Results

Table.1.'t'values obtained to test presence of trend in grass yield

Orders of Harvest	Number of turning points	't' value
1	10	0.40
2	11	0.20
3	12	0.79
4	10	0.40
5	9	0.99

4. RESULT

Influence of various weather elements during the growing period of lemongrass on grass yield and oil yield was studied using the procedures described in Chapter 3. The coefficients of correlation of yield (grass yield and oil yield) with weather elements of growing period as well as the prediction models developed to forecast grass yield and oil yield at various stages of the crop are presented in this Chapter.

4.1. Test for trend:

The details of the 't' statistic computed for various orders of harvest to test the presence of trend in both grass yield and oil yield data are given in Table.1 and 2 respectively. None of the 't' values were found to be statistically significant indicating that there was no trend in the series of both grass and oil yield data for the various harvests. Hence a term corresponding to trend was not included in the regression models.

4.2. Grass Yield:

4.2.1. First Harvest (During first fortnight of May):

Coefficients of correlation of five weather variables and their logarithms during the six weeks of growing period of the crop with the relevant grass yield of various orders of harvest are presented in Table 3. It could be noted that for the first harvest, number of rainy days (X_1), one, three and four weeks prior to the week of harvest (pwh) and total rainfall (X_2) along with its logarithm one week pwh had a significant positive correlation with grass yield.

Table.1.'t'values obtained to test presence of trend in grass yield

Orders of Harvest	Number of turning points	't' value
1	10	0.40
2	11	0.20
3	12	0.79
4	10	0.40
5	9	0.99

Table. 2. 't' values obtained to test presence of trend in oil yield

Orders of Harvest	Number of turning points	't' value
1	9	0.99
2	10	0.40
3	11	0.20
4	11	0.20
5	12	0.79

Further, coefficients of correlation of logarithms of weather variables pertaining to the six weeks pwh with logarithm of grass yield (Table 4) for various orders of harvest revealed that, for the first harvest, logarithm of number of rainy days (L_1) three weeks pwh and logarithm of total rainfall (L_2) one-week pwh had a significant positive correlation with logarithm of grass yield.

4.2.1.1. Two stage Regression Models:

First stage models estimated for each order of harvest using weather variables pertaining to each of the six weeks of growing period using Model I are provided in Table 5. Prediction models along with the coefficient of determination (R^2) and adjusted coefficient of determination ($\bar{R}^2$) are given in these tables. Two stage models developed are presented in Table 6. Model obtained for sixth week pwh had a predictability of 48 % ($\bar{R}^2$ = 0.45). By the fifth week pwh, predictability of the model obtained had gone upto 52 % ($\bar{R}^2$ = 0.46). Predicted values of fifth (P_5) and sixth (P_6) week's pwh were the explanatory variables of this model. On the other hand, model obtained for fourth week pwh had a coefficient of determination of 0.58 ($\bar{R}^2$ = 0.53). The independent variables of the model being predicted values of fourth (P_4) and sixth (P_6) week's pwh. Models obtained for both second and third week pwh had a predictability of 68% ($\bar{R}^2$ = 0.61). The independent variables in the model were predicted values of fourth (P_4), fifth (P_5) and sixth (P_6) week's pwh. Two-stage model one-week pwh was found to have maximum predictability of 75% ($\bar{R}^2$ = 0.67). Predicted values of first (P_1), third (P_3), fourth (P_4) and sixth (P_6) week's pwh were the explanatory variables of this model.

Table 3. Coefficients of correlation of weather variables and their logarithms pertaining to six weeks with grass yield for various orders of harvest

Order of Harvest	Week No.	X_1	X_2	X_3	X_4	X_5	L_1	L_2	L_3	L_4	L_5
1	1	0.606**	0.469*	0.403	0.038	0.016	-0.272	0.520*	0. 406	0. 031	0.007
	2	0.299	0.355	0.067	-0.208	-0.120	0.338	0.118	0. 074	-0. 213	-0.123
	3	0.299	0.142	-0.153	-0.330	0.055	0.394	-0.003	-0.158	-0. 332	0.055
	4	0.494*	0.183	0.082	-0.338	0.195	0.438	0.277	0. 085	-0. 342	0.192
	5	-0.064	-0.204	-0.314	0.350	0.017	-0.278	-0.097	-0. 084	-0. 051	-0.222
	6	-0.253	0.388	0.107	-0.149	-0.012	0.320	-0.232	-0. 295	-0. 242	0.392
2	1	0.158	0.556*	-0.459	0.431	-0.143	0.079	0.561*	-0. 453	0 .418	-0.157
	2	0.168	0.135	0.415	0.490*	-0.226	0.097	0.131	0. 382	0. 476*	-0.280
	3	-0.211	0.165	-0.165	0.362	-0.402	-0.150	0. 303	-0. 153	0. 347	-0.415
	4	-0.291	0.335	-0.103	0.510*	-0.302	-0.294	0. 122	-0. 098	0.502*	-0.306
	5	0.556*	0.033	0.012	0.364	-0.462	0.548*	0. 273	0. 008	0. 358	-0.468*
	6	0.199	-0.353	0.048	0.404	-0.246	0.011	0. 075	0. 042	0. 407	-0.239
3	1	0.484*	-0.004	-0.060	-0.489	0.131	0.049	0.509*	0. 439	0. 498*	-0.004
	2	0.122	-0.426	0.340	-0.272	0.115	-0.355	0.218	0. 049	0. 137	-0.414
	3	0.047	-0.583*	0.284	-0.026	-0.063	0.301	-0.376	0. 295	0. 016	-0.070
	4	0.409	0.073	-0.385	-0.201	-0.001	0.430	0.198	-0. 382	-0. 198	-0.003
	5	-0.563*	-0.011	0.109	-0.034	0.111	-0.549*	0.030	0. 112	-0. 040	0.101
	6	-0.472*	-0.297	0.179	-0.333	0.503*	-0.555*	-0.445	-0. 518*	-0. 404	-0.289
4	1	-0.175	-0.100	0.308	-0.814**	0.360	-0.249	-0.267	0. 301	-0.815**	0.364
	2	0.397	0.339	-0.018	-0.769**	0.403	-0.076	0.287	-0. 019	-0.767**	0.400
	3	0.447	0.378	-0.150	-0.753**	0.292	0.106	0.474	-0. 148	-0.754**	0.286
	4	0.001	0.163	0.221	-0.836**	0.487*	-0.201	0.138	0. 216	-0.833**	0.483*
	5	-0.095	-0.258	0.282	-0.641**	0.292	-0.010	-0.261	0. 285	-0.644**	0.288
	6	-0.059	0.130	0.341	-0.798**	0.189	0.259	0.141	0. 340	-0.800**	0.189
5	1	- 0.239	-0.379	0.635**	-0.718**	-0.090	-0.122	-0.521*	0. 633**	-0.698**	-0.094
	2	- 0.135	0.013	0.495*	-0.755**	0.163	-0.010	0.028	0. 487*	-0.744**	0.165
	3	0.347	0.343	0.403	-0.748**	0.237	0.009	0.115	0. 403	-0.737**	0.241
	4	- 0.232	-0.124	0.388	-0.822**	0.141	0.204	-0.218	0. 376	-0.817**	0.140
	5	- 0.039	0.073	0.397	-0.740**	0.213	-0.058	0.068	0. 397	-0.714**	0.212
	6	0.351	0.105	0.489*	-0.791**	0.161	0.425	0.009	0. 496*	-0.785**	0.164

* Significant at 5% level

** Significant at 1% level

Table.4. Coefficients of correlation between logarithms of weekly weather variables and logarithm of grass yield

Orders of harvest	No. of weeks pwh	L_1	L_2	L_3	L_4	L_5
1	1	0. 330	0. 603**	0. 412	0. 007	0.029
	2	0. 391	0. 348	0. 041	-0. 210	-0.162
	3	0.475*	- 0. 028	-0. 159	-0. 370	0.033
	4	0.400	0. 264	0. 090	-0. 340	0.156
	5	0. 081	0. 031	-0. 308	-0. 349	0.070
	6	-0.140	0. 269	0. 072	-0. 176	-0.048
2	1	0. 092	0.570*	-0. 470*	0. 380	-0.013
	2	0. 113	0.017	0. 310	0.430**	-0.240
	3	-0. 170	0.340	-0. 200	0. 300	-0. 380
	4	-0. 294	0.150	-0.120	0. 470**	-0.290
	5	0. 548*	0. 300	-0 .010	0. 340	-0. 450
	6	0. 014	0. 090	-0. 020	0. 390	-0. 270
3	1	-0. 280	0. 360	-0. 087	-0. 498*	0. 112
	2	0. 229	-0. 380	0. 346	-0. 261	0. 079
	3	-0. 247	-0. 386	0. 292	0. 024	-0. 086
	4	0. 439	0.199	-0. 379	-0. 197	-0. 009
	5	-0. 551*	0. 034	0. 108	-0. 024	0. 088
	6	-0. 474*	-0. 026	0. 184	-0. 249	0. 389
4	1	-0. 240	-0. 227	0. 291	-0. 844**	0. 386
	2	0. 216	0. 239	0. 002	-0. 808**	0. 399
	3	0. 189	0. 471*	-0. 061	-0. 732**	0. 228
	4	-0. 176	0. 105	0. 236	-0. 823**	0. 455**
	5	-0. 095	-0. 342	0. 344	-0. 589**	0. 255
	6	0. 192	0. 180	0. 340	-0. 800**	0. 189
5	1	-0.161	-0.503*	0.610**	-0.733**	-0.100
	2	0. 009	0. 087	0.449	-0.766**	0.225
	3	-0.108	0.125	0.406	-0.746**	0.295
	4	0.136	-0.230	0.328	-0.871**	0.203
	5	-0.024	0.096	0.351	-0.756**	0.260
	6	0.391	-0. 039	0.533*	-0.837**	0.167

Table. 5. First stage regression models for grass yield of various orders of harvest using Model I for six weeks pwh

Orders of harvest	No. of weeks pwh	Prediction Model	R^2	$\bar{R}^2$
I	1	$Y = 307.89 + 470.47 X_1^{*} + 512.97 X_3 - 118.99 X_5$	0.51^{*}	0.40
	2	$Y = 3533.09 + 6.17 X_2$	0.13	0.07
	3	$Y = 19189.08 - 381.41 X_4 + 238.40 X_1 - 275.96 X_3$	0.24	0. 07
	4	$Y = 16059.20 + 410.91 X_1^{*} - 589.82 X_4$	0.40^{*}	0.32
	5	$Y = 17308.31 - 547.44 X_4^{*} - 22.94 X_2$	0.27	0.17
	6	$Y = -2271.48 + 22.23 X_2^{*} - 587.85 X_1^{*} - 415.59 X_4 + 640.62 X_3$	0.48	0.32
2	1	$Y = -13469.18 + 11.76 X_2 + 606.86 X_4 + 132.76 X_5 - 292.61 X_1 - 200.49 X_3$	0.73^{**}	0.66
	2	$Y = -1985.72 + 334.94 X_4^{*} + 6.81 X_2$	0.35^{*}	0.26
	3	$Y = 7674.49 - 92.21 X_5 + 7.53 X_2^{*} + 265.01 X_4$	0.39	0.26
	4	$Y = -13443.35 + 474.93 X_4^{**} + 11.01 X_2^{*} + 300.22 X_3 - 236.89 X_1$	0.58^{*}	0.45
	5	$Y = 15313.05 + 295.29 X_1^{*} - 119.40 X_5$	0.45^{*}	0.37
	6	$Y = -1985.83 + 316.01 X_4 + 193.13 X_1$	0.23	0.13
3	1	$Y = 7789.84 + 420.62 X_1^{*} - 6.25 X_2$	0.27	0.18
	2	$Y = 7612.23 - 14.32 X_2^{**} + 617.01 X_1^{*}$	0.56^{**}	0.50
	3	$Y = -1506.13 - 11391 X_2^{**} + 492.21 X_1^{*} + 368.69 X_3$	0.57^{**}	0.47
	4	$Y = 30483.22 + 729.86 X_1^{**} - 11.22 X_2^{*} - 485.57 X_4 - 135.73 X_5$	0.46	0.30
	5	$Y = 6491.26 - 652.43 X_1^{*} + 69.88 X_5$	0.37^{*}	0.28
	6	$Y = 20932.39 - 402.52 X_1^{*} - 436.32 X_4$	0.33	0.24
4	1	$Y = 28177.09 - 1539.49 X_4^{**} + 870.70 X_1^{*} - 21.97 X_2^{*} + 149.84 X_5$	0.80^{**}	0.74
	2	$Y = 46302.01 - 1345.05 X_4^{**} - 282.67 X_3$	0.63^{**}	0.58
	3	$Y = 30002.11 - 959.10 X_4^{**}$	0.57^{**}	0.54
	4	$Y = 27228.55 - 1211.35 X_4^{**} + 102.16 X_5$	0.72^{**}	0.69
	5	$Y = 46939.15 - 1659.39 X_4^{**} + 572.52 X_3 - 187.32 X_5$	0.59^{**}	0.50
	6	$Y = 61215.31 - 1824.61 X_4^{**} + 437.23 X_3^{*} - 256.79 X_5^{*}$	0.84^{**}	0.80
5	1	$Y = 105.26 - 436.94 X_4^{*} + 313.89 X_3 + 50.43 X_5$	0.60^{**}	0.51
	2	$Y = 19495.16 - 684.89 X_4^{**}$	0.57^{**}	0.54
	3	$Y = 17796.57 - 620.68 X_4^{**} + 18.22 X_2^{*}$	0.68^{**}	0.63
	4	$Y = 23912.36 - 847.59 X_4^{**} - 341.09 X_1^{**} + 8.61 X_2$	0.73^{**}	0.68
	5	$Y = -2130.31 - 611.13 X_4^{**} + 129.73 X_5^{*} + 310.20 X_3$	0.71^{**}	0.65
	6	$Y = 46840.33 - 1384.01 X_4^{**} - 380.99 X_3 + 207.99 X_1$	0.72^{**}	0.66

Table 6. Two stage regression models for grass yield using Model I for six weeks pwh

Orders of harvest	No. of weeks pwh	Prediction Model	R^2	$\bar{R}^2$
1	1	$Y = -3769.43 + 0.52\ P_1 + 0.66\ P_3 + 0.44 P_6 + 0.30\ P_4$	0.75^{**}	0.67
	2	$Y = -3371.21 + 0.76\ P_6^{**} + 0.68\ P_3 + 0.38\ P_4$	0.68^{**}	0.62
	3	$Y = -3371.21 + 0.76\ P_6^{**} + 0.68\ P_3 + 0.38\ P_4$	0.68^{**}	0.62
	4	$Y = -1292.32 + 0.73\ P_6^{*} + 0.59\ P_4$	0.58^{**}	0.53
	5	$Y = -1113.29 + 0.84\ P_6^{*} + 0.43\ P_5$	0.52^{**}	0.46
	6	$Y = P_6^{**}$	0.48^{**}	0.45
2	1	$Y = -1737.64 + 0.83\ P_1^{**} + 0.44\ P_5^{*}$	0.82^{**}	0.80
	2	$Y = -1598.84 + 0.74\ P_4 + 0.50\ P_5$	0.65^{**}	0.60
	3	$Y = -1598.84 + 0.74\ P_4 + 0.50\ P_5$	0.65^{**}	0.60
	4	$Y = -1598.84 + 0.74\ P_4 + 0.50\ P_5$	0.65^{**}	0.60
	5	$Y = P_5$	0.45^{**}	0.41
	6	$Y = P_6$	0.23^{*}	0.18
3	1	$Y = -4951.26 + 0.44\ P_3 + 0.65\ P_2^{**} + 0.44\ P_4$	0.82^{**}	0.78
	2	$Y = -4951.26 + 0.44\ P_3 + 0.65\ P_2^{**} + 0.44\ P_4$	0.82^{**}	0.78
	3	$Y = -5965.71 + 0.68\ P_3^{*} + 0.60\ P_6 + 0.37\ P_5$	0.72^{**}	0.66
	4	$Y = -6162.38 + 0.55 P_4 + 0.59\ P_5 + 0.53\ P_6$	0.65^{**}	0.57
	5	$Y = -5368.42 + 0.81\ P_5^{*} + 0.78\ P_6^{*}$	0.55^{**}	0.49
	6	$Y = P_6$	0.33^{*}	0.29
4	1	$Y = -1358.77 + 0.56\ P_6^{**} + 0.38\ P_1 + 0.24\ P_3$	0.91^{**}	0.89
	2	$Y = -907.09 + 0.69\ P_6 + 0.42\ P_4$	0.89^{**}	0.87
	3	$Y = -907.09 + 0.69\ P_6 + 0.42\ P_4$	0.89^{**}	0.87
	4	$Y = -907.09 + 0.69\ P_6 + 0.42\ P_4$	0.89^{**}	0.87
	5	$Y = P_6^{**}$	0.84^{**}	0.83
	6	$Y = P_6^{**}$	0.84^{**}	0.83
5	1	$Y = -326.85 + 0.57\ P_4 + 0.49\ P_6$	0.78^{**}	0.75
	2	$Y = -326.85 + 0.57\ P_4 + 0.49\ P_6$	0.78^{**}	0.75
	3	$Y = -326.85 + 0.57\ P_4 + 0.49\ P_6$	0.78^{**}	0.75
	4	$Y = -326.85 + 0.57\ P_4 + 0.49\ P_6$	0.78^{**}	0.75
	5	$Y = -264.31 + 0.54\ P_6 + 0.52\ P_5$	0.76^{**}	0.73
	6	$Y = P_6^{**}$	0.72^{**}	0.70

The first-stage models developed using Model II are given in Table 7 and two-stage models in Table 8. It could be noted that, prediction model obtained for the sixth week pwh using predicted values of the same week (P_6) as independent variable, had a coefficient of determination as high as 73% ($\bar{R}^2 = 0.71$). The prediction model obtained for the fourth and fifth weeks pwh had a predictability of 77% ($\bar{R}^2 = 0.74$). Predicted values of fifth (P_5) and sixth (P_6) weeks were the independent variables of this prediction model. In the case of third week pwh, the predictability was about 81% ($\bar{R}^2 = 0.79$), the predictors of the model were the predicted values of third (P_3) and sixth (P_6) week pwh. In the case of second week pwh, the model with independent variables as predicted values of second (P_2), third (P_3) and sixth (P_6) week pwh had a coefficient of determination of 0.85 ($\bar{R}^2 = 0.81$). Prediction model for the first week had the maximum predictability of 89 % ($\bar{R}^2 = 0.85$).

First stage models developed for grass yield of first harvest using Model III are provided Table 9 and the corresponding two-stage models in Table 10. Model obtained for sixth week pwh had a very low coefficient of determination of 0.081($\bar{R}^2 = 0.023$). In the fifth week pwh, the coefficient of determination of the model obtained was 0.18 ($\bar{R}^2 = 0.13$). On the other hand, predictability of the model obtained for fourth week pwh was 36 % ($\bar{R}^2 = 0.28$). The explanatory variables of this model being, predicted values of fourth (P_4) and sixth (P_6) weeks pwh. Predictability of the model obtained for third week pwh was found to be 58 % ($\bar{R}^2 = 0.49$). The independent variables of this model being, predicted values of third (P_3) and fourth (P_4) weeks pwh. However, models obtained for second week pwh was same as that obtained for the third week pwh. Among the models

Table.7. First stage regression models for grass yield of various orders of harvest using Model II for six weeks pwh

Orders of harvest	No. of Weeks pwh	Prediction Model	R^2	$\bar{R}^2$
1	1	$Y = 2805968.30 + 259.55 X_1 + 21501.73 L_3 - 1854580 L_5 + 8779.14 X_5 + 547.64 L_2$	0.61^*	0.45
	2	$Y = 11003.73 + 29.61 X_2^{**} - 5971.56 L_2^{**} + 2223.51 L_1$	0.54^*	0.44
	3	$Y = 32657.02 + 9743.31 L_1 - 22219.3 L_4 - 966.78 X_1$	0.35	0.21
	4	$Y = 45118.45 + 410.55 X_1^* - 31310.4 L_4$	0.40^*	0.32
	5	$Y = 9633.35 - 368.72 X_4 - 63.49 X_2^* + 3521.09 L_2$	0.38	0.25
	6	$Y = -634316.12 + 18.89 X_2^* - 790.91 X_1^{**} + 2670.96 L_1 - 11679.42 X_4 + 61989.22 L_3^* + 601874.35 L_4$	0.73^{**}	0.58
2	1	$Y = 766419.66 - 734.93 L_2 + 556.89 X_4^{**} + 10.97 X_2^* + 2658.02 X_5 - 6312.87 L_1 - 280.06 X_3 - 512952 L_5 + 513.52 X_1$	0.84^{**}	0.70
	2	$Y = 945361.74 - 619602.43 L_5 + 3019.00 X_5$	0.33^*	0.24
	3	$Y = 945361.74 - 619602.43 L_5 + 3019.00 X_5$	0.33^*	0.24
	4	$Y = 588560.19 + 11036.55 X_4^* + 16.69 X_2^{**} - 606426.50 L_4^* - 1153.12 L_2^* - 37187.96 L_1^* + 3102.71 X_1^*$	0.80^{**}	0.69
	5	$Y = 53341.41 + 115.22 X_1 - 26090.39 L_5^* + 2598.94 L_2 - 17.88 X_2$	0.54^*	0.40
	6	$Y = -21831.39 + 19446.11 L_4^* + 1132.59 X_1^* - 8147.45 L_1^* + 1440.41 L_2^* - 16.24 X_2^*$	0.72^{**}	0.60
3	1	$Y = 6210.74 + 319.80 X_1 - 15.00 X_2^* + 1652.60 L_2$	0.43^*	0.31
	2	$Y = -1339536.47 - 4.77 X_2 + 594.58 X_1^{**} - 1962.52 L_2^* + 1349600.89 L_3^* - 21513.96 X_3^*$	0.78^{**}	0.69
	3	$Y = -1339536.47 - 4.77 X_2 + 594.58 X_1^{**} - 1962.52 L_2^* + 1349600.89 L_3^* - 21513.96 X_3^*$	0.78^{**}	0.69
	4	$Y = 61271.22 + 7533.07 L_1^{**} - 11.35 X_2^* - 30746.37 L_4 - 151.42 X_5$	0.52^*	0.37
	5	$Y = 3356.64 - 790.65 X_1^{**} + 5943.19 L_2 - 15.39 X_2$	0.46^*	0.34
	6	$Y = 42211.72 - 401.35 X_1^* - 23008.05 L_4$	0.33^*	0.24

Table 7 (Contd.)

4	1	$Y = 108092.04 - 82832.41 L_4^{**} + 209.13 X_1 - 4945.97 L_2^{**} + 173.12 X_5^{*} + 8957.34 L_1$	0.88^{**}	0.82
	2	$Y = -434622.10 - 1407.27 X_4^{**} - 7561.67 X_3 + 474381.65 L_3$	0.66^{**}	0.59
	3	$Y = 77941.64 - 52134.39 L_4^{**} + 816.39 X_1 - 25.15 X_2$	0.67^{**}	0.60
	4	$Y = 34804.13 - 1119.82 X_4^{**} - 1772.64 L_1^{*} + 438.02 L_2$	0.79^{**}	0.74
	5	$Y = 5905760.34 + 162288.56 L_4 - 976593.06 L_3 - 4228740.61 L_5^{*} + 20619.16 X_5^{*} - 32168.46 X_4 + 16158.69 X_3$	0.74^{**}	0.60
	6	$Y = 679539.47 - 101281.97 L_4^{**} + 8486.78 X_3 - 261.65 X_5^{*} - 516655.41 L_3$	0.86^{**}	0.81
5	1	$Y = -131056.92 - 3808.43 X_4 - 1446.52 L_2 + 164508.95 L_4$	0.71^{**}	0.65
	2	$Y = -3035437.61 - 18135.61 X_4^{**} + 900326.13 L_4^{**} - 7693.81 X_5^{**} + 1486891.77 L_5^{**} + 676.27 X_3^{*} - 714.84 L_1 - 1783.84 L_2 + 350.27 X_1$	0.90^{**}	0.81
	3	$Y = 68.25 - 644.61 X_4^{**} + 27.72 X_2^{*} - 699.09 L_2 + 871.41 L_1 + 9490.69 L_5$	0.77^{**}	0.67
	4	$Y = -415394.18 - 9677.18 X_4^{**} + 472080.08 L_4^{**} - 330.58 X_1 + 597.13 L_2$	0.81^{**}	0.76
	5	$Y = -415394.18 - 9677.18 X_4^{**} + 472080.08 L_4^{**} - 330.58 X_1 + 597.13 L_2$	0.81^{**}	0.76
	6	$Y = 25803.57 - 969.92 X_4^{**} + 2204.27 L_1^{*}$	0.75^{**}	0.71

Table.8. Two stage regression models for grass yield using Model II for six weeks pwh

Orders of harvest	No. of weeks pwh	Prediction Model	R^2	$\bar{R}^2$
1	1	$Y = -1627.31 + 0.56\,P_6^{*} + 0.25\,P_3 + 0.58\,P_2 + 0.38\,P_1 - 0.37\,P_4$	0.89^{**}	0.85
	2	$Y = -1877.10 + 0.72\,P_6^{**} + 0.40\,P_3 + 0.34\,P_2$	0.85^{**}	0.81
	3	$Y = -1576.54 + 0.86\,P_6^{**} + 0.52\,P_3^{*}$	0.81^{**}	0.79
	4	$Y = -948.09 + 0.86\,P_6^{**} + 0.37\,P_5$	0.77^{**}	0.74
	5	$Y = P_6^{**}$	0.73^{**}	0.71
	6	$Y = P_6^{**}$	0.48^{**}	0.45
2	1	$Y = -1178.51 + 0.47\,P_1^{**} + 0.38\,P_6^{*} + 0.33\,P_4$	0.93^{**}	0.92
	2	$Y = -1068 + 0.66\,P_4^{**} + 0.50\,P_6^{**}$	0.89^{**}	0.87
	3	$Y = -1068 + 0.66\,P_4^{**} + 0.50\,P_6^{**}$	0.89^{**}	0.87
	4	$Y = -1068 + 0.66\,P_4^{**} + 0.50\,P_6^{**}$	0.89^{**}	0.87
	5	$Y = P_6^{**}$	0.72^{**}	0.70
	6	$Y = P_6^{**}$	0.72^{**}	0.70
3	1	$Y = -3633.72 + 0.77\,P_3^{**} + 0.35\,P_5 + 0.28\,P_6$	0.85^{**}	0.82
	2	$Y = -3633.72 + 0.77\,P_3^{**} + 0.35\,P_5 + 0.28\,P_6$	0.85^{**}	0.82
	3	$Y = -3633.72 + 0.77\,P_3^{**} + 0.35\,P_5 + 0.28\,P_6$	0.85^{**}	0.82
	4	$Y = -4876.81 + 0.61\,P_4^{*} + 0.59\,P_5^{*} + 0.33\,P_6$	0.70^{**}	0.63
	5	$Y = -3726.11 + 0.78\,P_5^{*} + 0.62\,P_6$	0.57^{**}	0.51
	6	$Y = P_6^{**}$	0.33	0.29
4	1	$Y = -1358.77 + 0.56\,P_6^{**} + 0.38\,P_1 + 0.24\,P_3$	0.91^{**}	0.89
	2	$Y = -907.09 + 0.69\,P_6 + 0.42\,P_4$	0.89^{**}	0.87
	3	$Y = -907.09 + 0.69\,P_6 + 0.42\,P_4$	0.89^{**}	0.87
	4	$Y = -907.09 + 0.69\,P_6 + 0.42\,P_4$	0.89^{**}	0.87
	5	$Y = P_6^{**}$	0.84^{**}	0.83
	6	$Y = P_6^{**}$	0.84^{**}	0.83
5	1	$Y = -326.85 + 0.57\,P_4 + 0.49\,P_6$	0.78^{**}	0.75
	2	$Y = -326.85 + 0.57\,P_4 + 0.49\,P_6$	0.78^{**}	0.75
	3	$Y = -326.85 + 0.57\,P_4 + 0.49\,P_6$	0.78^{**}	0.75
	4	$Y = -326.85 + 0.57\,P_4 + 0.49\,P_6$	0.78^{**}	0.75
	5	$Y = -264.31 + 0.54\,P_6 + 0.52\,P_5$	0.76^{**}	0.73
	6	$Y = P_6^{**}$	0.72^{**}	0.70

Table.9. First stage regression models for grass yield of various orders of harvest using Model III for six weeks pwh

Orders of harvest	No. of weeks pwh	Prediction model	R^2	$\bar{R}^2$
1	1	$Y = 0.01 + 0.11 L_2^{*} - 0.16 L_1 + 2.45 L_3$	0.56^{**}	0.46
	2	$Y = 3.47 + 0.24 L_1$	0.15	0.10
	3	$Y = 9.62 + 0.34 L_1^{*} - 2.51 L_4 - 1.97 L_3$	0.40	0.27
	4	$Y = 8.21 + 0.30 L_1 - 3.52 L_4$	0.32	0.23
	5	$Y = 8.45 - 1.82 L_4 - 1.67 L_3$	0.18	0.07
	6	$Y = 3.49 + 0.07 L_2$	0.08	0.02
2	1	$Y = - 0.55 + 0.09 L_2^{*} + 1.56 L_4 + 1.06 L_5$	0.49^{*}	0.38
	2	$Y = 2.05 + 1.21 L_4^{*} + 0.06 L_2$	0.30	0.21
	3	$Y = 1.94 - 0.24 L_5 + 0.08 L_2^{*} + 1.59 L_4^{*}$	0.48^{*}	0.36
	4	$Y = 1.70 + 1.59 L_4^{*} - 0.17 L_1 + 0.03 L_2$	0.35	0.21
	5	$Y = 6.80 + 0.14 L_1 - 1.63 L_5 + 0.05 L_2$	0.49^{*}	0.38
	6	$Y = - 0.68 + 1.75 L_4^{*} + 0.06 L_2 + 1.31 L_3$	0.29	0.13
3	1	$Y = 7.07 + 0.05 L_2 - 0.21 L_1 - 1.55 L_5$	0.33	0.19
	2	$Y = 4.11 - 0.20 L_2^{**} + 0.37 L_1^{*}$	0.44^{*}	0.37
	3	$Y = 4.05 - 0.05 L_2$	0.15	0.10
	4	$Y = 5.05 + 0.39 L_1^{*} - 0.15 L_2 - 0.77 L_4$	0.40	0.27
	5	$Y = 4.10 - 0.40 L_1^{**} + 0.07 L_2$	0.38^{*}	0.30
	6	$Y = 1.85 - 0.18 L_1^{*} + 1.14 L_5$	0.32	0.23
4	1	$Y = 64.71 - 41.54 L_3^{*} - 1.88 L_1$	0.26	0.16
	2	$Y = - 18.21 + 15.78 L_4$	0.11	0.06
	3	$Y = - 21.79 + 12.82 L_5$	0.059	0.001
	4	$Y = - 21.79 + 12.82 L_5$	0.059	0.001
	5	$Y = 1.31 + 2.98 L_1^{**}$	0.44^{**}	0.40
	6	$Y = 3.24 - 2.43 L_1^{**} + 1.08 L_2^{**}$	0.89^{**}	0.88
5	1	$Y = 6.46 - 3.35 L_4^{**} - 0.20 L_2^{*} + 0.95 L_5$	0.70^{**}	0.64
	2	$Y = 10.06 - 4.73 L_4^{**} - 0.14 L_1$	0.64^{**}	0.59
	3	$Y = 4.86 - 3.86 L_4^{**} + 2.03 L_5$	0.65^{**}	0.61
	4	$Y = 11.60 - 5.90 L_4^{**}$	0.76^{**}	0.74
	5	$Y = - 5.45 - 3.80 L_4^{**} + 4.65 L_5^{**} + 3.49 L_3^{*} + 0.13 L_1$	0.81^{**}	0.75
	6	$Y = 18.49 - 8.69 L_4^{**} + 0.20 L_1 - 2.14 L_3$	0.82^{**}	0.79

Table. 10. Two stage regression models for grass yield for six weeks pwh using Model III

Orders of Harvest	No. of weeks pwh	Prediction Model	R^2	$\bar{R}^2$
1	1	$Y = -4.61 + 0.65\, P_1^{*} + 0.42\, P_4 + 0.44\, P_3 + 0.77\, P_6$	0.74^{**}	0.65
	2	$Y = -4.55 + 0.80\, P_3^{*} + 0.60\, P_4$	0.58^{**}	0.49
	3	$Y = -4.55 + 0.80\, P_3^{*} + 0.60\, P_4$	0.58^{**}	0.49
	4	$Y = -2.49 + 0.94\, P_4^{*} + 0.74\, P_6$	0.36	0.28
	5	$Y = P_5$	0.18	0.13
	6	$Y = P_6$	0.08	0.02
2	1	$Y = -1.33 + 0.31\, P_5 + 0.55\, P_1 + 0.49\, P_3$	0.65^{**}	0.58
	2	$Y = -1.42 + 0.81\, P_5 + 0.56\, P_2$	0.57^{**}	0.51
	3	$Y = -0.64 + 0.61\, P_5\ 0.56\, P_3$	0.57^{**}	0.51
	4	$Y = -1.13 + 0.82\, P_5^{*} + 0.47\, P_6$	0.54^{**}	0.48
	5	$Y = -1.13 + 0.82\, P_5^{*} + 0.47\, P_6$	0.54^{**}	0.48
	6	$Y = P_6^{**}$	0.29	0.24

Table 10 (Contd.)

3	1	$Y = -3.01 + 0.73 P_2^{**} + 0.70 P_4^{*} + 0.33 P_6$	0.71^{**}	0.65
	2	$Y = -3.01 + 0.73 P_2^{**} + 0.70 P_4^{*} + 0.33 P_6$	0.71^{**}	0.65
	3	$Y = -5.12 + 0.88 P_4^{**} + 0.94 P_3^{*} + 0.45 P_5$	0.67^{**}	0.60
	4	$Y = -2.68 + 0.59 P_4 + 0.59 P_5 + 0.50 P_6$	0.62^{**}	0.54
	5	$Y = -1.82 + 0.76 P_5^{*} + 0.70 P_6$	0.52^{**}	0.45
	6	$Y = P_6^{*}$	0.32^{*}	0.28
4	1	$Y = 0.73 + 1.12 P_6^{**} - 0.35 P_1$	0.91^{**}	0.90
	2	$Y = P_6^{**}$	0.89^{**}	0.88
	3	$Y = P_6^{**}$	0.89^{**}	0.88
	4	$Y = P_6^{**}$	0.89^{**}	0.88
	5	$Y = P_6^{**}$	0.89^{**}	0.88
	6	$Y = P_6^{**}$	0.89^{**}	0.88

Table 10 (Contd.)

5	1	$Y = -0.39 + 0.72\,P_6^{**} + 0.39\,P_1$	0.86^{**}	0.85
	2	$Y = -0.13 + 0.59\,P_6 + 0.45\,P_5$	0.85^{**}	0.82
	3	$Y = -0.13 + 0.59\,P_6 + 0.45\,P_5$	0.85^{**}	0.82
	4	$Y = -0.13 + 0.59\,P_6 + 0.45\,P_5$	0.85^{**}	0.82
	5	$Y = -0.13 + 0.59\,P_6 + 0.45\,P_5$	0.85^{**}	0.82
	6	$Y = P_6^{**}$	0.82^{**}	0.81

for six weeks pwh, maximum predictability was obtained for the model developed for one-week pwh, and the predictability was 74% ($\bar{R}^2 = 0.65$). Predicted values of first (P_1), third (P_3), fourth (P_4) and sixth (P_6) weeks pwh were the explanatory variables of this model.

4.2.1.2. Influence of fortnightly weather variables:

Coefficient of correlation of fortnightly weather variables pertaining to three fortnights pwh and their logarithms with grass yield are presented in Table 11. It could be noted that number of rainy days (X_1) and its logarithm (L_1), pertaining to first and second fortnight pwh had significant positive correlation with grass yield of first harvest. Further, coefficients of correlation of logarithms of weather variables three fortnights pwh with logarithm of grass yield presented in Table 12 revealed that logarithm of number of rainy days (L_1), one fortnight and two fortnights pwh had significant positive correlation with logarithm of grass yield of first harvest.

Models obtained for grass yield based on Model I using fortnightly weather variables are given in Table 13. Yield prediction model for grass yield of first harvest for third fortnight pwh had a predictability of 70% ($\bar{R}^2 = 0.57$). All the weather variables of the corresponding fortnight had entered into the prediction model. Model obtained for second fortnight pwh, had a coefficient of determination of 0.75 ($\bar{R}^2 = 0.70$). Number of rainy days (X_{12}), total rainfall (X_{22}) pertaining to the same fortnight and minimum temperature (X_{43}) of the previous fortnights were the explanatory variables of this model. Maximum predictability among the models fitted for three fortnights was obtained for the

Table.11. Coefficients of correlation of weather variables and their logarithms pertaining to three fortnights pwh with grass yield for various orders of harvest

Orders of harvest	No. of Fortnights	X_1	X_2	X_3	X_4	X_5	L_1	L_2	L_3	L_4	L_5
1	1	0.624**	0.468	0.279	-0.084	-0.037	0.602**	0.165	0.286	-0.091	-0.043
	2	0.522*	0.188	-0.088	-0.284	0.100	0.551*	0.199	-0.093	-0.283	0.108
	3	-0.250	0.121	0.251	-0.383	-0.113	-0.209	0.037	0.262	-0.391	-0.109
2	1	0.173	0.414	0.364	0.470*	-0.213	0.090	0.518*	0.323	0.456	-0.229
	2	-0.285	0.215	-0.250	0.456	-0.370	-0.278	0.269	-0.250	0.451	-0.370
	3	0.496*	0.189	-0.196	0.409	-0.343	0.496*	0.101	-0.201	0.410	-0.344
3	1	0.461	-0.485*	0.188	-0.125	-0.120	0.486*	-0.336	0.177	-0.423	0.176
	2	0.234	-0.411	-0.057	-0.329	0.143	0.182	-0.364	-0.055	-0.335	0.136
	3	-0.597**	-0.161	0.170	-0.306	0.387	-0.575*	-0.104	0.173	-0.315	0.376
4	1	0.186	0.153	0.126	-0.802**	0.390	0.087	-0.034	0.123	-0.801**	0.391
	2	0.319	0.338	0.007	-0.813**	0.421	0.264	0.332	0.004	-0.812**	0.418
	3	-0.090	-0.032	0.328	-0.746**	0.266	0.007	0.035	0.328	-0.747**	0.263
5	1	-0.235	-0.257	0.590**	-0.767**	0.020	0.073	-0.260	0.586*	-0.755**	0.015
	2	0.043	0.025	0.428	-0.810**	0.191	0.429	-0.158	0.422	-0.805**	0.196
	3	0.137	0.110	0.489*	-0.781**	0.245	0.281	-0.014	0.492*	-0.769**	0.245

Table. 12. Coefficients of correlation of logarithm of fortnightly weather variables pertaining to three fortnights pwh with logarithm of grass yield for various orders of harvest

Orders of harvest	No. of Fortnights	L_1	L_2	L_3	L_4	L_5
1	1	0.675**	0.209	0.272	-0.104	-0.067
	2	0.586*	0.197	-0.092	-0.293	0.075
	3	-0.164	0.011	0.274	-0.415	-0.135
2	1	0.104	0.544*	0.253	0.413	-0.194
	2	-0.289	0.265	-0.240	0.421	-0.385
	3	0.496*	0.093	-0.198	0.399	-0.340
3	1	0.492*	-0.425	0.171	-0.124	-0.137
	2	0.167	-0.376	-0.069	-0.326	0.106
	3	-0.568**	-0.129	0.186	-0.302	0.374
4	1	0.125	0.035	0.131	-0.838**	0.404
	2	0.211	0.294	0.071	-0.795**	0.375
	3	-0.009	0.043	0.365	-0.692**	0.223
5	1	0.054	-0.220	0.556*	-0.785**	0.036
	2	0.341	-0.138	0.398	-0.836**	0.264
	3	0.305	-0.031	0.488*	-0.817**	0.269

Table 13. Models obtained for grass yield using Model I for three fortnights pwh

Orders of Harvest	No. of Fortnights	Prediction Model	R^2	$\bar{R}^2$
1	1st Fortnight	$Y = -43640.12 - 111.05 X_{11} + 1035.12 X_{12}^{**} - 101.31 X_{43} - 24.84 X_{22}^{**} + 1050.83 X_{31}^{*} + 125.65 X_{51} + 269.16 X_{41}$	0.87^{**}	0.77
	2nd Fortnight	$Y = 10588.62 + 733.27 X_{12}^{**} - 18.48 X_{22}^{**} - 409.23 X_{43}^{**}$	0.75^{**}	0.70
	3rd Fortnight	$Y = 28127.26 - 488.06 X_{43}^{**} - 537.56 X_{13}^{**} - 195.48 X_{53}^{**} + 22.91 X_{23}^{**} + 230 X_{33}$	0.70^{**}	0.57
2	1st Fortnight	$Y = 7701.217 + 215.381 X_{11}^{**} + 5.55 X_{21}^{**} + 239.97 X_{41} - 371.016 X_{32}$	0.74^{**}	0.66
	2nd Fortnight	$Y = 7028.411 + 225.58 X_{13}^{*} + 354.97 X_{42} - 395.30 X_{32}$	0.49^{*}	0.38
	3rd Fortnight	$Y = -6981.69 + 202.62 X_{13}^{*} + 515.33 X_{43}$	0.40^{*}	0.32
3	1st Fortnight	$Y = -910.52 - 229.55 X_{11}^{**} + 199.62 X_{53}^{*} - 807.94 X_{32}^{**} - 10.27 X_{21}^{**} + 226.93 X_{11}^{**} + 263.08 X_{51}^{**} + 1.13 X_{22}$	0.96^{**}	0.93
	2nd Fortnight	$Y = -23856.24 - 288.19 X_{13}^{**} + 94.01 X_{53} - 284.40 X_{32} - 581.99 X_{43}^{*} + 184.16 X_{12}^{*} - 3.43 X_{22}$	0.86^{**}	0.78
	3rd Fortnight	$Y = 8481.64 - 366.68 X_{13}^{**} + 130.45 X_{53} - 322.49 X_{43}$	0.67^{**}	0.60
4	1st Fortnight	$Y = 79645.05 - 422.53 X_{42} + 40.79 X_{11} - 1038.54 X_{43}^{*} - 446.92 X_{53}^{**} - 656.83 X_{41}^{*} + 192.43 X_{52}^{*}$	0.94^{**}	0.90
	2nd Fortnight	$Y = 70857.94 - 669.92 X_{42}^{**} - 1328.92 X_{43}^{**} - 449.70 X_{53}^{**} + 180.11 X_{52} + 284.23 X_{33}$	0.91^{**}	0.86
	3rd Fortnight	$Y = 77170.69 - 2169.27 X_{43}^{**} - 356.05 X_{53}^{*} + 469.91 X_{33}^{*}$	0.80^{**}	0.76
5	1st Fortnight	$Y = 17891.48 - 863.03 X_{42} - 16.45 X_{21}^{*} - 603.01 X_{43} + 84.56 X_{53} + 575.87 X_{41}$	0.79^{**}	0.70
	2nd Fortnight	$Y = 23763.92 - 517.42 X_{42} - 338.51 X_{43}$	0.68^{**}	0.64
	3rd Fortnight	$Y = 15939.84 - 850.15 X_{43}^{**} + 89.28 X_{53}$	0.67^{**}	0.62

prediction model developed for first fortnight pwh. The model with independent variables viz. number of rainy days (X_{11}), (X_{12}), pertaining to the first and second fortnight respectively, minimum temperature (X_{41}), (X_{43}) pertaining to the first fortnight and third fortnight respectively, total rainfall pertaining to the second fortnight (X_{22}), maximum temperature (X_{31}) and relative humidity (X_{51}) pertaining to first fortnight, had a coefficient of determination of 0.87 ($\bar{R}^2$ = 0. 77).

Models obtained for the three fortnights pwh, based on Model II are presented in Table 14. Prediction model for the third fortnight pwh had the predictors namely total rainfall (X_{23}), relative humidity (X_{53}), logarithms of number of rainy days (L_{13}), maximum temperature (L_{33}) and minimum temperature (L_{43}), pertaining to the same fortnight. The predictability of the model was 71% ($\bar{R}^2$ = 0.58). However a predictability of 75% ($\bar{R}^2$ = 0.68) was obtained for the model developed for second fortnight pwh. The independent variables of the model comprised of number of rainy days (X_{12}) and its logarithm (L_{12}), minimum temperature (X_{42}), pertaining to the second fortnight pwh and logarithm of minimum temperature (L_{43}) of the third fortnight pwh. Model developed for first fortnight pwh had the maximum predictability of 76% ($\bar{R}^2$ = 0.65). Number of rainy days (X_{11}), total rainfall (X_{21}), and its logarithm (L_{21}) pertaining to the first fortnight, number of rainy days (X_{12}) and its logarithm (L_{12}) pertaining to the second fortnight pwh were the explanatory variables.

Models for grass yield based on Model III, for the three fortnights pwh are presented in Table 15. The model for third fortnight pwh contained logarithms of all the

Table.14. Models obtained for grass yield using Model II for three fortnights pwh

Orders of harvest	No. of Fortnights	Prediction Model	R^2	$\bar{R}^2$
1	1 st Fortnight	$Y = 4716.06 - 267.42\,X_{11} + 9562.31\,L_{12} - 4086.20\,L_{21}^{**} + 16.96\,X_{21}^{*} - 618.76\,X_{12}$	0.76^{**}	0.65
	2 nd Fortnight	$Y = 34779.98 - 4071.40\,L_{12} - 23531.52\,L_{43}^{**} - 19.93\,X_{42}^{*} + 1004.40\,X_{12}$	0.75^{**}	0.68
	3 rd Fortnight	$Y = 50561.93 - 32257.46\,L_{43}^{**} - 208.85\,X_{53}^{**} - 8733.51\,L_{13}^{**} + 22.44\,X_{23}^{**} + 14862.24\,L_{33}$	0.71^{**}	0.58
2	1 st Fortnight	$Y = 1242774.60 + 2190.44\,L_{21}^{**} + 299.78\,X_{41} - 12.49\,X_{13} + 272.56\,X_{11} + 4352.78\,X_{51}^{**} - 845196.27\,L_{51}^{*} + 4.30\,X_{23}^{*} + 648.46\,X_{43}^{*} - 7006.79\,L_{11}^{*}$	0.95^{**}	0.88
	2 nd Fortnight	$Y = 7028.411 + 225.587\,X_{13}^{*} + 354.973\,X_{42} - 395.30\,X_{32}$	0.49^{*}	0.38
	3 rd Fortnight	$Y = -10498.78 + 208.10\,X_{13}^{*} + 627.29\,X_{43}^{*} + 3.07\,X_{23}$	0.51^{*}	0.40
3	1 st Fortnight	$Y = 85350.73 - 286.46\,X_{13}^{*} - 5.29\,X_{21} + 942.80\,X_{11} - 14487.62\,L_{22}^{**} + 5737.63\,L_{12}^{**} + 18.44\,X_{22}^{**} - 29379.69\,L_{43}^{*} - 17948.43\,L_{11}$	0.88^{**}	0.78
	2 nd Fortnight	$Y = 107475.96 - 279.95\,X_{13}^{*} - 37021.14\,L_{43} - 271.65\,X_{42} + 7779.83\,L_{12}^{**} - 13685.60\,L_{22}^{**} + 14.50\,X_{22}^{*} - 195.65\,X_{52}$	0.87^{**}	0.77
	3 rd Fortnight	$Y = 45587.58 - 375.70\,X_{13}^{**} - 24033.37\,L_{43}$	0.48^{**}	0.41
4	1 st Fortnight	$Y = 4332774.36 - 165.31\,X_{41} - 3.47\,X_{13} - 60286.30\,L_{43}^{**} - 2765336.99\,L_{53}^{**} - 1017.88\,X_{41}^{**} + 13199.47\,X_{53}^{**}$	0.96^{**}	0.94
	2 nd Fortnight	$Y = 721853.40 - 484.92\,X_{42}^{*} + 191683.02\,L_{43} - 90273.71\,L_{53}^{**} + 1695.48\,L_{12}^{*} - 5473.53\,X_{43} + 10447.10\,X_{13} - 659919.95\,L_{13}$	0.94^{**}	0.89
	3 rd Fortnight	$Y = 6276832 + 325418.02\,L_{43} - 3511791.69\,L_{53}^{*} + 19025.21\,X_{33}^{*} - 1177949.61\,L_{33}^{*} + 16783.62\,X_{53}^{*} - 8207.17\,X_{43}$	0.90^{**}	0.84
5	1 st Fortnight	$Y = 41967 - 987.75\,X_{42} - 654.52\,L_{21} + 1580.62\,L_{12}^{*} - 610.82\,X_{43} - 399.81\,X_{31} - 13.93\,X_{21} + 496.12\,X_{41}$	0.88^{**}	0.80
	2 nd Fortnight	$Y = -851103.57 + 357.21\,X_{42} + 1966.83\,L_{12}^{*} - 18680.77\,X_{43}^{**} + 938090.89\,L_{43}^{*} - 176.96\,X_{12}^{*}$	0.85^{**}	0.78
	3 rd Fortnight	$Y = -624992.81 - 13918.31\,X_{43}^{**} + 697675.22\,L_{43}^{*}$	0.74^{**}	0.71

Table.15. Models obtained for grass yield using Model III for three fortnights pwh

Orders of harvest	No. of Fortnights	Prediction Model	R^2	$\bar{R}^2$
1	1 st Fortnight	$Y = -1.43 + 0.07 L_{11} - 0.02 L_{43} + 0.08 L_{12}^{**} - 0.001 L_{22}^{**} + 3.59 L_{31}$	0.81^{**}	0.72
	2 nd Fortnight	$Y = 1057 + 0.49 L^{**} - 1.75 L_{43} - 2.41 L_{52} - 0.08 L_{22}$	0.62^{**}	0.51
	3 rd Fortnight	$Y = 6.50 + 0.96 L_{13} - 2.44 L_{43} - 0.18 L_{23}$	0.64^{**}	0.56
2	1 st Fortnight	$Y = -1.63 + 0.22 L_{21}^{**} + 1.82 L_{41}^{*} + 0.13 L_{13} - 0.15 L_{11} + 1.24 L_{51}$	0.79^{**}	0.71
	2 nd Fortnight	$Y = 10.99 + 0.22 L_{11} + 0.61 L_{42} + 0.32 L_{22} - 2.94 L_{52} - 0.33 L_{12} - 2.14 L_{43}$	0.59	0.37
	3 rd Fortnight	$Y = 1.48 + 1.71 L_{43}$	0.18	0.13
3	1 st Fortnight	$Y = 2.84 - 0.18 L_{13} - 0.64 L_{53} + 0.08 L_{11} - 0.08 L_{21} - 0.27 L_{22}^{**} + 0.31 L_{12} + 2.122 L_{31}^{*}$	0.87^{**}	0.78
	2 nd Fortnight	$Y = 12.10 - 0.15 L_{13} - 0.07 L_{53} - 0.27 L_{22}^{**} + 0.36 L_{12}^{**} - 2.11 L_{42} - 2.38 L_{52}$	0.77^{**}	0.64
	3 rd Fortnight	$Y = 2.05 - 0.38 L_{13}^{**} + 1.16 L_{53}$	0.48^{**}	0.41
4	1 st Fortnight	$Y = 24.95 - 4.73 L_{41}^{**} - 1.23 L_{31}^{*} - 3.57 L_{43}^{**} - 6.23 L_{53}^{**} + 2.16 L_{52}^{*}$	0.95^{**}	0.93
	2 nd Fortnight	$Y = 17.90 - 2.60 L_{42}^{*} - 4.14 L_{43}^{*} - 5.92 L_{53}^{**} + 2.42 L_{52} + 1.41 L_{33}$	0.85^{**}	0.79
	3 rd Fortnight	$Y = 19.61 - 7.27 L_{43}^{**} - 4.63 L_{53}^{*} + 2.24 L_{33}^{*}$	0.74^{**}	0.68
5	1 st Fortnight	$Y = 16.52 - 7.355 L_{42} + 0.85 L_{52} - 0.12 L_{21}^{*} - 3.33 L_{43} - 2.72 L_{31} + 3.03 L_{41}$	0.86^{**}	0.79
	2 nd Fortnight	$Y = 8.417 - 3.22 L_{42} + 1.48 L_{52} - 2.45 L_{43}$	0.77^{**}	0.72
	3 rd Fortnight	$Y = 5.48 - 5.83 L_{43}^{**} + 3.16 L_{53}^{*} - 0.07 L_{23}$	0.77^{**}	0.73

weather variables pertaining to the same fortnight as independent variables. It had a coefficient of determination of 0.62 ($\bar{R}^2 = 0.46$). Logarithms of number of rainy days (L_{12}) and total rainfall (L_{22}) pertaining to second fortnight, logarithm of minimum temperature (L_{43}) pertaining to the third fortnight were the predictors of the model obtained for second fortnight pwh, which had a predictability of 66% ($\bar{R}^2 = 0.59$). Model for first fortnight had the maximum predictability of 76% ($\bar{R}^2 = 0.63$). Logarithm of number of rainy days (L_{11}), pertaining to first fortnight and logarithms of all the weather variables pertaining to the third fortnight pwh were the independent variables of this model.

Coefficients of correlation of generated weather variables of Model IV in chapter 3. with grass yield of various orders of harvest are given in Tables 16-20. Generated weather variables whose correlation coefficient was significant at 1 % level were chosen to obtain models for three fortnights pwh. However in the case of yield of first harvest, since no generated variables were found to be significant at 1 % level, for the third fortnight variables significant at 5 % level were chosen to obtain model for this fortnight.

Models obtained using generated variables of three fortnights pwh for various order of harvests are presented in Table 21. For the first harvest, model for third fortnight pwh had a relatively low predictability of 23% ($\bar{R}^2 = 0.18$) as compared to that of the first and second fortnights pwh with predictabilities 88% ($\bar{R}^2 = 0.78$) and 77% ($\bar{R}^2 = 0.65$) respectively.

Table. 16. Coefficients of correlation of generated weather variables pertaining to three fortnights pwh with grass yield of first harvest

No .of Fortnights	j	Z_1	Z_2	Z_3	Z_4	Z_5	Q_{12}	Q_{13}	Q_{14}	Q_{15}	Q_{23}	Q_{24}	Q_{25}	Q_{34}	Q_{35}	Q_{45}
I	0	0.562*	0.448	0.024	-0.247	0.034	0.502*	0.551*	0.537*	0.537*	0.454	0.452	0.437	-0.275	0.037	-0.200
	1	0.709**	0.554*	0.576*	-0.333	0.266	0.641**	0.731**	0.686**	0.716**	0.573*	0.564*	0.551*	-0.544*	0.320	-0.418
	2	0.758**	0.551*	0.122	-0.344	0.135	0.635**	0.779**	0.738**	0.756**	0.562*	0.558*	0.543*	-0.375	0.225	-0.405
2	0	0.268	0.282	-0.125	-0.307	0.046	0.276	0.236	0.214	0.260	0.267	0.275	0.279	-0.379	-0.001	-0.170
	1	0.552*	0.513*	-0.403	-0.339	0.177	0.501*	0.561*	0.527*	0.577*	0.519*	0.511*	0.533*	-0.476*	0.265	-0.349
	2	0.505*	0.386	-0.291	-0.356	0.192	0.296	0.508*	0.427	0.546*	0.367	0.365	0.389	-0.506*	0.135	-0.363
3	0	-0.214	0.168	-0.168	-0.247	0.014	0.049	-0.218	-0.26	-0.189	0.159	0.166	0.169	-0.275	-0.020	-0.093
	1	-0.258	0.467	-0.373	-0.289	0.019	0.451	-0.244	-0.306	-0.248	0.474*	0.461	0.470*	-0.387	0.054	-0.176
	2	-0.256	0.325	-0.294	-0.319	0.016	0.103	-0.243	-0.301	-0.245	0.315	0.309	0.327	-0.421	-0.01	-0.219

Table.17. Coefficients of correlation of generated weather variables pertaining to three fortnights pwh with grass yield of second harvest

No. of Fortnights	j	Z_1	Z_2	Z_3	Z_4	Z_5	Q_{12}	Q_{13}	Q_{14}	Q_{15}	Q_{23}	Q_{24}	Q_{25}	Q_{34}	Q_{35}	Q_{45}
1	0	0.344	0.308	0.293	0.477*	-0.367	0.372	0.372	0.493*	0.224	0.340	0.360	0.289	0.462	0.099	0.348
	1	0.552*	0.567*	-0.478*	0.482*	-0.408	0.512*	0.574*	0.618**	0.525*	0.570*	0.605**	0.560*	0.492*	-0.496*	0.443
	2	0.559*	0.492*	0.344	0.487*	-0.433	0.483*	0.576*	0.659**	0.404	0.484*	0.579*	0.466	0.493*	0.164	0.470*
2	0	0.267	0.168	-0.081	0.469*	-0.434	0.283	0.097	0.436	0.146	0.177	0.202	0.148	0.390	-0.308	0.241
	1	0.531*	0.429	-0.178	0.477*	-0.445	0.466	0.490*	0.586*	0.514*	0.442	0.422	0.437	0.453	-0.343	0.327
	2	0.385	0.142	-0.157	0.485*	-0.451	0.385	0.437	0.626**	0.383	0.151	0.228	0.111	0.481*	-0.365	0.354
3	0	0.496*	-0.190	0.031	0.422	-0.404	0.123	0.349	0.572*	0.441	-0.198	-0.143	-0.23	0.469*	-0.213	0.213
	1	0.551*	-0.355	0.042	0.424	-0.436	0.455	0.468	0.614**	0.497*	-0.359	-0.320	-0.373	0.471*	-0.236	0.261
	2	0.558*	-0.352	0.047	0.424	-0.452	0.278	0.509*	0.622**	0.505*	0.358	-0.312	-0.373	0.472*	-0.252	0.268

Table.18. Coefficients of correlation of generated weather variables pertaining to three fortnights pwh with grass yield of third harvest

No. of Fortnights	j	Z_1	Z_2	Z_3	Z_4	Z_5	Q_{12}	Q_{13}	Q_{14}	Q_{15}	Q_{23}	Q_{24}	Q_{25}	Q_{34}	Q_{35}	Q_{45}
1	0	0.116	-0.501*	0.110	-0.121	0.018	-0.452	0.180	0.081	0.118	-0.499*	-0.485*	-0.505*	-0.063	0.074	-0.175
	1	0.668**	-0.584*	0.587*	-0.389	0.321	-0.494*	0.683**	0.671**	0.653**	-0.574*	-0.572*	-0.594**	-0.627**	0.447	-0.389
	2	-0.136	-0.641**	0.187	-0.157	0.184	-0.491*	-0.058	-0.283	-0.002	-0.631**	-0.625**	-0.646**	-0.175	0.106	-0.345
2	0	-0.197	-0.298	0.052	-0.122	0.092	-0.389	-0.188	-0.221	-0.164	-0.293	-0.314	-0.286	-0.084	0.081	-0.104
	1	-0.637**	-0.469*	0.458	-0.139	0.19	-0.439	-0.639**	-0.663**	-0.606**	-0.475*	-0.457	-0.482*	-0.547*	0.338	0.292
	2	-0.476*	-0.529*	-0.108	-0.138	0.227	-0.423	-0.493*	-0.560*	-0.367	-0.535*	-0.513*	-0.539*	-0.276	0.088	-0.243
3	0	-0.622**	-0.041	0.090	-0.132	0.174	-0.354	-0.626**	-0.665**	-0.570*	-0.026	-0.060	-0.019	-0.016	0.167	0.024
	1	-0.629**	-0.052	0.083	-0.215	0.217	-0.354	-0.639**	-0.668**	-0.578*	-0.049	-0.078	-0.021	0.193	0.169	0.002
	2	-0.633**	-0.052	0.076	-0.231	0.234	-0.339	-0.648**	-0.671**	-0.582*	-0.048	-0.079	-0.021	-0.009	0.167	-0.014

Table 19. Coefficients of correlation of generated weather variables pertaining to three fortnights pwh with grass yield of fourth harvest

No. of Fortnights	j	Z_1	Z_2	Z_3	Z_4	Z_5	Q_{12}	Q_{13}	Q_{14}	Q_{15}	Q_{23}	Q_{24}	Q_{25}	Q_{34}	Q_{35}	Q_{45}
1	0	0.236	0.262	0.183	-0.877**	0.396	0.281	0.272	0.075	0.286	0.270	0.182	0.287	-0.688**	0.433	-0.704**
	1	0.537*	0.496*	0.373	-0.880**	0.433	0.500*	0.525*	-0.482*	0.549*	0.494*	0.466	0.511*	-0.750**	0.506*	-0.749**
	2	0.258	0.318	0.344	-0.881**	0.461	0.296	0.307	-0.156	0.369	0.333	0.179	0.363	-0.772**	0.541*	-0.798**
2	0	0.152	0.204	0.194	-0.853**	0.352	0.189	0.180	0.024	0.200	0.220	0.144	0.229	-0.588*	0.421	-0.759**
	1	0.302	0.450	0.358	-0.859**	0.394	0.366	0.292	-0.263	0.324	0.448	0.418	0.469*	-0.668**	0.489*	-0.802**
	2	0.228	0.277	0.324	-0.864**	0.430	0.168	0.260	-0.073	0.324	0.297	0.172	0.321	-0.699**	0.511*	-0.841**
3	0	-0.090	-0.032	0.334	-0.751**	0.262	-0.066	-0.063	-0.151	-0.068	-0.006	-0.065	-0.020	-0.305	0.455	-0.815**
	1	-0.012	-0.344	0.333	-0.759**	0.259	-0.219	-0.019	-0.054	-0.037	-0.325	-0.353	-0.330	-0.312	0.455	-0.834**
	2	-0.097	-0.245	0.306	-0.769**	0.275	-0.194	-0.066	-0.149	-0.07	-0.217	-0.277	-0.228	-0.286	0.441	-0.842**

Table.20. Coefficients of correlation of generated weather variables pertaining to three fortnights pwh with grass yield of fifth harvest

No. of Fortnights	j	Z_1	Z_2	Z_3	Z_4	Z_5	Q_{12}	Q_{13}	Q_{14}	Q_{15}	Q_{23}	Q_{24}	Q_{25}	Q_{34}	Q_{35}	Q_{45}
1	0	0.021	-0.005	0.534*	-0.819**	0.148	0.067	0.057	-0.045	0.040	0.029	-0.064	0.012	-0.619**	0.548*	-0.595**
	1	0.586*	0.561*	0.553*	-0.820**	0.269	0.606**	0.601**	-0.579*	0.580*	0.576*	-0.523*	0.558*	-0.624**	0.561*	-0.600**
	2	0.237	-0.042	0.571*	-0.821**	0.214	0.220	0.317	0.048	0.270	0.023	-0.124	-0.022	-0.628**	0.571*	-0.605**
2	0	0.097	0.071	0.474*	-0.827**	0.217	0.127	0.133	0.031	0.110	0.105	0.010	0.085	-0.592**	0.579*	-0.562*
	1	0.551*	0.475*	0.480*	-0.828**	0.227	0.490*	0.563*	0.560*	0.538*	0.484*	0.442	0.462	-0.605**	0.582*	-0.572*
	2	0.291	0.284	0.485*	-0.829**	0.234	0.441	0.357	0.106	0.326	0.323	0.178	0.309	-0.617**	0.584*	-0.581*
3	0	0.136	0.110	0.486*	-0.783**	0.204	0.165	0.181	0.069	0.145	0.148	0.052	0.117	-0.490*	0.596**	-0.488*
	1	0.373	0.112	0.491*	-0.787**	0.206	0.289	0.408	0.334	0.365	0.153	0.052	0.119	-0.489*	0.596**	-0.489*
	2	0.348	0.114	0.495*	-0.789**	0.209	0.297	0.400	0.255	0.347	0.156	0.053	0.120	-0.488*	0.596**	-0.490*

Table. 21. Models obtained for grass yield of various orders of harvest using Model IV for three fortnights pwh

Orders of Harvest	No. of Fortnights	Prediction Model	R^2	$\bar{R}^2$
1	1	$Y = 12266.87 + 36.84 Q_{1321} - 17.77 Q_{3422}^{*} + 12.63 Q_{2313}^{**} - 14.73 Q_{2412}^{**} - 40.44 Q_{1521} + 146.16 Q_{1412} + 5.51 Q_{1512}^{*} - 3.54 Q_{1212}$	0.88^{**}	0.78
	2	$Y = 10726.01 + 7.37 Q_{1512}^{**} - 13.66 Q_{3422} + 0.29 Q_{2313} - 9.65 Q_{2412}^{*} + 8.34 Q_{2312}^{*} - 5.17 Q_{1212}$	0.77^{**}	0.65
	3	$Y = 3855.71 + 0.31 Q_{2313}^{*}$	0.18	0.23
2	1	$Y = 2577.76 + 28.44 Q_{1421}^{*} + 0.07 Q_{2421} - 6.61 Q_{1211}^{*} + 1.76 Q_{2411} - 168.77 Z_{111}$	0.77^{**}	0.68
	2	$Y = 4033.42 + 38.90 Q_{1422}^{*} - 5.24 Q_{1523}$	0.45^{*}	0.37
	3	$Y = 4544.05 + 36.09 Q_{1423}^{*} - 5.54 Q_{1523}$	0.45^{*}	0.37
3	1	$Y = 10109.26 + 38.83 Q_{1423} - 703.16 Z_{113} + 123.19 Z_{111} - 1.41 Q_{1511} - 3.91 Q_{2421}^{*} + 0.58 Q_{2511} + 0.23 Q_{2521}$	0.88^{**}	0.80
	2	$Y = 12183.25 - 111.70 Q_{1423}^{*} + 2359.60 Z_{113}^{*} - 4.38 Q_{1312} + 18.18 Q_{1512}^{*} - 1926.80 Z_{112}$	0.82^{**}	0.74
	3	$Y = 13608.49 - 162.92 Q_{1423}^{**} + 4015.78 Z_{113}^{*} - 44.12 Q_{1313}$	0.69^{**}	0.62
4	1	$Y = 56928.55 - 2393.18 Z_{421}^{**} - 23.62 Q_{4523}^{**} + 7.82 Q_{1511}^{*} + 1009.42 Z_{423} + 8.84 Q_{4521} - 22.91 Q_{1311}^{*} + 183.14 Z_{111} + 551.29 Z_{412}$	0.98^{**}	0.97
	2	$Y = 57837.25 - 14984.78 Z_{422} - 13.91 Q_{4523}^{**} + 14099.29 Z_{412}$	0.90^{**}	0.88
	3	$Y = 59337.86 - 17.42 Q_{4523}^{**} - 642.98 Z_{423}$	0.76^{**}	0.73
5	1	$Y = 23393.42 - 539.83 Z_{422}^{*} + 1.14 Q_{1211}^{*} - 10.72 Q_{3421}$	0.79^{**}	0.75
	2	$Y = 24419.94 - 883.01 Z_{422}^{**}$	0.69^{**}	0.67
	3	$Y = 26482.45 - 13026.31 Z_{423} + 12067.92 Z_{403}$	0.68^{**}	0.64

4.2.1.3.Principal component analysis for grass yield:

The latent roots, percentage variance and cumulative variance accounted by different components in explaining the variation in grass yield as obtained from the principal component analysis for various orders of harvest are presented in Table.22. Models worked out with principal components as explanatory variables are given in Table.23.

Principal component analysis for grass yield of five harvests included generated variables selected for developing Model IV. The analysis showed that first two components could explain 97% of the total variation. In the case of second harvest, first component alone could explain 95% of variation. As for the third harvest first two components together explained 99% of variation, of which first component alone explained 78% of the variation. In the case of fourth harvest also first two components explained 91% of variation, in which about 70% of variation was explained by the first component alone. Finally about 96% of variation was explained by the first component for fifth harvest.

The regression of grass yield on principal components for various orders of harvest showed that there was no appreciable increase in the value of coefficient of determination (R^2), by choosing principal components as explanatory variables.

The prediction models fitted for the first harvest using first two components as explanatory variables had a coefficient of determination of 0.44 ($\bar{R}^2$= 0.37). In the case of second harvest model fitted using only first component as explanatory variable had a predictability of 32% ($\bar{R}^2$= 0.28). However for the third harvest, the model developed

Table 22. Latent roots, percentage variance and cumulative variance for grass yield

Orders of harvest	Components	Latent Roots	Percentage Variance	Cumulative Variance
First	1	54284191.11	62.04	62.04
	2	30977232.60	35.40	97.44
Second	1	78984582.50	95.47	95.47
Third	1	87403559.10	77.51	77.51
	2	25322304.65	22.46	99.96
Fourth	1	150390.34	69.57	69.57
	2	46878.01	21.69	91.25
Fifth	1	182411.13	95.79	95.79

Table.23. Models obtained for grass yield of various orders of harvest using principal components as explanatory variables

Orders of harvest	Prediction Model	R^2	$\bar{R}^2$
1	$Y = 2851.85 + 0.11 F_1^{**} + 0.07 F_2$	0.44	0.37
2	$Y = 5735.58 + 0.09 F_1^{*}$	0.32	0.28
3	$Y = 10038.81 + 0.11 F_1^{**} - 0.007 F_2$	0.53	0.47
4	$Y = 50697.99 - 4.10 F_1^{**} - 5.79 F_2^{**}$	0.77^{**}	0.74
5	$Y = -29368.54 + 5.04 F_1^{**}$	0.51	0.48

had a coefficient of determination of 0.53 ($\bar{R}^2 = 0.47$) and the explanatory variables of the model being the first two components. First two components explained about 77% ($\bar{R}^2 = 0.74$) of variation in the yield of fourth harvest. Lastly for the fifth harvest, model developed using first component alone had a predictability of 51% ($\bar{R}^2 = 0.48$).

4.3.1. Oil yield:

Coefficients of correlation of weather variables pertaining to the growth period with oil yield for various orders of harvests are presented in Table 24. It may be noted that number of rainy days (X_1) pertaining to sixth week pwh had significant negative correlation with oil yield. Maximum temperature (X_3) and its logarithm (L_3) pertaining to third, fourth and fifth week pwh also had a significant negative correlation with oil yield for same harvest. Relative humidity (X_5) and its logarithm (L_5) of first and second week pwh also had a significant negative correlation with the oil yield. The only weather variable which had a significant positive correlation with oil yield of first harvest was minimum temperature (X_4) and its logarithm (L_4) pertaining to first and second week pwh.

Coefficients of correlation of logarithms of weather variables pertaining to six weeks pwh with logarithm of oil yield are given in Table 25. Logarithms of minimum temperature (L_4), one, two and six week's pwh had a significant positive correlation with logarithm of oil yield. However logarithm of maximum temperature (L_3), three weeks and five weeks pwh had a significant negative correlation with logarithm of

Table.24. Coefficients of correlation of weather variables and their logarithms with oil yield of various orders of harvest

Orders of harvest	No. of weeks pwh	X_1	X_2	X_3	X_4	X_5	L_1	L_2	L_3	L_4	L_5
1	1	0.253	-0.123	-0.274	0.561*	-0.609**	-0.151	-0.015	-0.276	0.549*	-0.616**
	2	0.122	0.017	-0.209	0.498*	-0.529*	0.220	0.075	-0.212	0.494*	-0.533*
	3	-0.033	-0.113	-0.505*	0.310	-0.325	0.053	-0.032	-0.513*	0.320	-0.325
	4	0.079	-0.335	-0.509*	0.336	-0.240	0.014	-0.279	-0.512*	0.336	-0.233
	5	-0.343	-0.438	-0.496*	0.432	-0.237	-0.339	-0.436	-0.491*	0.430	-0.215
	6	-0.473*	0.085	-0.087	0.574*	-0.430	0.377	0.270	-0.090	0.571*	-0.431
2	1	-0.290	-0.232	0.023	0.655**	-0.417	-0.325	0.010	0.027	0.660**	-0.419
	2	-0.158	-0.447	0.278	0.692**	-0.465	-0.229	-0.555*	0.321	0.695**	-0.466
	3	-0.077	-0.543*	0.515*	0.804**	-0.407	-0.073	-0.547	0.513*	0.804**	-0.402
	4	0.157	-0.318	0.043	0.682**	-0.187	0.215	-0.460	0.040	0.680**	-0.187
	5	0.269	-0.125	0.044	0.377	-0.254	0.317	-0.056	0.047	0.371	-0.258
	6	0.094	-0.191	-0.083	0.248	0.026	0.170	-0.216	-0.077	0.238	0.023
3	1	0.104	-0.099	0.496*	-0.677**	0.324	-0.354	-0.012	0.503*	-0.683**	0.327
	2	0.074	-0.357	0.553*	-0.601**	0.329	0.063	-0.454	0.551*	-0.597	0.333
	3	-0.208	-0.044	0.321	-0.656**	0.415	0.310	-0.302	0.321	-0.657**	0.419
	4	-0.066	0.100	0.340	-0.511*	0.539*	-0.094	-0.049	0.344	-0.518*	0.540
	5	-0.102	0.326	0.099	-0.643**	0.237	-0.032	0.314	0.104	-0.645**	0.239
	6	0.055	-0.111	0.365	-0.591**	0.340	0.057	-0.022	0.370	-0.592**	0.339
4	1	-0.454	-0.155	0.573*	-0.692**	-0.127	-0.429	-0.308	0.569*	-0.700**	-0.126
	2	-0.097	-0.049	0.387	-0.667**	-0.122	-0.149	-0.045	0.384	-0.674**	-0.128
	3	0.177	0.172	0.020	-0.732**	-0.160	-0.127	0.215	0.015	-0.734**	-0.173
	4	0.216	0.163	0.316	-0.750**	0.064	0.021	0.198	0.315	-0.749**	0.054
	5	-0.284	-0.427	0.374	-0.454	0.208	-0.314	-0.254	0.384	-0.458	0.208
	6	-0.302	-0.148	0.642**	-0.375	0.089	0.106	-0.134	0.645**	-0.387	0.092
5	1	0.146	-0.067	0.385	-0.558*	0.146	-0.437	-0.320	0.380	-0.524*	0.136
	2	-0.073	0.152	0.326	-0.696**	0.372	0.100	0.038	0.319	-0.681**	0.369
	3	0.326	0.406	0.334	-0.609**	0.501*	-0.310	0.235	0.329	-0.575*	0.494*
	4	-0.117	-0.058	0.307	-0.746**	0.416	0.111	-0.227	0.300	-0.735**	0.422
	5	0.086	0.191	0.173	-0.710**	0.372	0.002	0.313	0.174	-0.689**	0.372
	6	0.310	0.035	0.429	-0.787**	0.348	0.354	0.089	0.431	-0.780**	0.353

Table.25. Coefficients of correlation of logarithms of weather variables pertaining to six weeks pwh with logarithm of oil yield for various orders of harvest

Orders of harvest	No. of weeks pwh	L_1	L_2	L_3	L_4	L_5
1	1	-0.211	-0.065	-0.317	0.505*	-0.558*
	2	0.214	-0.014	-0.229	0.471*	-0.512*
	3	0.029	-0.085	-0.504*	0.327	-0.318
	4	-0.077	-0.367	-0.464	0.340	-0.254
	5	-0.404	-0.505*	-0.490*	0.453	-0.227
	6	0.272	0.286	-0.098	0.566*	-0.390
2	1	-0.330	-0.023	0.038	0.674**	-0.453
	2	-0.258	-0.592*	0.330	0.691**	-0.470*
	3	-0.080	-0.541*	0.497*	0.805**	-0.414
	4	0.266	-0.453	0.003	0.667**	-0.187
	5	0.311	-0.060	0.015	0.394	-0.283
	6	0.161	-0.287	-0.134	0.272	-0.009
3	1	-0.370	-0.044	0.529*	-0.668**	0.346
	2	0.044	-0.423	0.522*	-0.601**	0.366
	3	0.301	-0.260	0.302	-0.651**	0.459
	4	-0.088	-0.044	0.342	-0.507*	0.557*
	5	-0.032	0.293	0.119	-0.643**	0.260
	6	0.071	-0.022	0.365	-0.583*	0.346
4	1	-0.424	-0.300	0.563*	-0.703**	-0.141
	2	-0.111	-0.004	0.348	-0.683**	-0.117
	3	-0.050	0.256	-0.008	-0.737**	-0.146
	4	-0.020	0.258	0.313	-0.744**	0.047
	5	-0.294	-0.285	0.396	-0.423	0.203
	6	0.115	-0.149	0.654**	-0.377	0.109
5	1	-0.387	-0.207	0.317	-0.568*	0.119
	2	0.201	0.089	0.276	-0.655**	0.351
	3	-0.293	0.185	0.266	-0.611**	0.509
	4	0.101	-0.209	0.230	-0.752**	0.472*
	5	-0.099	0.329	0.125	-0.660**	0.438
	6	0.394	0.088	0.415	-0.746**	0.424

yield. Also logarithm of relative humidity (L_5), pertaining to first and second week pwh had a significant negative correlation with logarithm of oil yield of first harvest.

4.3.1.1. Two stage Regression Models:

First-stage prediction models obtained for oil yield using Model I are given in Table 26 and the corresponding two stage models in Table 27. The two- stage models obtained for sixth week pwh had a predictability of 48% ($\bar{R}^2 = 0.44$). Model obtained for five weeks pwh had a predictability of 61% ($\bar{R}^2 = 0.56$). Predicted values of fifth (P_5) and sixth (P_6) week pwh were the independent variables of this model. For the second, third and fourth week pwh the prediction models were same with a predictability of 62 % ($\bar{R}^2 = 0.57$). The predicted values of fourth (P_4) and fifth (P_5) weeks pwh were the independent variables of this model. Model obtained for first week pwh had a coefficient of determination of 0.67 ($\bar{R}^2 = 0.62$). The predictors of the model being predicted values of first (P_1) and fourth (P_4) week pwh.

First stage regression models to predict oil yield using Model II are provided in Table 28 and the two stage models in Table 29. Two-stage model obtained for oil yield for sixth week pwh had a predictability of 78% ($\bar{R}^2 = 0.77$). In the fifth week pwh, the model with predicted values of fifth (P_5) and sixth (P_6) week's pwh as explanatory variables had a coefficient of determination of 0.81 ($\bar{R}^2 = 0.78$). For the fourth week pwh, the model obtained had a predictability of 82 % ($\bar{R}^2 = 0.80$). Predicted values of fourth (P_4) and sixth (P_6) week pwh were the independent variables of this model. Model obtained for third week, had a predictability of 88% ($\bar{R}^2 = 0.87$). The predictors

Table. 26. First stage regression models for oil yield using Model I for six weeks pwh

Orders of Harvest	No. of weeks pwh	Prediction Model	R^2	$\bar{R}^2$
1	1	$Y = 64080.09 - 890.16\ X_5 + 1067.63 X_1 + 1461.94\ X_4$	0.53^{*}	0.43
	2	$Y = 156625.21 - 1096.71\ X_5^{*} - 1447.31\ X_3$	0.35^{*}	0.27
	3	$Y = 148807.6\ 4 - 2295.40\ X_3^{*} - 759.12\ X_5$	0.39^{*}	0.31
	4	$Y = 110434.21 - 2573.14\ X_3^{**} - 78.26\ X_2^{*} + 824.04\ X_1 - 253.22\ X_5$	0.57^{*}	0.44
	5	$Y = 32350.38 - 2526.63\ X_3^{**} + 2334.67\ X_4^{**}$	0.55^{*}	0.49
	6	$Y = -14345.98 + 1572.79\ X_4^{*} - 1396.52\ X_1 + 34.08\ X_2$	0.48^{*}	0.36
2	1	$Y = -33237.11 + 2046.73\ X_4^{**}$	0.43^{**}	0.39
	2	$Y = -17627.67 + 1425.07\ X_4^{**} - 19.27\ X_2$	0.53^{**}	0.46
	3	$Y = -\ 47394.12 + 1845.96\ X_4^{**} + 696.77\ X_3 - 524.14\ X_1$	0.72^{**}	0.66
	4	$Y = -129776.49 + 3195.29\ X_4^{**} + 707.35\ X_5^{*} + 1291.38\ X_1 - 21.32\ X_2$	0.71^{**}	0.63
	5	$Y = -14440.42 + 1079.54\ X_4 + 615.78\ X_1$	0.20	0.09
	6	$Y = -3476.10 + 763.89\ X_4$	0.061	0.002

Table 26 (Contd.)

3	1	$Y = 65978.93 - 2045.21\ X_4^{**}$	0.46^{**}	0.42
	2	$Y = 71715.91 - 2365.59\ X_4^{**} - 24.74\ X_2^{**} + 793.66\ X_1$	0.62^{**}	0.54
	3	$Y = 64475.19 - 1986.80\ X_4^{**}$	0.43^{**}	0.40
	4	$Y = 2471.33 + 371.45\ X_5 - 740.98\ X_4$	0.34^{*}	0.26
	5	$Y = 104960.05 - 2738.71\ X_4^{**} - 260.24\ X_5$	0.48^{**}	0.41
	6	$Y = 45657.62 - 1913.71\ X_4^{*} + 632.57\ X_3$	0.42^{*}	0.34
4	1	$Y = 133711.88 - 2886.28\ X_4^{**} - 490.92\ X_5$	0.58^{**}	0.52
	2	$Y = 125626.93 - 3035.19\ X_4^{**} - 339.25\ X_5 - 580.64\ X_1$	0.59^{**}	0.51
	3	$Y = 108666.10 - 2297.85\ X_4^{**} - 348.91\ X_5$	0.63^{**}	0.58
	4	$Y = 78397.66 - 3020.76\ X_4^{**} - 349.99\ X_5 + 2044.96\ X_1^{*} - 38.73\ X_2 + 1511.82\ X_3$	0.80^{**}	0.72
	5	$Y = 40596.93 - 2026.74\ X_4^{*} + 1149.13\ X_3 - 30.42\ X_2$	0.47^{*}	0.35
	6	$Y = -1540.79 + 2235.49\ X_3^{**} - 1609.40\ X_4^{*}$	0.56^{**}	0.51

Table 26 (Contd.)

5	1	$Y = 33047.62 - 1773.61\ X_4^{**} + 291.35\ X_5$	0.44^{*}	0.37
	2	$Y = 92244.28 - 2258.90\ X_4^{**} + 172.17\ X_2 - 2716.85\ X_1 - 792.25\ X_3$	0.61^{*}	0.50
	3	$Y = 22929.54 - 1687.33\ X_4^{**} + 373.09\ X_5^{*} + 47.41\ X_2$	0.87^{**}	0.60
	4	$Y = -14412.50 - 1961.60\ X_4^{**} + 632.86\ X_5^{*} + 791.11\ X_3 - 492.55\ X_1$	0.73^{**}	0.65
	5	$Y = 28727.74 - 2318.43\ X_4^{**} + 492.38\ X_5^{**}$	0.71^{**}	0.67
	6	$Y = 97106.07 - 4260.13 X_4^{**} + 536.41\ X_5^{**} - 969.19\ X_3 - 83.77\ X_2^{**} + 1820.99\ X_1^{*}$	0.91^{**}	0.87

Table. 27. Two stage regression models for oil yield for six weeks pwh using Model I

Orders of Harvest	No. of weeks pwh	Prediction Model	R^2	$\bar{R}^2$
1	1.	$Y = -3600.67 + 0.67 P_4^{*} + 0.57 P_1$	0.67^{*}	0.62
	2	$Y = -1735.23 + 0.58 P_4 + 0.52 P_5$	0.62^{**}	0.57
	3	$Y = -1735.23 + 0.58 P_4 + 0.52 P_5$	0.62^{**}	0.57
	4	$Y = -1735.23 + 0.58 P_4 + 0.52 P_5$	0.62^{**}	0.57
	5.	$Y = -2919.98 + 0.69 P_5^{*} + 0.48 P_6$	0.61^{**}	0.56
	6.	$Y = P_6^{**}$	0.48^{**}	0.44
2	1.	$Y = -1373.55 + 0.56 P_3^{*} + 0.53 P_4$	0.78^{**}	0.75
	2	$Y = -1373.55 + 0.56 P_3^{*} + 0.53 P_4$	0.78^{**}	0.75
	3	$Y = -1373.55 + 0.56 P_3^{*} + 0.53 P_4$	0.78^{**}	0.75
	4	$Y = P_4^{**}$	0.71^{**}	0.70
	5	$Y = P_5$	0.20	0.15
	6	$Y = P_6$	0.061	0.002
3	1	$Y = P_2^{**}$	0.62^{**}	0.60
	2	$Y = P_3^{**}$	0.62^{**}	0.60
	3	$Y = P_5$	0.48	0.45
	4	$Y = P_5^{**}$	0.48^{**}	0.45
	5	$Y = P_5^{**}$	0.48^{**}	0.45
	6	$Y = P_6^{**}$	0.42^{**}	0.39
4	1	$Y = -4023.49 + 0.78 P_4^{**} + 0.39 P_1^{*}$	0.85^{**}	0.83
	2	$Y = -5145.47 + 0.78 P_4^{**} + 0.32 P_3 + 0.26 P_6$	0.86^{**}	0.83
	3	$Y = -5145.47 + 0.78 P_4^{**} + 0.32 P_3 + 0.26 P_6$	0.86^{**}	0.83
	4	$Y = -3214.70 + 0.81 P_4^{**} + 0.33 P_6$	0.83^{**}	0.81
	5	$Y = -2689.77 + 0.73 P_6 + 0.38 P_5$	0.59^{**}	0.54
	6	$Y = P_6^{**}$	0.56^{**}	0.54
5	1	$Y=P_6^{**}$	0.91^{**}	0.90
	2	$Y=P_6^{**}$	0.91^{**}	0.90
	3	$Y=P_6^{**}$	0.91^{**}	0.90
	4	$Y=P_6^{**}$	0.91^{**}	0.90
	5	$Y=P_6^{**}$	0.91^{**}	0.90
	6	$Y=P_6^{**}$	0.91^{**}	0.90

Table.28. First stage regression models for oil yield using Model II for six weeks pwh

Orders of harvest	No. of weeks pwh	Prediction Model	R^2	$\bar{R}^2$
1	1	$Y = 16496995.12 - 10746811.14\ L_5^{*} + 50245.50\ X_5^{*}$	0.58^{**}	0.52
	2	$Y = 16369842.74 - 10560852.66\ L_5 + 48985.94\ X_5 - 85703.21\ L_3$	0.46^{*}	0.34
	3	$Y = 9543471.46 - 11753929.08\ L_3^{**} + 18695.86\ X_3^{**} + 244.15\ L_2 + 2347620.59\ L_4^{*} - 41463.92\ X_4^{*}$	0.85^{**}	0.79
	4	$Y = 347454.35 - 154605.28\ L_3^{**} - 75.19\ X_2^{*} + 3350.15\ X_1 - 54802.17\ L_5 - 20541.26\ L_1$	0.61^{*}	0.45
	5	$Y = -83411.73 - 2535.67\ X_3^{**} + 124694.98\ L_4^{**}$	0.55^{**}	0.49
	6	$Y = 1808552.28 + 34718.20\ X_4 + 17508.30\ L_1^{**} - 1540.09\ X_1^{*} - 1784957.18\ L_4 - 115358.96\ L_3$	0.78^{**}	0.69
2	1	$Y = -5487.77 + 405916.68\ L_4^{**} - 55376.87\ L_1^{**} + 6097.78\ X_1^{**} - 31.68\ X_2 - 79323.98\ L_3$	0.75^{**}	0.65
	2	$Y = -86374.36 + 79991.96\ L_4^{**} - 6715.16\ L_2 + 30.31\ X_2$	0.62^{**}	0.54
	3	$Y = -99789.08 + 1840.31\ X_4^{**} + 50085.65\ L_3 - 4754.26\ L_1$	0.73^{**}	0.67
	4	$Y = 1009280.50 + 27347.60\ X_4 - 2673.20\ L_2^{*} + 144538.07\ L_5^{**} + 15700.78\ L_1^{*} - 1405786.42\ L_4$	0.78^{**}	0.70
	5	$Y = -12937.66 + 1012.46\ X_4 + 5106.47\ L_1$	0.21	0.10
	6	$Y = 2436250.89 + 45747.27\ X_4 - 2551538.87\ L_4$	0.20	0.10

Table 28 (Contd.)

3	1	$Y = -4789834.66 - 706801.13\ L_4 + 11628.55\ X_4 + 825.37\ X_1^{*} + 5524673.91\ L_3 - 88948.96\ X_3 - 2947.21\ L_2$	0.74^{**}	0.59
	2	$Y = -1507055.42 - 35139.56\ X_4 - 8021.67\ L_2^{**} + 937.56\ X_1 + 1722594.37\ L_4$	0.67^{**}	0.57
	3	$Y = -7025713.01 - 2141303.71\ L_4 - 3527.64\ L_2 + 5881283.11\ L_5 - 27302.59\ X_5 + 40480.19\ X_4$	0.60^{*}	0.43
	4	$Y = -257893.59 + 149414.12\ L_5^{**} - 9811.59\ L_2^{*} + 31.00\ X_2$	0.52^{*}	0.41
	5	$Y = 312991.62 - 143940.27\ L_4^{**} - 50418.57\ L_5$	0.48^{**}	0.41
	6	$Y = 98630.85 - 99270.07\ L_4^{*} + 38608.51\ L_3$	0.42^{*}	0.35
4	1	$Y = 3138222.45 - 3257344.28\ L_4^{*} + 57333.73\ X_4^{*}$	0.82^{**}	0.57
	2	$Y = 2147137.82 + 2926204.20\ L_4 - 58574.29\ X_4 - 6657.31\ L_2 - 3136069.11\ L_5 + 9601.59\ L_1 + 15261.47\ X_5$	0.73^{*}	0.58
	3	$Y = 7134981.81 - 101430.77\ L_4^{**} - 4601684.77\ L_5^{**} + 22419.10\ X_5^{**}$	0.73^{**}	0.74
	4	$Y = -446271.33 - 74126.83\ X_4^{**} - 4750519.26\ L_5^{*} + 3257.96\ X_1^{**} + 23483.51\ X_5^{*} + 3802444.09\ L_3^{*} - 62.22\ X_2^{**} + 3943236.21\ L_4^{**} - 54722.18\ X_3^{*} - 2473.78\ L_2 + 3207.79\ L_1$	0.96^{**}	0.91
	5	$Y = -2699446.21 - 106093.28\ L_4^{*} + 2790352.58\ L_3 - 41736.54\ X_3$	0.50*	0.39
	6	$Y = -337961.68 + 245179.00\ L_3^{**} + 6056.91\ L_2^{*} - 23.75\ X_2$	0.65^{**}	0.58

Table 28 (Contd.)

5	1	$Y = 3169962.13 - 16480.87\ X_4 + 726237.51\ L_4 + 815.41\ X_1 - 7001.20\ L_2 - 3564575.77\ L_3 + 50339.00\ X_3 - 4141.90\ L_1$	0.84^{**}	0.72
	2	$Y = -1472832.96 - 35221.51\ X_4^{*} + 1690334.00\ L_4^{*}$	0.64^{**}	0.60
	3	$Y = -1071318.11 - 26291.62\ X_4^{**} + 1244533.34\ L_4^{**} + 104.55\ X_2 - 1266.26\ X_1$	0.77^{**}	0.70
	4	$Y = -2880437.02 - 61804.04\ X_4^{**} + 3175075.78\ L_4^{**}$	0.74^{**}	0.71
	5	$Y = -115789.68 - 2320.44\ X_4^{**} + 96664.45\ L_5^{**}$	0.71^{**}	0.61
	6	$Y = 1250838.90 - 4698.18\ X_4^{**} + 92937.17\ L_5^{*} - 1236842.75\ L_3 - 109.57\ X_2^{**} + 1593.91\ X_1^{*} + 4572.31\ L_2 + 17156.14\ X_3$	0.93^{**}	0.89

Table.29.Two stage regression models for oil yield for six weeks pwh using Model II

Orders of Harvest	No. of weeks pwh	Prediction Model	R^2	$\bar{R}^2$
1	1	$Y = -1303.15 + 0.67\ P_4^{**} + 0.40\ P_6$	0.88**	0.87
	2	$Y = -1303.15 + 0.67\ P_4^{**} + 0.40\ P_6$	0.88**	0.87
	3	$Y = -1303.15 + 0.67\ P_4^{**} + 0.40\ P_6$	0.88**	0.87
	4	$Y = -2516.74 + 0.75\ P_6^{**} + 0.39\ P_4$	0.82**	0.80
	5	$Y = -2341.05 + 0.81\ P_6^{**} + 0.33\ P_5^{*}$	0.81**	0.78
	6	$Y = P_6^{**}$	0.78**	0.77
2	1	$Y = -2333.34 + 0.61\ P_4^{**} + 0.54\ P_1^{**}$	0.89**	0.87
	2	$Y = -1247.28 + 0.65\ P_4^{*} + 0.43\ P_3$	0.83**	0.80
	3	$Y = -1247.28 + 0.65\ P_4^{*} + 0.43\ P_3$	0.83**	0.80
	4	$Y = P_4^{**}$	0.79**	0.77
	5	$Y = -7903.63 + 0.77\ P_5 + 0.75\ P_6$	0.31	0.22
	6	$Y = P_6$	0.20	0.15
3	1	$Y = -3911.14 + 0.45\ P_1 + 0.45\ P_4^{*} + 0.61\ P_2 - 0.31\ P_1$	0.84**	0.79
	2	$Y = -3948.14 + 0.94\ P_2^{**} + 0.61\ P_4^{**} - 0.35\ P_6$	0.80**	0.76
	3	$Y = -4564.62 + 0.69\ P_3^{**} + 0.54\ P_4^{**}$	0.69**	0.65
	4	$Y = -4352.51 + 0.65\ P_4^{*} + 0.51\ P_5$	0.61**	0.56
	5	$Y = P_5^{**}$	0.48**	0.45
	6	$Y = P_6^{**}$	0.42**	0.39
4	1	$Y = -1719.07 + 0.82\ P_4 + 0.13\ P_6 + 0.12\ P_3$	0.97**	0.96
	2	$Y = -1719.07 + 0.82\ P_4 + 0.13\ P_6 + 0.12\ P_3$	0.97**	0.96
	3	$Y = -1719.07 + 0.82\ P_4 + 0.13\ P_6 + 0.12\ P_3$	0.97**	0.96
	4	$Y = -1222.51 + 0.91\ P_4^{**} + 0.14\ P_6$	0.96**	0.96
	5	$Y = P_6^{**}$	0.65**	0.96
	6	$Y = P_6^{**}$	0.65**	0.96
5	1	$Y = P_6^{**}$	0.93**	0.93
	2	$Y = P_6^{**}$	0.93**	0.93
	3	$Y = P_6^{**}$	0.93**	0.93
	4	$Y = P_6^{**}$	0.93**	0.93
	5	$Y = P_6^{**}$	0.93**	0.93
	6	$Y = P_6^{**}$	0.93**	0.93

of the model were predicted values of third (P_3) and sixth (P_6) pwh. Models obtained for first and second week pwh were the same as that obtained of the third week pwh.

The first-stage models developed based on Model III are given in Table 30 and two stage models in Table 31. Predictability of the two-stage model obtained for sixth week pwh was 49% ($\bar{R}^2 = 0.45$). In the fifth week pwh, it had gone upto 60% ($\bar{R}^2 = 0.55$). The independent variables of this model being predicted values of fifth (P_5) and sixth (P_6) week pwh. However model obtained for first, second, third and fourth weeks pwh were same; and it had a coefficient of determination of 0.61 ($\bar{R}^2 = 0.56$). Predicted values of fourth (P_4) and fifth (P_5) weeks pwh were the independent variables of this model.

4.3.1.2. Influence of fortnightly weather variables:

Coefficients of correlation of fortnightly weather variables and their logarithms with oil yield are presented in Table 32. It could be noted that number of rainy days (X_1) and its logarithm (L_1), three fortnights pwh had a significant negative correlation with oil yield. Coefficients of correlation of minimum temperature (X_4) and its logarithm (L_4) throughout the three fortnights had significant positive correlation with oil yield. However, relative humidity (X_5) and its logarithm (L_5) one fortnight pwh had significant negative correlation with oil yield of this harvest.

Coefficients of correlation of logarithm of weather variables pertaining to three fortnights with logarithm of oil yield for various orders of harvests are presented in Table 33. It could be noted that, while logarithm of minimum temperature (L_4) throughout the

Table 30. First stage regression models for oil yield using Model III for six weeks pwh

Order of harvest	No. of weeks pwh	Prediction Model	R^2	$\bar{R}^2$
1	1	$Y = 14.01 - 4.99\ L_5^{*}$	0.31^{*}	0.27
	2	$Y = 17.38 - 5.13\ L_5^{*} - 2.16\ L_3$	0.34^{*}	0.26
	3	$Y = 15.92 - 3.24\ L_3^{*} - 3.59\ L_5$	0.38^{*}	0.30
	4	$Y = 12.46 - 3.21\ L_3^{*} - 0.12\ L_2^{*} - 1.77\ L_5$	0.48^{*}	0.36
	5	$Y = 5.22 - 0.004\ L_2 - 3.48\ L_3^{**} + 2.94\ L_4^{*}$	0.58^{*}	0.48
	6	$Y = 4.82 + 2.80\ L_4^{**} - 3.15\ L_3 + 0.18\ L_1$	0.49^{*}	0.38
2	1	$Y = -0.17 + 3.24\ L_4^{**} - 0.17\ L_1$	0.53^{**}	0.47
	2	$Y = 1.40 + 2.14\ L_4^{**} - 0.12\ L_2^{*}$	0.62^{**}	0.57
	3	$Y = -1.94 + 3.02\ L_4^{**} + 1.37\ L_3 - 0.14\ L_1$	0.72^{**}	0.66
	4	$Y = -10.50 + 4.87\ L_4^{**} - 0.08\ L_2^{*} + 3.98\ L_5^{*} + 0.42\ L_1^{*}$	0.75^{**}	0.67
	5	$Y = 1.60 + 1.77\ L_4 + 0.14\ L_1$	0.22	0.12
	6	$Y = 2.25 + 1.37\ L_4$	0.07	0.02

Table 30 (Contd.)

3	1	$Y = 5.10 - 1.99\,L_4^{*} + 1.31L_3$	0.49^{**}	0.43
	2	$Y = 7.96 - 2.56\,L_4^{**} - 0.18\,L_2^{*} + 0.22\,L_1$	0.60^{**}	0.52
	3	$Y = 5.41 - 2.04\,L_4^{*} + 0.14\,L_1 + 1.07\,L_3$	0.53^{*}	0.42
	4	$Y\ -2.13 + 3.34\,L_5^{**} - 0.07\,L_2$	0.39^{*}	0.31
	5	$Y = 10.66 - 3.22\,L_4^{**} - 1.03\,L_5$	0.46^{**}	0.39
	6	$Y = 6.08 - 2.26\,L_4^{*} + 0.88\,L_3$	0.41^{*}	0.33
4	1	$Y = 12.72 - 3.20\,L_4^{**} - 2.05\,L_5$	0.60^{**}	0.55
	2	$Y = 12.26 - 4.00\,L_4^{**} - 1.22\,L_5 - 0.10\,L_2 + 0.14\,L_1$	0.67^{**}	0.57
	3	$Y = 13.10 - 2.94\,L_4^{**} - 2.42\,L_5^{*} + 0.12\,L_1 - 0.03\,L_2$	0.69^{**}	0.60
	4	$Y = 13.55 - 3.55\,L_4^{**} - 2.25\,L_5^{*} + 0.05\,L_2^{*}$	0.73^{**}	0.67
	5	$Y = 5.18 - 2.08\,L_4 + 1.51\,L_3 - 0.05\,L_2 - 0.11\,L_1$	0.50^{*}	0.34
	6	$Y = -2.43 + 4.62\,L_3^{**} + 0.08\,L_2^{**}$	0.60^{**}	0.55

Table 30 (Contd.)

5	1	$Y = 4.82 - 2.94\ L_4^{**} + 1.75\ L_5$	0.45^{*}	0.38
	2	$Y = 5.86 - 3.08\ L_4^{**} + 1.31\ L_5$	0.47^{**}	0.40
	3	$Y = 2.18 - 2.88\ L_4^{**} + 3.07\ L_5^{**}$	0.65^{**}	0.60
	4	$Y = 0.11 - 3.77\ L_4^{**} + 3.73\ L_5^{*} + 1.36\ L_3$	0.73^{**}	0.67
	5	$Y = 2.18 - 3.82\ L_4^{**} + 3.73\ L_5^{**}$	0.73^{**}	0.69
	6	$Y = 9.93 - 7.57\ L_4^{**} + 4.01\ L_5^{**} - 2.11\ L_3 - 0.08\ L_2$	0.82^{**}	0.77

Table. 31. Two stage regression models for oil yield for six weeks pwh using Model III

Orders of Harvest	No. of weeks pwh	Prediction Model	R^2	$\bar{R}^2$
1	1	$Y = -0.57 + 0.72 P_5 + 0.41 P_4$	0.61^{**}	0.56
	2	$Y = -0.57 + 0.72 P_5 + 0.41 P_4$	0.61^{**}	0.56
	3	$Y = -0.57 + 0.72 P_5 + 0.41 P_4$	0.61^{**}	0.56
	4	$Y = -0.57 + 0.72 P_5 + 0.41 P_4$	0.61^{**}	0.56
	5	$Y = -0.45 + 0.73 P_5 + 0.38 P_6$	0.60^{**}	0.55
	6	$Y = P_6^{**}$	0.49^{**}	0.45
2	1	$Y = -0.39 + 0.59 P_4^{*} + 0.50 P_3^{*}$	0.81^{**}	0.78
	2	$Y = -0.39 + 0.59 P_4^{*} + 0.50 P_3^{*}$	0.81^{**}	0.78
	3	$Y = -0.39 + 0.59 P_4^{*} + 0.50 P_3^{*}$	0.81^{**}	0.78
	4	$Y = P_4^{**}$	0.75^{**}	0.74
	5	$Y = P_5^{**}$	0.22^{*}	0.17
	6	$Y = P_6$	0.07	0.02
3	1	$Y = -0.83 + 0.80 P_2^{**} + 0.38 P_4$	0.64^{**}	0.59
	2	$Y = -0.83 + 0.80 P_2^{**} + 0.38 P_4$	0.64^{**}	0.59
	3	$Y = -0.81 + 0.75 P_3^{**} + 0.43 P_4$	0.57^{**}	0.51
	4	$Y = -0.59 + 0.70 P_5 + 0.43 P_4$	0.50^{**}	0.43
	5	$Y = P_5^{**}$	0.46^{**}	0.37
	6	$Y = P_6^{**}$	0.41^{**}	0.43
4	1	$Y = -1.45 + 0.29 P_4 + 0.14 P_6 + 0.54 P_3 + 0.35 P_5$	0.85^{**}	0.81
	2	$Y = -1.45 + 0.29 P_4 + 0.14 P_6 + 0.54 P_3 + 0.35 P_5$	0.85^{**}	0.81
	3	$Y = -1.45 + 0.29 P_4 + 0.14 P_6 + 0.54 P_3 + 0.35 P_5$	0.85^{**}	0.81
	4	$Y = -0.83 + 0.71 P_4^{**} + 0.48 P_6^{*}$	0.81^{**}	0.78
	5	$Y = -0.59 + 0.72 P_6 + 0.42 P_5$	0.64^{**}	0.59
	6	$Y = P_6^{**}$	0.60^{**}	0.57
5	1	$Y = 0.20 + 0.82 P_6^{**} + 0.48 P_4 - 0.35 P_2$	0.86^{**}	0.83
	2	$Y = 0.20 + 0.82 P_6^{**} + 0.48 P_4 - 0.35 P_2$	0.86^{**}	0.83
	3	$Y = -0.05 + 0.94 P_6^{**} + 0.44 P_4 - 0.37 P_3$	0.86^{**}	0.83
	4	$Y = -0.27 + 0.73 P_6^{**} + 0.34 P_4$	0.84^{**}	0.82
	5	$Y = P_6^{**}$	0.82^{**}	0.81
	6	$Y = P_6^{**}$	0.82^{**}	0.81

Table 32. **Coefficients of correlation of weather variables and their logarithms pertaining to three fortnights pwh with oil yield for various orders of harvest**

Orders of harvest	No. of fortnights	X_1	X_2	X_3	X_4	X_5	L_1	L_2	L_3	L_4	L_5
1	1	0.258	-0.051	-0.281	0.554*	-0.469*	0.307	0.057	-0.284	0.546*	-0.472
	2	0.033	-0.331	-0.163	0.595**	-0.271	-0.271	0.097	-0.164	0.591	-0.265
	3	-0.484*	-0.236	-0.097	0.544*	-0.384	-0.548*	-0.284	-0.089	0.541*	-0.383
2	1	-0.218	-0.368	0.284	0.683**	-0.461	-0.300	-0.328	0.306	0.688**	-0.463
	2	0.037	0.291	-0.376	0.503*	-0.252	0.087	0.331	-0.370	0.502*	-0.257
	3	0.239	-0.238	0.080	0.640**	-0.374	0.283	-0.324	0.072	0.641**	-0.376
3	1	0.114	-0.416	0.627**	-0.682**	0.379	0.173	-0.438	0.628**	-0.682**	0.383
	2	-0.161	0.041	0.441	-0.636**	0.324	-0.165	0.018	0.442	-0.633**	0.328
	3	-0.012	0.119	0.251	-0.641**	0.276	-0.013	0.158	0.258	-0.644**	0.277
4	1	-0.241	-0.121	0.503*	-0.694**	-0.145	-0.285	-0.289	0.498	-0.703**	-0.148
	2	0.249	0.206	0.156	-0.762**	-0.069	0.215	0.212	0.153	-0.761**	-0.078
	3	-0.344	-0.316	0.546*	-0.432	0.153	-0.262	-0.305	0.551*	-0.439	0.155
5	1	0.011	0.065	0.379	-0.647**	0.258	0.009	-0.140	0.374	-0.623**	0.250
	2	0.110	0.104	0.341	-0.692**	0.493*	0.156	-0.084	0.336	-0.673**	0.497*
	3	0.210	0.143	0.337	-0.765**	0.408	0.356	0.101	0.340	-0.754**	0.412

Table.33. Coefficients of correlation of logarithms of weather variables pertaining to three fortnights pwh with logarithm of oil yield for various orders of harvest

Orders of harvest	No. of Fortnight	L_1	L_2	L_3	L_4	L_5
1	1	0.318	-0.017	-0.318	0.511*	-0.431
	2	0.027	-0.381	-0.095	0.594**	-0.268
	3	-0.523*	-0.330	-0.091	0.538*	-0.355
2	1	-0.317	-0.389	0.321	0.691**	-0.483*
	2	0.118	-0.356	-0.385	0.516*	-0.254
	3	0.272	-0.317	0.073	0.649**	-0.373
3	1	0.148	-0.425	0.624**	-0.676**	0.413
	2	-0.138	0.041	0.425	-0.635**	0.364
	3	-0.004	0.147	0.263	-0.639**	0.291
4	1	-0.284	-0.256	0.471*	-0.710**	-0.146
	2	0.286	0.283	0.135	-0.760**	-0.065
	3	-0.281	-0.327	0.563*	-0.416	0.163
5	1	-0.034	-0.072	0.317	-0.636**	0.233
	2	0.110	-0.082	0.263	-0.703**	0.530*
	3	0.440	0.110	0.304	-0.722**	0.488*

three fortnights had significant positive correlation with logarithm of oil yield, logarithm of number of rainy days (L_1) pertaining to third fortnight pwh had a significant negative correlation with logarithm of oil yield.

Models obtained to predict oil yield for various order of harvests, using weather variables pertaining to three fortnights pwh based on Model I are given in Table 34. Model developed for third fortnight pwh with number of rainy days (X_1) and minimum temperature (X_4) as the independent variables, had a predictability of 41% ($\bar{R}^2 = 0.34$). Number of rainy days (X_{12}), total rainfall (X_{22}), maximum temperature (X_{32}), minimum temperature (X_{42}) and relative humidity (X_{52}), all of which belongs to the second fortnight pwh and number of rainy days (X_{13}) pertaining to the third fortnight pwh were the predictors of the model obtained for second fortnight pwh. It had a coefficient of determination of 0.71($\bar{R}^2 = 0.55$). Maximum predictability among the models of the three fortnights was for the model obtained for first fortnight pwh. It had a predictability of 81% ($\bar{R}^2 = 0.70$), number of rainy days (X_{11}), maximum temperature (X_{31}) and relative humidity (X_{51}) pertaining to first fortnight pwh and number of rainy days (X_{12}), total rainfall (X_{22}) and minimum temperature (X_{42}), pertaining to the second fortnight pwh were the independent variables of this model.

Models obtained to predict oil yield for various orders of harvest based on Model II using weather variables pertaining to three fortnights pwh are presented in Table 35. Model obtained for third fortnight pwh had a predictability of 44 %($\bar{R}^2 = 0.37$). Logarithms of minimum temperature (L_{43}) and number of rainy days (L_{13}) were the independent variables in this model. In the second fortnight pwh, the model had a

Table.34. Models obtained for three fortnights pwh to predict oil yield for various orders of harvest based on Model I

Order of Harvest	No. of Fortnights	Prediction Models	R^2	$\bar{R}^2$
1	1st Fortnight	$Y = -104525.32 + 2481.793 X_{42}^{**} + 65.884 X_{11} - 67.627 X_{22}^{*} - 505.316 X_{51} + 3824.062 X_{31}^{*} + 1559.825 X_{12}$	0.81^{**}	0.70
	2nd Fortnight	$Y = 23558.58 + 1173.40 X_{42} - 62.76 X_{22}^{*} + 1106.39 X_{12} - 1983.46 X_{32} - 720.58 X_{13} + 361.09 X_{52}$	0.71^{*}	0.55
	3rd Fortnight	$Y = -5477.33 + 1196.23 X_{43} - 909.29 X_{13}$	0.41^{*}	0.34
2	1st Fortnight	$Y = -23719.43 + 1700.56 X_{41}^{**} - 8.65 X_{21}$	0.51^{**}	0.44
	2nd Fortnight	$Y = -132431.98 + 4427.93 X_{43} + 403.55 X_{13} + 479.06 X_{52}$	0.50^{*}	0.39
	3rd Fortnight	$Y = -68165.85 + 3524.96 X_{43}^{**} + 396.31 X_{13}$	0.46^{*}	0.44
3	1st Fortnight	$Y = -15684.88 - 1685.99 X_{41} + 528.10 X_{11} + 845.77 X_{32} - 541.39 X_{53} + 1757.5 X_{31} + 502.12 X_{51}$	0.77^{**}	0.65
	2nd Fortnight	$Y = 94895.77 - 2916.98 X_{43}^{**} + 1120.04 X_{32} - 448.64 X_{53}$	0.59^{**}	0.50
	3rd Fortnight	$Y = 110153.22 - 2916.15 X_{43}^{**} - 273.32 X_{53}$	0.46^{**}	0.39
4	1st Fortnight	$Y = 147602.93 - 2041.32 X_{42}^{**} + 1302.19 X_{31}^{**} - 1109.39 X_{52}^{**} + 4.55 X_{22} + 992.94 X_{12}^{**} - 16.98 X_{22} - 1863.46 X_{43}^{*} - 339.88 X_{11} + 281.89 X_{51} + 4.47 X_{23}$	0.97^{**}	0.93
	2nd Fortnight	$Y = 139026.39 - 1965.69 X_{42}^{**} - 694.46 X_{52} + 1180.88 X_{33} - 1864.09 X_{43} + 1061.94 X_{12}^{**} - 30.24 X_{22}^{*}$	0.89^{**}	0.83
	3rd Fortnight	$Y = 28076.31 + 1729.96 X_{33}^{**} - 2214.34 X_{43}^{*} - 11.52 X_{23}$	0.55^{**}	0.45
5	1st Fortnight	$Y = 39109.86 - 2638.16 X_{43}^{**} + 457.97 X_{5}^{**}$	0.75^{**}	0.72
	2nd Fortnight	$Y = 39109.86 - 2638.16 X_{43}^{**} + 457.97 X_{5}^{**}$	0.75^{**}	0.72
	3rd Fortnight	$Y = 83630.385 - 2817.10 X_{4}^{**}$	0.59^{**}	0.56

Table.35. Models obtained for three fortnights pwh to predict oil yield for various orders of harvest based on Model II

Order of Harvest	No. of Fortnights	Prediction Model	R^2	$\bar{R}^2$
1	1st Fortnight	$Y = 10990986.61 + 2520.85\ X_{42} + 58.80\ X_{11} - 64.41\ X_{22}^{*} - 7539012.95\ L_{51} + 348772.18\ L_{31}^{*} + 1657.35\ X_{12} + 97907.66\ L_{43} + 35521.01\ X_{51} - 103665.08\ L_{41}$	0.88^{**}	0.75
	2nd Fortnight	$Y = 193278.40 + 607.84\ X_{42} - 15728.78\ L_{13} - 57.14\ X_{22} - 119004.56\ L_{32} + 884.46\ X_{12}$	0.69^{**}	0.57
	3rd Fortnight	$Y = -55981.65 - 16837.73\ L_{13} + 63000.88\ L_{43}$	0.44^{*}	0.37
2	1st Fortnight	$Y = -173868.55 + 55796.28\ L_{41} - 44144.93\ L_{31}^{**} + 2720.19\ X_{11}^{*} - 5491.43\ L_{21} + 103020.14\ L_{43}$	0.75^{**}	0.64
	2nd Fortnight	$Y = -365034.64 + 253830.49\ L_{43}^{**} + 875.26\ X_{13}^{*} + 32322.11\ L_{12} - 17.58\ X_{22}$	0.60^{*}	0.48
	3rd Fortnight	$Y = -239750.80 + 185632.82\ L_{43}^{**} + 391.68\ X_{13}$	0.46^{**}	0.39
3	1st Fortnight	$Y = -4187108.95 - 111959.01\ L_{41}^{**} + 11221.37\ L_{11}^{*} + 4497034.39\ L_{31} + 136765\ X_{32}^{*} - 100395.35\ L_{53}^{*} - 71502.87\ X_{31}$	0.82^{**}	0.72
	2nd Fortnight	$Y = 3336590.58 - 225261.75\ L_{43}^{**} + 44366.11\ X_{32}^{*} - 109920.67\ L_{53} - 2794660.01\ L_{32}^{*} + 4152.41\ L_{12}$	0.74^{**}	0.63
	3rd Fortnight	$Y = 332843.02 - 152693.23\ L_{43}^{**} - 54508.40\ L_{53}$	0.46^{**}	0.39

4	1st Fortnight	$Y= 10050137.48 - 2512.66 X_{42}^{*} + 80028.43 X_{31}^{*} - 3249006.28 L_{52} + 15678.38 X_{52} - 5182574.60 L_{31}^{*} + 126100.61 L_{33}^{*} - 919.45 L_{23} - 85509.28 L_{43} + 119328.84 L_{41}$	0.94^{**}	0.87
	2nd Fortnight	$Y= 7551046.02 - 2252.94 X_{42}^{**} - 4987518.49 L_{52}^{**} + 244244.37 X_{52} + 61089.10 L_{33}$	0.85^{**}	0.81
	3rd Fortnight	$Y= 26136.89 + 112026.57 L_{33}^{*} - 119489.57 L_{43}^{*} - 11.15 X_{23}$	0.55^{**}	0.46
5	1st Fortnight	$Y= -2920126.94 - 59562.93 X_{43}^{*} - 79611.83 L_{52} + 2789402.88 L_{43}^{*} + 232324.83 L_{42}^{*} + 223644.53 L_{53}^{*} - 42520.97 L_{51}$	0.89^{**}	0.82
	2nd Fortnight	$Y= -3405707.43 - 52976.14 X_{43}^{*} - 105309.21 L_{52} + 2520855.37 L_{43} + 1089271.17 L_{42} + 176678.57 L_{53}^{*} - 17716.23 X_{42}$	0.88^{**}	0.81
	3rd Fortnight	$Y = 1119722.77 - 23971.14 X_{43} + 77993.03 L_{53} + 1130127.47 L_{43}$	0.77^{**}	0.72

predictability of 70% ($\bar{R}^2$ = 0.59). Number of rainy days (X_{12}), total rainfall (X_{22}), minimum temperature (X_{42}) and logarithm of maximum temperature (L_{32}) were the weather variables in this model in addition to logarithm of number of rainy days (L_{13}) pertaining to the third fortnight pwh. Model for first fortnight pwh had a predictability of 88 % ($\bar{R}^2$ = 0.75). Number of rainy days (X_{11}), relative humidity (X_{51}) and its logarithm (L_{51}) and logarithm of maximum temperature (L_{31}), pertaining to the first fortnight pwh, number of rainy days (X_{12}), total rainfall (X_{22}) and minimum temperature (X_{42}), pertaining to second fortnight pwh and logarithm of minimum temperature (L_{43}), pertaining to the third fortnight pwh were the predictors of this model.

Models obtained for various fortnights to predict oil yield for various orders of harvest using Model III are presented in Table 36. Model for third fortnight pwh with logarithms of number of rainy days (L_{13}) and minimum temperature (L_{43})as its explanatory variables had a coefficient of determination of 0.42 ($\bar{R}^2$ = 0.34). For the second fortnight, the predictability had gone up to 62 % ($\bar{R}^2$= 0.51). Logarithms of total rainfall (L_{22}), maximum temperature (L_{32}) and minimum temperature (L_{42}) of the second fortnight pwh and logarithm of number of rainy days of third fortnight pwh (L_{13}) were the predictors of this model. Model obtained for first fortnight pwh had a coefficient of determination of 0.82 ($\bar{R}^2$ = 0.73). Logarithms of number of rainy days (L_{11}), total rainfall (L_{21}), maximum temperature (L_{31}) and relative humidity (L_{51}) pertaining to the first fortnight pwh were the explanatory variables of this model in addition to logarithms of total rainfall (L_{22}) and minimum temperature (L_{42}) pertaining to the second fortnight pwh.

Table.36. Models obtained for three fortnights pwh to predict oil yield for various orders of harvest based on Model III

Order of Harvest	No. of Fortnights	Prediction Models	R^2	$\bar{R}^2$
1	1 st Fortnight	$Y = -0.57 + 3.54 L_{42}^{**} - 0.12 L_{22}^{**} - 3.06 L_{55}^{*} + 0.24 L_{1}^{*} + 4.30 L_{3}^{*} - 0.09 L_{2}$	0.82^{**}	0.73
	2 nd Fortnight	$Y = 6.45 + 1.22 L_{4} - 0.15 L_{2}^{*} - 0.38 L_{13} - 2.213 L_{3}$	0.62^{**}	0.51
	3 rd Fortnight	$Y = 2.48 + 1.47 L_{43} - 0.35 L_{13}$	0.42^{*}	0.34
2	1 st Fortnight	$Y = -1.93 + 1.75 L_{4} - 0.20 L_{1} + 2.85 L_{43}$	0.59^{**}	0.51
	2 nd Fortnight	$Y = -5.69 + 6.73 L_{43}^{**} + 0.47 L_{13} + 0.85 L_{1} - 0.24 L_{2}$	0.59^{*}	0.46
	3 rd Fortnight	$Y = -3.17 + 5.26 L_{43}^{**} + 0.21 L_{13}$	0.46^{**}	0.39
3	1 st Fortnight	$Y = 0.19 - 1.68 L_{41} + 0.26 L_{11}^{*} + 2.76 L_{31} + 1.01 L_{32} - 2.53 L_{53}^{*} + 2.86 L_{51}$	0.75^{**}	0.62
	2 nd Fortnight	$Y = 10.84 - 3.65 L_{43}^{**} + 0.05 L_{22} - 1.84 L_{53} + 1.29 L_{32}$	0.57^{*}	0.44
	3 rd Fortnight	$Y = 11.12 - 3.42 L_{43}^{**} - 1.12 L_{53}$	0.45^{*}	0.37
4	1 st Fortnight	$Y = 20.64 - 1.84 L_{42} - 5.05 L_{52} + 1.51 L_{31} + 0.16 L_{12} - 3.44 L_{43} - 0.16 L_{11} + 0.06 L_{21} - 1.04 L_{33}$	0.94^{**}	0.89
	2 nd Fortnight	$Y = 14.97 - 2.35 L_{42}^{*} - 3.05 L_{52}^{*} + 0.22 L_{12}^{*} - 1.91 L_{43} - 0.11 L_{22} + 0.856 L_{33}$	0.87^{**}	0.79
	3 rd Fortnight	$Y = 4.06 + 2.37 L_{33}^{*} - 2.21 L_{43}^{*} - 0.05 L_{23}$	0.54^{*}	0.44
5	1 st Fortnight	$Y = 9.10 - 7.69 L_{43}^{**} + 5.97 L_{53}^{**} - 2.53 L_{31} - 2.11 L_{51} + 1.34 L_{41}$	0.86^{**}	0.81
	2 nd Fortnight	$Y = 2.81 - 4.63 L_{42}^{**} + 3.97 L_{52}^{**}$	0.76^{**}	0.73
	3 rd Fortnight	$Y = 2.81 - 4.63 L_{43}^{**} + 3.97 L_{53}^{**}$	0.76^{**}	0.73

Coefficients of correlation of generated weather variables of Model IV mentioned in chapter 3. with oil yield for various orders of harvest are given in Tables 37- 41. Generated variables whose correlation coefficient was significant at 1 % level were chosen for developing prediction models. Models obtained for three fortnights pwh are presented in Table 42. It may be noted that for oil yield of first harvest, prediction model developed for third fortnight pwh had a predictability of 42 % ($\bar{R}^2 = 0.38$). However in the second fortnight pwh, the model had a predictability of 51 % ($\bar{R}^2 = 0.45$). Maximum predictability among the models fitted for three fortnights was for the model obtained for first fortnight pwh, and the coefficient of determination was 0.61($\bar{R}^2 = 0.53$).

4.3.1.3. Principal component analysis for oil yield:

The latent roots, percentage variance and cumulative variance accounted by the different components in explaining the variation in oil yield as obtained from the principal components analysis for various orders of harvest are presented in Table.43. Generated weather variables used for arriving at Models IV for various orders of harvest were used for principal component analysis.

Regression models were also worked out with principal components as explanatory variables. The prediction models developed in the process are given in Table.44.

The analysis showed that the first two components could explain about 97% of the total variations for first harvest. In the case of second and third harvest, the first component alone had explained 99% of variation. However for the fourth harvest, the

Table. 37. Coefficients of correlation of generated weather pertaining to three fortnights pwh with oil yield of first harvest

No. of fortnights	j	Z_1	Z_2	Z_3	Z_4	Z_5	Q_{12}	Q_{13}	Q_{14}	Q_{15}	Q_{23}	Q_{24}	Q_{25}	Q_{34}	Q_{35}	Q_{45}
1	0	-0.142	-0.192	-0.574*	0.509*	-0.399	-0.184	-0.214	-0.031	-0.230	-0.214	-0.143	-0.225	0.204	-0.555*	0.004
	1	-0.539*	-0.508*	0.631**	0.531**	-0.503*	-0.461	-0.561*	-0.490*	-0.597**	-0.541*	-0.560*	-0.493*	0.596**	-0.609**	0.252
	2	-0.557*	-0.512*	-0.650**	0.549*	-0.569*	-0.447	-0.573*	-0.401	-0.653**	-0.552*	-0.485*	-0.539*	0.456	-0.632**	0.165
2	0	-0.374	-0.352	-0.606**	0.470*	-0.320	-0.376	-0.444	-0.283	-0.429	-0.390	-0.318	-0.371	0.100	-0.488*	-0.340
	1	-0.567*	-0.529*	-0.651**	0.495*	-0.372	-0.475*	-0.587*	-0.498*	-0.639**	-0.566*	-0.521*	-0.542*	0.498*	-0.563*	0.240
	2	-0.575*	-0.517*	-0.656**	0.515*	-0.422	-0.500*	-0.586*	-0.509*	-0.644**	-0.557*	-0.494*	-0.544*	0.379	-0.616**	0.143
3	0	-0.563*	-0.185	-0.381	0.524*	-0.274	-0.356	-0.577*	-0.499*	-0.626**	-0.212	-0.149	-0.211	0.245	-0.360	-0.069
	1	-0.574*	-0.467	-0.476*	0.534*	-0.331	-0.441	-0.583*	-0.512*	-0.638**	-0.484*	-0.472*	-0.492*	0.420	-0.390	0.227
	2	-0.573*	-0.430	-0.492*	0.542*	-0.404	-0.444	-0.584*	-0.509*	-0.644**	-0.458	-0.411	-0.464	0.426	-0.425	0.121

Table. 38. Coefficients of correlation of generated weather pertaining to three fortnights pwh with oil yield of second harvest

No. of fortnights	j	Z_1	Z_2	Z_3	Z_4	Z_5	Q_{12}	Q_{13}	Q_{14}	Q_{15}	Q_{23}	Q_{24}	Q_{25}	Q_{34}	Q_{35}	Q_{45}
1	0	0.032	-0.435	0.267	0.599**	-0.329	-0.408	0.167	0.252	-0.049	-0.427	-0.349	-0.473*	0.450	0.148	0.593**
	1	0.392	-0.559*	0.387	0.702**	-0.438	-0.549*	0.455	0.581*	-0.408	-0.547*	-0.515*	-0.578*	0.621**	-0.309	0.708**
	2	0.037	-0.573*	0.445	0.727**	-0.452	-0.573*	0.064	0.530*	-0.167	-0.560*	-0.537*	-0.586*	0.709**	0.222	0.734**
2	0	0.284	-0.530*	0.206	0.618**	-0.265	-0.544*	0.311	0.501*	0.203	-0.542*	-0.473*	-0.555*	0.708**	-0.005	0.616**
	1	0.365	-0.582*	0.508*	0.704**	-0.361	-0.597**	0.344	0.554*	0.345	-0.586*	-0.545*	-0.594*	0.768**	-0.528*	0.694**
	2	0.330	-0.581*	0.509*	0.749**	-0.375	-0.595**	0.319	0.556*	0.249	-0.581*	-0.547*	-0.590**	0.788**	0.081	0.731**
3	0	0.239	-0.213	-0.017	0.344	-0.130	-0.169	0.229	0.300	0.213	-0.221	-0.172	-0.232	0.345	-0.080	0.343
	1	0.266	-0.223	-0.155	0. 357	-0.270	-0.179	0.256	0.324	0.237	-0.229	-0.191	-0.239	0.381	-0.107	0.343
	2	0.270	-0.224	-0.056	0.366	-0.253	-0.160	0.260	0.329	0.240	-0.228	-0.192	-0.240	0.395	-0.117	0.343

Table. 39. Coefficients of correlation of generated weather pertaining to three fortnights pwh with oil yield of third harvest

No. of fortnights	j	Z_1	Z_2	Z_3	Z_4	Z_5	Q_{12}	Q_{13}	Q_{14}	Q_{15}	Q_{23}	Q_{24}	Q_{25}	Q_{34}	Q_{35}	Q_{45}
1	0	-0.059	-0.064	0.515*	-0.668**	0.419	-0.068	0.067	-0.246	0.037	0.013	-0.177	-0.018	-0.416	0.574*	-0.521*
	1	-0.284	-0.500*	0.593**	-0.672**	0.452	-0.337	0.361	-0.351	0.299	-0.501*	-0.526*	-0.475*	-0.489*	0.607**	-0.557*
	2	-0.170	-0.049	0.624**	-0.676**	0.481*	-0.108	0.081	-0.344	0.020	0.081	-0.302	0.009	-0.509*	0.628**	-0.578*
2	0	-0.152	0.127	0.387	-0.656**	0.427	0.047	-0.089	-0.292	-0.071	0.190	0.038	0.160	-0.404	0.525*	-0.459
	1	-0.232	0.399	0.440	-0.661**	0.469*	0.288	-0.230	-0.346	-0.191	0.432	0.349	0.400	-0.453	0.563*	-0.485*
	2	-0.215	0.318	0.455	-0.665**	0.499*	0.178	-0.150	-0.343	-0.138	0.378	0.202	0.336	-0.464	0.587*	-0.496*
3	0	-0.012	0.120	0.260	-0.641**	0.293	0.044	0.040	-0.107	0.020	0.169	0.060	0.132	-0.260	0.389	-0.442
	1	-0.144	0.378	0.329	-0.642**	0.303	0.279	0.154	-0.219	0.128	0.387	0.362	0.359	-0.345	0.417	-0.447
	2	-0.065	0.300	0.355	-0.643**	0.312	0.160	0.067	-0.216	0.032	0.351	0.204	0.300	-0.371	0.436	-0.448

Table. 40. Coefficients of correlation of generated weather pertaining to three fortnights pwh with oil yield of fourth harvest

No. of fortnights	j	Z_1	Z_2	Z_3	Z_4	Z_5	Q_{12}	Q_{13}	Q_{14}	Q_{15}	Q_{23}	Q_{24}	Q_{25}	Q_{34}	Q_{35}	Q_{45}
1	0	-0. 217	-0. 125	0. 464	-0. 713**	-0. 037	-0. 101	-0. 170	-0 .352	-0. 191	-0. 088	-0. 203	-0. 109	-0. 342	0. 350	-0.857**
	1	-0. 526*	-0. 458	0. 581*	-0. 737**	-0. 392	-0. 523*	-0. 527*	-0. 567*	-0. 534*	-0. 436	-0. 473*	-0. 454	-0. 591**	0. 575*	-0. 854**
	2	-0. 450	-0. 364	0. 609**	-0.750**	0. 012	-0. 318	-0. 405	-0. 578	-0. 402	-0. 322	-0. 448	-0. 323	-0. 541	0. 555	-0. 847**
2	0	-0. 094	-0. 070	0. 395	-0. 674**	0. 043	-0. 050	-0. 057	-0. 190	-0. 068	-0. 046	-0. 124	-0. 053	-0. 313	0. 343	-0. 813**
	1	-0. 411	-0. 458	0. 554*	-0. 714**	0. 372	-0. 520	-0. 388	-0. 408	-0. 416	-0. 442	-0. 459	-0. 457	-0. 631**	0. 625**	-0. 830**
	2	-0. 232	-0. 346	0. 593**	-0. 738**	0. 066	-0. 285	-0. 150	-0. 367	-0. 174	-0. 307	-0. 417	-0. 304	-0. 552*	0. 577*	-0. 829**
3	0	-0. 344	-0. 316	0. 547*	-0. 432	0. 165	-0. 338	-0. 308	-0. 388	-0. 324	-0. 283	-0. 350	-0. 299	0. 063	0. 578*	-0. 459
	1	-0. 344	-0. 397	0. 581*	-0. 436	0. 186	-0. 393	-0. 308	-0. 388	-0. 325	-0. 374	-0. 424	-0. 379	0. 284	0. 600**	-0. 459
	2	-0. 344	-0. 423	0. 605**	-0. 439	0. 198	-0. 420	-0. 309	-0. 388	-0. 326	-0. 397	-0. 447	-0. 405	0. 162	0. 617**	-0. 459

Table. 41. Coefficients of correlation of generated weather pertaining to three fortnights pwh with oil yield of fifth harvest

No. of Fortnights	j	Z_1	Z_2	Z_3	Z_4	Z_5	Q_{12}	Q_{13}	Q_{14}	Q_{15}	Q_{23}	Q_{24}	Q_{25}	Q_{34}	Q_{35}	Q_{45}
1	0	0. 150	0. 133	0. 373	-0. 727**	0. 414	0. 133	0. 183	0. 087	0. 172	0. 162	0. 079	0. 149	-0 .640**	0. 643**	-0. 346
	1	0. 469	0. 452	0. 393	-0. 736**	0. 457	0. 347	0. 459	0. 494	0. 445	0. 424	0. 486	0. 440	-0. 652**	0. 658**	-0. 365
	2	0. 361	0. 412	0. 405	-0. 745**	0. 478*	0. 321	0. 392	0. 249	0. 383	0. 414	0. 376	0. 425	-0. 662**	0. 669**	-0. 376
2	0	0. 177	0. 140	0. 353	-0.754**	0. 468	0. 138	0. 208	0. 117	0. 191	0. 169	0. 085	0. 155	-0. 616**	0. 686**	0. 332
	1	0. 441	0. 469*	0. 380	-0. 759**	0. 476	0. 328	0. 432	0. 463	0. 428	0. 443	0. 491	0. 458	-0. 622**	0. 692**	-0. 355
	2	0. 361	0. 415	0. 398	-0. 763**	0. 484	0. 319	0. 387	0. 260	0. 379	0. 418	0. 380	0. 428	-0. 627**	0. 696**	-0. 368
3	0	0. 210	0. 143	0. 332	-0. 766**	0. 387	0. 150	0. 242	0. 152	0. 219	0. 169	0. 094	0. 150	-0. 627**	0. 616**	-0. 352
	1	0. 285	0. 189	0. 381	-0. 768**	0. 390	0. 152	0. 314	0. 231	0. 290	0. 203	0. 179	0. 193	-0. 625**	0. 627**	-0 .351
	2	0. 306	0. 191	0. 408	-0. 769**	0. 390	0. 154	0. 337	0. 247	0. 310	0. 206	0.162	0. 195	-0. 622**	0. 634**	-0. 349

Table.42. Models obtained for oil yield of various orders of harvest using Model IV for three fortnights pwh

Orders of Harvest	No. of Fortnights	Prediction Model	R^2	$\bar{R}^2$
1	1	$Y = 42119.41 - 1806.02\ Z_{322} + 47.80\ Q_{3411} - 14.28\ Q_{1522}$	0.61^{**}	0.53
	2	$Y = 85439.57 - 2287.89\ Z_{322} - 18.21\ Q_{1522}$	0.51^{**}	0.45
	3	$Y = 28444.54 - 30.84\ Q_{1523}^{**}$	0.42^{**}	0.38
2	1	$Y = -46043.24 + 32.48\ Q_{3422} + 18.20\ Q_{4522} - 2.63\ Q_{1222}$	0.72^{**}	0.66
	2	$Y = -46043.24 + 32.48\ Q_{3422} + 18.20\ Q_{4522} - 2.63\ Q_{1222}$	0.72^{**}	0.66
	3	$Y = -16369.41 + 41.50\ Q_{3423}$	0.16	0.10
3	1	$Y = 10839.31 - 71274.90\ Z_{421} + 69810.02\ Z_{411} + 1558.58\ Z_{401}$	0.59^{**}	0.51
	2	$Y = 69706.14 - 2218.86\ Z_{422}^{**}$	0.44^{**}	0.41
	3	$Y = 68886.64 - 2189.74\ Z_{423}^{**}$	0.41^{**}	0.38
4	1	$Y = 81656.63 - 38.98\ Q_{4501}^{**} + 112.67\ Q_{3523} - 103.51\ Q_{3513}$	0.82^{**}	0.78
	2	$Y = 61636.97 - 33.48\ Q_{4512}^{**} + 105.56\ Q_{3523} - 92.76\ Q_{3513}$	0.82^{**}	0.78
	3	$Y = -33633.35 + 143.09\ Q_{3523} - 120.43\ Q_{3513}$	0.43^{*}	0.36
5	1	$Y = 82795.09 - 1307.59\ Z_{413} + 18.33\ Q_{3503}^{**} - 871.30\ Q_{3403}^{*} + 750.05\ Q_{3423}$	0.84^{**}	0.79
	2	$Y = 74256.67 - 1235.03\ Z_{423} + 19.19\ Q_{3502}^{**} - 856.03\ Q_{3403}^{*} + 741.92\ Q_{3423}^{*}$	0.85^{**}	0.81
	3	$Y = 82795.09 - 1307.59\ Z_{413} + 18.33\ Q_{3503}^{**} - 871.30\ Q_{3403}^{*} + 750.05\ Q_{3423}$	0.84^{**}	0.79

Table .43. Latent roots, percentage variance and cumulative variance for oil yield

Orders of harvest	Components	Latent Roots	Percentage Variance	Cumulative Variance
First	1	149503.32	79.44	79.44
	2	33783.89	17.95	97.39
Second	1	61092928.81	99.14	99.14
Third	1	27006.91	99.92	99.92
Fourth	1	97083.80	71.45	71.45
	2	343680.25	25.29	96.74
Fifth	1	210104.23	92.01	92.01

Table. 44. Models obtained for oil yield of various orders of harvest using principal components as explanatory variables

Orders of harvest	Prediction model	R^2	$\bar{R}^2$
1	$Y = 60625.25 - 9.94\ F_1^{**} - 4.62\ F_2$	0.50	0.44
2	$Y = 19052.96 - 0.41\ F_1^{**}$	0.35	0.31
3	$Y = -24181.97 + 1.26\ F_1^{**}$	0.38	0.34
4	$Y = 73194.05 - 1.46\ F_1^{**} - 5.27\ F_2$	0.78^{**}	0.75
5	$Y = -42320.16 + 8.07\ F_1^{**}$	0.46	0.43

first two components together explained about 97% of variation. Of these the first component alone explained about 71% of variation. The first component in the case of fifth harvest explained 92% of variation.

The regression of oil yield on principal components for various orders of harvest showed that there was no appreciable amount of increase in the value of R^2 by choosing the component vectors as explanatory variables. The first two components as explanatory variables alone explained about 50% ($\bar{R}^2 = 0.44$) of variation in oil yield of first harvest. For the second harvest 35% ($\bar{R}^2 = 0.31$) of variation in oil yield could be explained by using first component alone. In the case of third harvest the predictability of the model fitted using the first component was 38 % ($\bar{R}^2 = 0.34$). However for the fourth harvest, a relatively higher degree of precision could be attained for the prediction model, using the first two components as explanatory variables. The model obtained had a coefficient of determination of 0.78 ($\bar{R}^2 = 0.75$). However for the fifth harvest, model obtained explained about 46% ($\bar{R}^2 = 0.43$) of variation in oil yield.

4.2.2.Second Harvest (By June last- first week of July):

Coefficients of correlation of weather variables pertaining to six weeks pwh with yield (From Table 3) showed that number of rainy days and its logarithm five weeks pwh had significant positive correlation with yield of second harvest. Minimum temperature and its logarithm two weeks and four weeks pwh, total rainfall and its logarithm, one-week pwh also had significant positive correlation with yield.

Coefficients of correlation of logarithms of weather variables pertaining to six weeks pwh with logarithms of grass yield (Table 4) showed that for second harvest, logarithms of number of rainy days, five weeks pwh and total rain fall one week pwh had significant positive correlation with logarithm of yield. Logarithm of maximum temperature one-week pwh had significant negative correlation with logarithm grass yield of second harvest. Logarithm of minimum temperature two weeks and four-week pwh had a significant positive correlation with logarithm of grass yield.

4.2.2.1. Two stage regression Models:

Two-stage models obtained for grass yield of second harvest (Table 6) showed that, the model obtained for six weeks pwh had a low coefficient of determination of 0.23 ($\bar{R}^2$ = 0.18). In the fifth week, pwh two stage model obtained with predicted value of fifth week pwh as independent variable had a predictability of 45% ($\bar{R}^2$ = 0.41). In the two-stage model obtained for fourth week pwh, predicted values of fourth and fifth week pwh obtained from first-stage model were the independent variables for the model. The coefficient of determination of this model was 0.65 ($\bar{R}^2$ = 0.60). Models obtained for second and third week pwh were the same as that obtained for the fourth week pwh. However, model for first week pwh had a maximum predictability of 82% ($\bar{R}^2$ = 0.80). Predicted values of first and fifth week pwh were the predictors of this model.

Two-stage models for grass yield of second harvest using Model II (Table 8) for sixth week pwh had a coefficient of determination of 0.73 ($\bar{R}^2$ = 0.71). Model obtained for fifth week pwh had a predictability of 77% ($\bar{R}^2$ = 0.74). Predicted values of fifth and sixth week pwh were the independent variables of this model. However model obtained for the fourth week pwh, was same as that of the fifth week pwh. In the case of third week pwh, the model obtained had a predictability of 81% ($\bar{R}^2$ = 0.79). Predicted values of third and sixth week pwh were the explanatory variables of this model. In the second week however, the predictability of the model developed had gone up to 85% ($\bar{R}^2$ = 0.81) and predicted values of second, third and sixth week pwh were the predictors of this model. Maximum predictability was obtained for the model developed for one-week pwh, ($\bar{R}^2$ = 0.89 and $\bar{R}^2$ = 0.85). The independent variables of the model comprised of predicted values of first, second, third, fourth and sixth weeks pwh.

First-stage prediction models obtained for yield based on Model III (Table 9) and two stage models developed (Table 10) showed that, two stage model obtained for sixth week pwh had a low predictability of 29% ($\bar{R}^2$ = 0.24). By the fifth week pwh, the predictability of the model was 54% ($\bar{R}^2$ = 0.48). Predicted values of fifth and sixth week's pwh were the independent variables of the model. Prediction model for fourth week pwh was same as that of the fifth week. In the third week, pwh the prediction model developed had predicted values of third week and fifth week pwh as independent variables and predictability of the model was 57% ($\bar{R}^2$ = 0.51). Prediction model for second week pwh had a predictability of 57% ($\bar{R}^2$ = 0.51). Predicted values of second week and fifth week pwh were the predictors of the model. However maximum predictability was obtained for one-week pwh, the coefficient of determination being 0.65 ($\bar{R}^2$ = 0.58). Predicted values of first, third and fifth week pwh were the predictors of the model.

4.2.2.2.Influence of fortnightly weather variables:

Coefficients of correlation of weather variables and their logarithms pertaining to three fortnights pwh with grass yield for various orders of harvest

(Table 11) showed that for second harvest, number of rainy days and its logarithm three fortnights pwh and minimum temperature one fortnight pwh had significant positive correlation with grass yield. Logarithms of total rainfall one fortnight pwh also had significant positive correlation with grass yield of second harvest.

Coefficients of correlation of logarithms of weather variables pertaining to three fortnights pwh with logarithms of grass yield presented in (Table 12) showed that, total rainfall one fortnight pwh was the only weather variable having significant positive correlation with logarithm of grass yield for second harvest.

Models developed for three fortnights pwh using Model I (Table 13) revealed that for second harvest, model obtained for third fortnight pwh had a coefficient of determination of 0.40 ($\bar{R}^2 = 0.32$). Number of rainy days and minimum temperature were the independent variables of this model. Model obtained for second fortnight pwh had a predictability of 49% ($\bar{R}^2 = 0.38$). Number of rainy days pertaining to the third fortnight, maximum temperature and minimum temperature pertaining to the second fortnight pwh were the independent variables of this model. Maximum predictability was attained for the model obtained for first fortnight pwh, the coefficient of determination being 0.74 ($\bar{R}^2 = 0.66$). Total rainfall and minimum temperature were the variables in the model pertaining to the first fortnight pwh, in addition to number of rainy days pertaining to third fortnight pwh and maximum temperature pertaining to the second fortnight pwh.

Models based on Model II (Table 14) for second harvest, indicated that, model developed for third fortnight pwh had a predictability of 49% ($\bar{R}^2 = 0.38$). Number of rainy days, total rainfall and minimum temperature pertaining to the same fortnight were the predictors of the model. Whereas for the second fortnight pwh, the model obtained had a coefficient of determination of 0.51 ($\bar{R}^2 = 0.40$). Number of rainy days pertaining to third fortnight pwh, maximum temperature and minimum temperature pertaining to the second fortnight pwh were the explanatory variables of this model. However, maximum predictability of 95% ($\bar{R}^2 = 0.88$) was attained for the model obtained for first fortnight pwh. Number of rainy days and its logarithm, logarithm of total rainfall, minimum temperature, relative humidity and its logarithm, all pertaining to the first fortnight, were the independent variables of this model in addition to number of rainy days, total rainfall and minimum temperature, pertaining to the third fortnight pwh.

Prediction model obtained for based on Model III (Table 15), revealed that the predictability of the model for third fortnight pwh was very poor ($R^2 = 0.18$, $\bar{R}^2 = 0.13$). Logarithm of minimum temperature was the only predictor of the model. However by the second fortnight, the predictability of the model had gone up to 59% ($\bar{R}^2 = 0.37$). Logarithms of number of rainy days, total rainfall, minimum temperature and relative humidity were the variables in the model pertaining to the second fortnight pwh. Logarithms of number of rainy days and minimum temperature pertaining to the third fortnight pwh were the other variables in this model. Logarithms of number of rainy days, total rainfall, minimum temperature and relative humidity pertaining to first fortnight pwh, were the variables in the model developed for one fortnight pwh. In addition to these, logarithm of number of rainy days pertaining to third fortnight pwh was the other independent variables of this model. The coefficient of determination of this model was 0.79 ($\bar{R}^2 = 0.71$).

Coefficients of correlation of generated weather variables with grass yield of second harvest (Table 17) revealed that there were several variables significant at both 1% and 5 % level. Generated weather variables significant at 1 % along with those significant at 5 % were used for model building. In the case of variables significant at 5 % level, those having a correlation coefficient greater than or equal to 0.5 were selected.

Models developed to forecast grass yield of second harvest using Model IV for three fortnights pwh (Table 21) showed that models obtained for second and third fortnights pwh were same and it had a coefficient of determination 0.45 ($\bar{R}^2$ =0.37). Model obtained for first fortnight pwh, however had a coefficient of determination of 0.77 ($\bar{R}^2$ = 0.68).

4.3.2.Oil yield:

Coefficients of correlation of weather variables and their logarithms with oil yield for various order of harvests (Table 24) showed that maximum temperature and its logarithm three weeks pwh, minimum temperature and its logarithm one, two, three and four weeks pwh had significant positive correlation with oil yield. Coefficients of correlation of logarithm of various weather variables with logarithm of oil yield of second harvest (Table 25) revealed that logarithm of total rainfall, two weeks and three weeks pwh had a significant negative correlation with logarithm of oil yield. Further logarithm of maximum temperature, three weeks pwh and logarithm of minimum temperature four weeks pwh had a significant positive correlation with logarithm of yield.

4.3.2.1. Two stage regression models

First stage models based on Model (Table 26) for oil yield of second harvest indicated that two-stage models based on Model I obtained for fifth and sixth weeks pwh (Table 27) had a very low predictability. The coefficient of determination being 0.20 ($\bar{R}^2$ = 0.15) and 0.051 ($\bar{R}^2$ = 0.002) respectively. However by fourth week pwh, the predictability of the model had gone up to 71% ($\bar{R}^2$ = 0.70). In the third week pwh, predictability of the model had further gone up to 78% ($\bar{R}^2$ = 0.75). Predicted values of third and fourth weeks pwh were the independent variables of this model. Models for first and second week pwh were the same as that of the third week.

First stage and two-stage models based on Model II (Table 28 and 29) revealed that, the two stage model for oil yield of second harvest obtained for third fortnight pwh had a coefficient of determination of 0.20 ($\bar{R}^2$ = 0.15). Model for fifth week pwh, with predicted values of fifth and sixth week's pwh as independent variables had a predictability of 31% ($\bar{R}^2$ = 0.22). On the other hand, model for fourth week pwh had a coefficient of determination of 0.79 ($\bar{R}^2$ = 0.77). However models obtained for second and third weeks pwh were found to be same, with a predictability of 83% ($\bar{R}^2$ = 0.80). Maximum predictability of 89 % ($\bar{R}^2$ = 0.87) was obtained for the model developed for first fortnight pwh. The predictors of this model , were predicted values of first and fourth week pwh.

Two-stage model developed for sixth week pwh using Model III (Table 31) had a very low coefficient of determination of 0.074 ($\bar{R}^2$ = 0.016). In the fifth week pwh, the model had a coefficient of determination of 0.22 ($\bar{R}^2$ = 0.17). However, there was a substantial increase in the value of coefficient of determination for the model obtained for fourth week pwh, the value being 0.75 ($\bar{R}^2 = 0.74$). However models for first, second and third weeks pwh were found to be same. The coefficient of determination of this model was 0.81 ($\bar{R}^2 = 0.78$). Predicted values of third week and fourth week pwh were the independent variables of the model developed for these weeks.

4.3.2.2. Influence of fortnightly weather variables:

Coefficients of correlation of weather variables and its logarithms pertaining to three fortnights pwh (Table 32) revealed that minimum temperature and its logarithm had significant positive correlation with oil yield of second harvest. Further logarithm of minimum temperature had significant positive correlation with logarithm of oil yield of second harvest (Table 33). In addition to this, logarithm of relative humidity had a significant negative correlation with logarithm of oil yield of second harvest.

Prediction models obtained for third fortnight pwh based on Model I (Table 34) to predict oil yield of second harvest, had a predictability of 46% ($\bar{R}^2 = 0.39$). Number of rainy days and minimum temperature were the explanatory variables of this model. However model obtained for second fortnight pwh had a predictability of 50% ($\bar{R}^2 = 0.39$). Relative humidity pertaining to the current fortnight and number of rainy days, minimum temperature pertaining to the previous fortnight were the independent variables of the model obtained for second fortnight pwh. Minimum temperature and total rainfall were the predictors of the model developed for one fortnight pwh, and predictability of the model was 51 % ($\bar{R}^2 = 0.44$).

On the other hand model for oil yield of second harvest obtained for third fortnight pwh using Model II (Table 35) had a predictability of 46% ($\bar{R}^2 = 0.39$). Number of rainy days and logarithm of minimum temperature were the independent variables of this model. Logarithms of number of rainy days, total rainfall, pertaining to second fortnight and number of rainy days, logarithm of minimum temperature pertaining to the third fortnight pwh were the variables of the model obtained for second fortnight pwh. The coefficient of determination of the model was 0.60 ($\bar{R}^2 = 0.48$). Maximum predictability among the models for three fortnights pwh was obtained for the model developed for one fortnight pwh. Number of rainy days and its logarithm, logarithms of total rainfall and minimum temperature were the variables pertaining to first fortnight pwh in this model. In addition to these, logarithm of minimum temperature pertaining to the third fortnight was the other explanatory variable of the model for first fortnight pwh. The predictability of this model was 75 % ($\bar{R}^2 = 0.64$).

Predictability of model obtained for third fortnight pwh using Model III (Table 36) to forecast oil yield of second harvest, was 46% ($\bar{R}^2 = 0.39$). Logarithms of number of rainy days and minimum temperature were the most influencing variables during that fortnight. The coefficient of determination of the model for second fortnight was 0.59 ($\bar{R}^2 = 0.46$). Logarithms of number of rainy days, total rainfall were the variables pertaining to the second fortnight pwh in this model. Explanatory variables of the model obtained for third fortnight pwh were the other independent variables of this model. Logarithm of number of rainy days, minimum temperature pertaining to one fortnight pwh and logarithm of minimum temperature pertaining to third fortnight pwh, were the predictors of the model obtained for first fortnight pwh. The coefficient of determination of this model was 0.59 ($\bar{R}^2 = 0.51$).

Generated variables whose correlation coefficient was significant at 1 % level (Table 38) were used for developing prediction models. Model using Model IV (Table 42) for third fortnight pwh to forecast oil yield of second harvest had a coefficient of determination of 0.16 ($\bar{R}^2 = 0.10$). However, models developed for first and second fortnight pwh were found to be same, their predictability being 72 % ($\bar{R}^2 = 0.66$).

4.2.3.Third Harvest (By mid August):

Coefficients of correlation of weather variables and their logarithms (Table 3) showed that number of rainy days and its logarithm five and six weeks pwh had significant negative correlation with yield. While total rainfall and its logarithm two weeks pwh had significant negative correlation, total rainfall three weeks pwh alone had significant negative correlation with yield. Similarly logarithm of number of rainy days, five weeks and six weeks pwh had significant negative correlation with logarithm of grass yield of third harvest (Table 4). Logarithm of minimum temperature, one-week pwh also had a significant negative correlation with logarithm of yield.

4.2.3.1.Two stage regression models:

Two stage models obtained for six weeks pwh based on Model I (Table 6) revealed that model obtained for sixth week pwh, had a coefficient of determination of 0.33 ($\bar{R}^2 = 0.29$). On the other hand, model obtained for fifth week pwh had a predictability of 55 % ($\bar{R}^2 = 0.49$). Predicted values of fifth and sixth weeks pwh were the predictors of this model. Model obtained for four weeks pwh had a predictability of 65 %

($\bar{R}^2$ = 0.57). Predicted values of fourth, fifth and sixth week's pwh were the independent variables of the model. By the third week pwh, the predictability of the developed model had further increased to 72% ($\bar{R}^2$ = 0.66). The independent variables of the model comprised of predicted values of third, fifth and sixth weeks pwh. The model obtained for second week pwh had a predictability of 82 % ($\bar{R}^2$ = 0.78). Predicted values of second, third and fourth weeks pwh were the predictors of this model. However prediction model for first week pwh was the same as that of the second week.

Two stage models developed for grass yield based on Model II (Table.8) indicated that model for sixth weeks pwh had a predictability of 33 % ($\bar{R}^2$ = 0.29). The coefficient of determination of model obtained for fifth week pwh was 0.57 ($\bar{R}^2$ = 0.51). The explanatory variables of this model were predicted values of fifth and sixth week's pwh. Model obtained for four weeks pwh had a predictability of 70 % ($\bar{R}^2$ = 0.63). Predicted values of fourth, fifth and sixth week's pwh were the independent variables of this model. However the coefficient of determination of the model obtained for third week pwh was found to be 0.85 ($\bar{R}^2$ = 0.82). The explanatory variables of this model comprised of predicted values of third, fifth and sixth weeks pwh. Model obtained for first and second weeks pwh were found to be same as that obtained for third week pwh.

Two-stage model based on Model III for sixth week pwh for third harvest (Table 10) had a predictability of 32 % ($\bar{R}^2$ = 0.28). The coefficient of determination of the model obtained for fifth week pwh was found to be 0.52 ($\bar{R}^2$ = 0.45). The independent variables of this model comprised of predicted values of fifth and sixth weeks pwh. By the fourth week pwh the predictability had further gone up to 62 % ($\bar{R}^2$ = 0.54). Predicted values till the fourth week pwh were the independent variables of this model. In the third week pwh, the coefficient of determination of the model obtained was found to be 0.67 ($\bar{R}^2$ = 0.60). Predicted values of third, fourth and fifth weeks pwh were the explanatory variables of this model. Model obtained for second week pwh had a predictability of 71 % ($\bar{R}^2$ = 0.65). The explanatory variables of this model were, predicted values of second, fourth and sixth weeks pwh. However model obtained for first week pwh was same as that obtained for the second week pwh.

4.2.3.2. Influence of fortnightly weather variables:

Coefficients of correlation of fortnightly weather variables and their logarithms with grass yield (Table 11) revealed that, number of rainy days and its logarithm three fortnights pwh had a significant negative correlation with yield of this harvest. Logarithm of number of rainy days however had a significant positive correlation with yield. Total rainfall one fortnight pwh had a significant negative correlation with grass yield.

While logarithm of number of rainy days, one fortnight pwh had a significant positive correlation with logarithm of grass yield, it was found to have a negative correlation with logarithm of yield during the third fortnight pwh (Table 12).

Model obtained for third fortnight pwh using Model I (Table 13) had a coefficient of determination of 0.67 ($\bar{R}^2$ = 0.60). Number of rainy days, relative humidity and minimum temperature pertaining to the same fortnight were the independent variables of this model. Predictability of the model obtained for second fortnight pwh was found to be 86% ($\bar{R}^2$= 0.78). In addition to explanatory variables of the model obtained for third fortnight, number of rainy days, total rainfall and maximum temperature pertaining to second fortnight pwh were the explanatory variables of the model obtained for second fortnight pwh. The coefficient of determination of model obtained for first fortnight pwh was found to be 0.96 ($\bar{R}^2 = 0.93$). The independent variables of this model were, number of rainy days and relative humidity pertaining to third fortnight, total rainfall and maximum temperature pertaining to second fortnight and number of rainy days, total rainfall and relative humidity pertaining to first fortnight pwh pertaining to first fortnight.

Model obtained for third fortnight pwh using Model II (Table 14) had a coefficient of determination of 0.48 ($R^2 = 0.41$). Number of rainy days and logarithm of minimum temperature pertaining to third fortnight were the explanatory variables of this model. Model obtained for second fortnight pwh had a predictability of 87 % ($\bar{R}^2 = 0.77$). Minimum temperature, logarithm of number of rainy days, total rainfall and its logarithm and relative humidity pertaining to second fortnight pwh were the explanatory variables of this model, in addition to number of rainy days and logarithm of minimum temperature pertaining to the third fortnight pwh. Predictability of the model obtained for first fortnight pwh was found to be 88 % ($\bar{R}^2 = 0.78$) and the independent variables of this model were, number of rainy days and its logarithm, total rainfall pertaining to first fortnight pwh, total rainfall and its logarithm pertaining to second fortnight, logarithm of number of rainy days pertaining to second fortnight, number of rainy days and logarithm of minimum temperature pertaining to third fortnight pwh.

Model obtained for third fortnight pwh had a coefficient of determination of 0.46 ($\bar{R}^2 = 0.41$). Logarithms of number of rainy days and relative humidity pertaining to third fortnight were the explanatory variables of this model. Predictability of the model obtained for second fortnight pwh was 77 % ($\bar{R}^2 = 0.64$). Logarithms of number of rainy days, total rainfall, minimum temperature and relative humidity pertaining to second fortnight pwh were the explanatory variables of this model in addition to logarithms of number of rainy days and relative humidity pertaining to third fortnight pwh. Model obtained for first fortnight pwh had a coefficient of determination of 0.87 ($\bar{R}^2$ = 0.78). Logarithms of number of rainy days, total rainfall and maximum temperature pertaining to first fortnight pwh were the explanatory variables of this model, in addition to logarithm of number of rainy days, total rainfall of second fortnight and logarithm of number of rainy days and relative humidity pertaining to third fortnight pwh.

Model obtained for third fortnight pwh using Model IV (Table.21) had a predictability of 69 % ($\bar{R}^2$= 0.62). Whereas models developed for first and second fortnights pwh had substantial predictabilities of 88 % ($\bar{R}^2$= 0.80) and 82 % ($\bar{R}^2$= 0.74) respectively.

4.3.3. Oil yield:

Minimum temperature and its logarithm throughout six weeks pwh had significant negative correlation with oil yield for this harvest (Table 24). Relative humidity and its logarithm four weeks pwh had a significant positive correlation with yield. Maximum temperature and its logarithm one week and two weeks pwh had a significant positive correlation with oil yield.

Coefficients of correlation of logarithms of weather variables with logarithm of oil yield (Table 25) revealed that logarithm of minimum temperature of second, third, fourth and fifth weeks pwh had a significant negative correlation with logarithm of oil yield. Logarithm of maximum temperature pertaining to second week pwh and logarithm of relative humidity pertaining to fourth week pwh had a significant positive correlation with logarithm of oil yield.

4.3.3.1. Two stage regression models:

First stage models obtained for oil yield of this harvest using Model I are presented in Table (26). Two stage models obtained (Table 27) revealed that, the predictability of the model obtained for six weeks pwh was 42 % ($\bar{R}^2 = 0.39$). Predicted value of fifth week pwh was the predictor of the model obtained for fifth week pwh. The coefficient of determination of this model was 0.48 ($\bar{R}^2 = 0.45$). On the other hand, coefficient of determination of the model obtained for four weeks pwh had a predictability of 61 % ($\bar{R}^2 = 0.56$). Predicted values of fourth and fifth weeks pwh were the explanatory variables of this model. Predicted values of third and fourth weeks pwh were the predictors of the model obtained for three weeks pwh. It had a coefficient of determination of 0.69 % ($\bar{R}^2 = 0.65$). However a predictability of 80 % was obtained for the model two weeks pwh. Predicted values of second, fourth and sixth weeks pwh were the predictors of this model. A coefficient of determination of 0.84 ($\bar{R}^2 = 0.79$) was attained for the model obtained for first week pwh. The explanatory variables of this model comprised of predicted values of first, second, fourth and sixth weeks pwh.

Two-stage model obtained using Model II for six weeks pwh (Table 29) showed that model obtained for sixth week pwh had a coefficient of determination of 0.42 ($\bar{R}^2 = 0.39$). Model obtained for five weeks pwh had a predictability of 48 % ($\bar{R}^2 = 0.45$). Predicted value of fifth week pwh was the explanatory variable of this model. However model obtained for third and fourth week pwh were same as that obtained for fifth week pwh. Model obtained for second week pwh had a coefficient of determination of 62 % ($\bar{R}^2 = 0.60$). The model for first week pwh was same as that of the model obtained for the second week pwh.

Two-stage model obtained for sixth week pwh using Model III (Table 31) had a predictability of 41% ($\bar{R}^2 = 0.37$). The coefficient of determination of the model obtained for five weeks pwh was 0.46 ($\bar{R}^2 = 0.43$). Predicted values of fourth and fifth weeks pwh were the explanatory variables of the model obtained for four weeks pwh. The coefficient of determination of this model was 0.50 ($\bar{R}^2 = 0.43$). The predictability of the model obtained for three weeks pwh was 57 % ($\bar{R}^2 = 0.51$). Predicted values of third and fourth weeks pwh were the independent variables of this model. Maximum predictability was obtained for the model developed for two weeks pwh . It had a coefficient of determination of 0.64 ($\bar{R}^2 = 0.59$), and the explanatory variables of this model were predicted values of second and third weeks pwh. However model obtained for one-week pwh was same as that obtained for two weeks pwh.

4.3.3.2. Influence of fortnightly weather variables:

Coefficients of correlation of weather variables and their logarithms pertaining to three fortnights pwh with oil yield of this harvest (Table 32) also revealed significant negative correlation for minimum temperature and its logarithm throughout the three fortnights pwh. Further maximum temperature and its logarithm one fortnight pwh had a significant positive correlation with oil yield of this harvest

Model obtained for third fortnight pwh using Model I (Table34) had a coefficient of determination of 0.46 ($\bar{R}^2$ = 0.39). Minimum temperature and relative humidity pertaining to the same fortnight were the predictors of this model. The predictability of the model obtained for second fortnight pwh was found to be 59% ($\bar{R}^2$ = 0.50). Explanatory variables of the model pertaining to the third fortnight and maximum temperature pertaining to second fortnight pwh were the predictors of the model obtained for second fortnight pwh. Predictability of 77 % ($\bar{R}^2$ = 0.65) was obtained for the model developed for one fortnight pwh. The explanatory variables of this model were number of rainy days, maximum temperature, minimum temperature and relative humidity pertaining to the first fortnight pwh, maximum temperature pertaining to the second fortnight and relative humidity pertaining to third fortnight pwh.

Model obtained for third fortnight pwh using Model II (Table 35) had a coefficient of determination of 0.46 ($\bar{R}^2$ = 0.39). Logarithms of minimum temperature and relative humidity were the independent variables of this model. The predictability of the model obtained for second fortnight pwh was 74 % ($\bar{R}^2$ = 0.63). In addition to the explanatory variables of the model pertaining to the third fortnight, maximum temperature pertaining to second fortnight and logarithms of number of rainy days and maximum temperature pertaining to second fortnight were the explanatory variables of the model for second fortnight pwh. The coefficient of determination of the model obtained for one fortnight was 0.82 ($\bar{R}^2$ = 0.72). Maximum temperature and its logarithm, logarithms of number of rainy days and minimum temperature were the explanatory variables of this model pertaining to first fortnight pwh. In addition to this, maximum temperature pertaining to second fortnight and logarithm of relative humidity pertaining to third fortnight pwh were the other explanatory variables in this model.

Model obtained for third fortnight pwh using Model III (Table 36) had a coefficient of determination of 0.45 ($\bar{R}^2$ = 0.37). Logarithms of minimum temperature and relative humidity pertaining to the third fortnight were the independent variables of this model. By second fortnight pwh, the predictability of the model obtained had increased to 57 % ($\bar{R}^2$ = 0.44). In addition to the explanatory variables of the model obtained for third fortnight pwh, logarithms of total rainfall and maximum temperature pertaining to second fortnight pwh were the explanatory variables of the model obtained for second fortnight pwh. Maximum predictability among the three models was obtained for the model developed for one fortnight pwh. It had a coefficient of determination of 0.75($\bar{R}^2$ = 0.62). Logarithms of number of rainy days , maximum temperature and relative humidity were the explanatory variables pertaining to first fortnight pwh in this model. In addition to these, logarithms of relative humidity pertaining to third fortnight pwh and maximum temperature pertaining to second fortnight were the other explanatory variables of the model.

Model obtained for third fortnight pwh using Model IV had a coefficient of determination of 0.41 ($\bar{R}^2$ = 0.38). Predictabilities of models obtained for first and second fortnight pwh were found to be 44 %($\bar{R}^2$= 0.41) and 59 % ($\bar{R}^2$= 0.51) respectively.

4.2.4. Fourth Harvest (During second-third week of October):

Minimum temperature and its logarithm throughout the six weeks pwh had significant negative correlation with yield (Table 3). Logarithm of minimum temperature also had significant negative correlation with logarithm of yield throughout the six weeks (Table 4). Logarithms of total rainfall three weeks pwh and relative humidity was the four weeks pwh were the weather variables having significant positive correlation with logarithm of yield.

4.2.4.1. Two stage regression models:

First stage prediction models using Model I for fourth harvest are given in Table 5 and the corresponding two stage regression models in Table 6. It could be noted that prediction model obtained for the sixth week pwh had a predictability of 84% ($\bar{R}^2$ = 0.83). Model for fifth week pwh was same as that of the sixth week pwh. Model obtained for fourth week pwh with predicted values of fourth and sixth weeks as independent variables had a coefficient of determination of 0.89 ($\bar{R}^2$ = 0.87). However models obtained for second and third weeks pwh were same as that of the fourth week pwh. Maximum predictability was obtained for the model one-week pwh. It had a coefficient of determination of 0.91 ($\bar{R}^2$ = 0.89).

First stage models using Model II for grass yield of fourth harvest are provided in Table 7 and the two stage models in Table 8. As could be noted model for sixth week pwh had a coefficient of determination of 0.86 ($\bar{R}^2$ = 0.85). Model for fifth week pwh, with predicted values of fifth and sixth week as predictors had a predictability of 88% ($\bar{R}^2$ = 0.86). Predicted values of fourth, fifth and sixth week's pwh were the predictors of the model obtained for fourth week pwh. The model had a coefficient of determination of 0.93 ($\bar{R}^2$ = 0.91). On the other hand, a predictability of 94% ($\bar{R}^2$ = 0.92) was obtained for the model obtained for third week pwh. Predicted values of third, fourth, fifth and sixth weeks pwh were the explanatory variables of this model. However, model for second week pwh was same as that of the third week pwh. Coefficient of determination of 0.95 ($\bar{R}^2$ = 0.94) was obtained for the model obtained for first week pwh. The independent variables of this model comprised of predicted values of first, third and fifth weeks pwh.

First stage models obtained for yield of fourth harvest using Model III are presented in Table 9 and the corresponding two stage models in Table 10. In the case of model obtained for sixth week pwh , the coefficient of determination was found to be 0.89 ($\bar{R}^2$ = 0.88). However, the same model was obtained for second, third, fourth and fifth weeks pwh. Model obtained for first week pwh had a predictability of 91% ($\bar{R}^2$ = 0.90). Predicted values of first and sixth weeks pwh were the explanatory variables of this model.

4.2.4.2. Influence of fortnightly weather models:

Minimum temperature and its logarithm throughout the three fortnights pwh was the only weather variable having significant negative correlation with grass field of fourth harvest (Table 11). Logarithm of minimum temperature also had significant negative correlation with logarithm of grass yield (Table 12).

Models obtained for third fortnight pwh using Model I (Table 13) had a predictability of 80% ($\bar{R}^2$ = 0.76). Maximum temperature, minimum temperature and relative humidity of this fortnight were the explanatory variables of the model. In addition to these weather variables, minimum temperature and relative humidity pertaining to the second fortnight pwh were the explanatory variables of the model obtained for the second fortnight pwh and it had a coefficient of determination of 0.91 ($\bar{R}^2 = 0.90$). Minimum temperature and relative humidity pertaining to the third fortnight pwh, relative humidity and minimum temperature pertaining to the second fortnight pwh, number of rainy days and minimum temperature pertaining to first fortnight pwh, were the explanatory variables of the model, obtained for first fortnight pwk. It had a coefficient of determination of 0.94 ($\bar{R}^2 = 0.90$).

Models obtained for three fortnights pwh using Model II (Table 14) revealed that maximum temperature and its logarithm, minimum temperature and its logarithm, relative humidity and its logarithm, of the third fortnight pwh were the explanatory variables of the model obtained for the third fortnight. It had a predictability of 90% ($\bar{R}^2 = 0.84$). Model obtained for second fortnight pwh had a coefficient of determination of 0.94 ($\bar{R}^2 = 0.89$). Number of rainy days and its logarithm, minimum temperature and its logarithm and logarithm of relative humidity were the explanatory variables pertaining to third fortnight pwh in the model obtained. Weather variables of the second fortnight pwh namely minimum temperature and logarithm of number of rainy days were the other explanatory variables of this model. On the other hand, the model obtained for first fortnight pwh had the explanatory variables namely minimum temperature, relative humidity and their logarithms corresponding to the third fortnight, number of rainy days and minimum temperature corresponding to the first fortnight. The predictability of the model was 96% ($\bar{R}^2 = 0.94$).

Models obtained for fourth harvest using Model III (Table 15) indicated that, logarithms of maximum temperature, minimum temperature and relative humidity were the explanatory variables of the model obtained for the third fortnight pwh. The coefficient of determination of the model was 0.74 ($\bar{R}^2 = 0.68$). These weather variables along with logarithms of minimum temperature and relative humidity of the second fortnight were the predictors of the model obtained for second fortnight. The predictability of this model was 85% ($\bar{R}^2 = 0.79$). However maximum predictability of 95% ($\bar{R}^2 = 0.93$) was obtained for the model one-fortnight pwh. Logarithms of minimum temperature, relative humidity of the third fortnight pwh, relative humidity of the second fortnight pwh and maximum temperature, minimum temperature of the first fortnight pwh were the explanatory variables of this model.

Model obtained for third fortnight pwh using Model IV (Table 21) had a predictability of 76% ($\bar{R}^2 = 0.73$). However predictability of the model obtained for second fortnight had gone upto 90% ($\bar{R}^2 = 0.88$). Coefficient of determination of the model obtained for one fortnight pwh was 0.98 ($\bar{R}^2 = 0.97$).

4.3.4. Oil yield:

Maximum temperature and its logarithm one week and six weeks pwh had significant positive correlation with oil yield of fourth harvest (Table 24). Minimum temperature and its logarithm one, two, three and four week's pwh had a significant negative correlation with yield for this harvest. Logarithm of maximum temperature one week and six weeks pwh had a significant positive correlation with logarithm of oil yield

(Table 25) for fourth harvest. Logarithm of minimum temperature one, two, three and four weeks pwh had a significant negative correlation with logarithm of oil yield.

4.3.4.1 Two stage regression models:

Two stage prediction models for oil yield of fourth harvest using Model I (Table 27) indicated that, model for sixth week pwh had a coefficient of determination of 0.56 ($\bar{R}^2$ = 0.54). Model obtained for fifth week pwh had a predictability of 59% ($\bar{R}^2$ = 0.54). Predicted values of fifth and sixth weeks pwh were the independent variables of the model. Model obtained for fourth week pwh had a coefficient of determination of 0.83 ($\bar{R}^2$ = 0.81). Predictors of this model were predicted values of fourth and sixth weeks pwh. Model obtained for second and third week pwh were same. It had a predictability of 85% ($\bar{R}^2$ = 0.83) and the independent variables of this model were predicted values of third, fourth and sixth weeks pwh. Predictability of model obtained for one-week pwh was 86% ($\bar{R}^2$ = 0.83). Predicted values of one week and four weeks pwh were the explanatory variables in this model.

Two stage models obtained using Model II (Table 29) revealed that models obtained for fifth and sixth weeks pwh were same. The predictability of these models were 65% ($\bar{R}^2$ = 0.63). Predicted value of sixth week pwh was the explanatory variable of this model. However models obtained for fourth week pwh had a substantial predictability of 97% ($\bar{R}^2$ = 0.96). Predicted values of fourth and sixth weeks pwh were found to be the independent variables of this model. Models obtained for one, two and three week's pwh were same. Predicted values of third, fourth and sixth weeks pwh were the independent variables of this model, and it too had a coefficient of determination of 0.97 ($\bar{R}^2$ = 0.96).

Two stage model obtained for sixth week pwh using Model III (Table 31) had a coefficient of determination of 0.60 ($\bar{R}^2 = 0.57$) by the fifth week pwh, predictability of the model had gone up to 64% ($\bar{R}^2 = 0.59$). Predicted values of fifth and sixth week pwh were the explanatory variables of this model. On the other hand, predicted values of fourth and sixth weeks pwh were the independent variables of the model obtained for fourth week pwh. The predictability of this model was 81% ($\bar{R}^2 = 0.78$). However models obtained for first, second and third weeks pwh were found to be same. Predicted values of third, fourth, fifth and sixth week's pwh were the explanatory variables of this model, and it had a coefficient of determination of 0.85 ($\bar{R}^2 = 0.81$).

Maximum temperature and its logarithm one fortnight and three fortnights pwh had significant positive correlation with oil yield of fourth harvest. Minimum temperature and its logarithm pertaining to first and second fortnight however had a significant negative correlation with yield (Table 32). In the same manner, logarithms of the aforesaid variables had significant correlation with logarithm of oil yield for this harvest (Table 33).

Prediction models obtained for three fortnights pwh (Table 34) for oil yield of fourth harvest using Model I revealed that model obtained for third fortnight pwh had a coefficient of determination of 0.55 ($\bar{R}^2 = 0.45$). Total rainfall, maximum temperature and minimum temperature pertaining to third fortnight pwh were the explanatory variables of this model. However, a predictability of 89% ($\bar{R}^2 = 0.83$) was obtained for the model developed for second fortnight pwh. Maximum temperature and minimum temperature pertaining to third fortnight pwh, number of rainy days, total rainfall, minimum temperature and relative humidity pertaining to second fortnight pwh were the explanatory variables of this model. Model obtained for first fortnight pwh had a coefficient of determination of 0.97 ($\bar{R}^2$ = 0.93). Number of rainy days of first and second fortnights pwh, total rainfall of all the three fortnights, maximum temperature of first fortnight pwh, minimum temperature pertaining to second and third fortnights pwh and relative humidity pertaining to first and second fortnights pwh were the independent variables of this model.

Model obtained for third fortnight pwh using Model III (Table 35) had a coefficient of determination of 0.54 ($\bar{R}^2$ = 0.44). Logarithms of total rainfall, maximum temperature and minimum temperature were the predictors of this model. On the other hand, prediction model obtained for second fortnight pwh had a predictability of 87% ($\bar{R}^2$ = 0.79). Logarithms of maximum and minimum temperature pertaining to third fortnight pwh and logarithms of number of rainy days, total rainfall, minimum temperature and relative humidity pertaining to second fortnight pwh were the independent variables of this model. In the case of model obtained for first fortnight pwh, the coefficient of determination was 0.94 ($\bar{R}^2$ = 0.90). Logarithm of maximum temperature pertaining to the third fortnight pwh, logarithms of number of rainy days, minimum temperature and relative humidity, pertaining to the second fortnight and logarithms of number of rainy days, total rainfall and maximum temperature pertaining to first fortnight pwh were the predictors of this model.

Model obtained for third fortnight pwh using Model IV (Table 42) had a coefficient of determination of 0.43 ($\bar{R}^2$ = 0.36). On the other hand, predictability of the models obtained for first and second fortnights pwh were 82% ($\bar{R}^2$ = 0.78).

4.2.5. Fifth harvest (First fortnight of December):

Minimum temperature and its logarithm throughout the six weeks pwh had significant negative correlation with yield of this harvest (Table 3). Maximum temperature and its logarithm one, two and six week's pwh had a significant positive correlation with grass yield of this harvest. Similarly logarithm of minimum temperature had a significant negative correlation with logarithm of yield (Table 4) throughout the six weeks pwh. In addition to this, logarithm of maximum temperature one week and six weeks pwh had a significant positive correlation with logarithm of grass yield for this harvest.

4.2.5.1. Two stage regression models:

Two-stage model obtained for sixth week pwh based on Model I (Table 6) had a coefficient of determination of 0.72 ($\bar{R}^2 = 0.70$). By the fifth week, predictability of the model obtained had gone upto 76 % ($\bar{R}^2 = 0.73$). The explanatory variables of this model comprised of predicted valued of fifth and sixth weeks pwh. On the other hand, model obtained for fourth week pwh had a coefficient of determination of 0.78 ($\bar{R}^2 = 0.75$). The independent variables of this model comprised of values of fourth and sixth weeks pwh. However, models obtained for first, second and third weeks pwh were found to be same as that of the fourth week pwh.

Two-stage model for sixth week pwh using Model II (Table 8) had a predictability of 75 % ($\bar{R}^2 = 0.73$). However models obtained for fourth and fifth weeks pwh were found to be same. The independent variables of this model was fond to be predicted value of fifth week pwh and it had a coefficient of determination of 0.81

($\bar{R}^2$ = 0.80). Model obtained for three weeks pwh had a predictability of 86 % ($\bar{R}^2$ = 0.85). The explanatory variables of this model comprised of predicted values of third and fifth weeks pwh. Maximum predictability among the model for six weeks pwh, was obtained for the model one week pwh. It had a predictability of 92 % ($\bar{R}^2$ = 0.91). The explanatory variables of this model were predicted values of fourth and fifth weeks pwh.

Two stage models obtained for six weeks pwh (Table 10) using predicted values of first stage models based on Model III (Table 9) revealed that, model obtained for sixth week pwh had a predictability of 82 % ($\bar{R}^2$ = 0.81). On the other hand, model obtained for fifth week pwh had a coefficient of determination of 0.85 ($\bar{R}^2$ = 0.82). The explanatory variables of this model being predicted values of fifth and sixth week's pwh. However models obtained for second, third and fourth weeks pwh were found to be same as that obtained for the fifth week pwh. Model obtained for one-week pwh had a predictability of 86 % ($\bar{R}^2$ = 0.85). The independent variables of this model were found to be predicted values of first and sixth weeks pwh.

4.2.5.2. Influence of fortnightly weather variables:

Minimum temperature and its logarithm were found to have a significant negative correlation with yield throughout the three fortnights pwh. Maximum temperature and its logarithm however had a significant positive correlation with yield for first and third fortnights pwh.

Logarithm of minimum temperature had a significant negative correlation with logarithm of grass yield throughout the three fortnights pwh (Table 12). Logarithm of maximum temperature, during first and third fortnights pwh however had a significant positive correlation with logarithm of grass yield for this harvest.

Prediction model obtained for third fortnight pwh using Model I (Table 13) had a coefficient of determination of 0.67 ($\bar{R}^2$ = 0.62). The predictors of this model were minimum temperature and relative humidity pertaining to third fortnight pwh. The predictability of the model obtained for two fortnights pwh was 68 % ($\bar{R}^2$ = 0.64). Minimum temperature pertaining to second and third fortnight pwh were the independent variables of this model. However the model obtained for first fortnight pwh had a predictability of 79% ($\bar{R}^2$ = 0.70). Total rainfall and minimum temperature pertaining to first fortnight pwh, minimum temperature pertaining to second and third fortnights pwh and relative humidity pertaining to third fortnight were the explanatory variables of the model obtained for first fortnight pwh.

Model obtained for third fortnight using Model II (Table 14) had a coefficient of determination of 0.74 ($\bar{R}^2$ = 0.71). Minimum temperature and its logarithm pertaining to the third fortnight pwh were the explanatory variables of this model. On the other hand the predictability of the model obtained for second fortnight pwh was 0.85 ($\bar{R}^2$ = 0.78). The independent variables of this model comprised of the explanatory variables of the model obtained for third fortnight pwh in addition to, minimum temperature pertaining to second fortnight pwh, number of rainy days and its logarithm pertaining to second fortnight. The coefficient of determination of the model obtained for first fortnight pwh was 0.88 ($\bar{R}^2$ = 0.80). Minimum temperature pertaining to the three fortnights, logarithm of number of rainy days pertaining to second fortnight, maximum temperature, total rainfall and its logarithm pertaining to first fortnight pwh were the explanatory variables of this model.

Model obtained for third fortnight pwh using Model III (Table 15) had a predictability of 77 % ($\bar{R}^2$ = 0.73). Logarithms of total rainfall, minimum temperature and relative humidity were the explanatory variables of the model. Model obtained for second fortnight pwh had a coefficient of determination of 0.77 ($\bar{R}^2$ = 0.72). Logarithms of minimum temperature, relative humidity pertaining to second fortnight in addition to logarithm of total rainfall of the third fortnight comprised the independent variables of the model. However model obtained for first fortnight pwh had a predictability of 86 % ($\bar{R}^2$ = 0.79). The explanatory variables of this model were logarithms of total rainfall, maximum temperature and minimum temperature pertaining to first fortnight pwh, in addition to logarithm of minimum temperature, relative humidity pertaining to second fortnight pwh and logarithm of minimum temperature of the third fortnight pwh.

Model IV (Table 21) obtained for third fortnight pwh had a coefficient of determination of 0.68 ($\bar{R}^2$ = 0.64). By second fortnight pwh, predictability of the model obtained had gone upto 69 % ($\bar{R}^2$ = 0.67). On the other hand, model obtained for first fortnight pwh had a predictability of 79% ($\bar{R}^2$ = 0.75).

4.3.5. Oil yield:

Minimum temperature and its logarithm was found to have a significant negative correlation with oil yield throughout the six weeks pwh. In addition to this relative humidity and its logarithm three weeks pwh had a significant positive correlation with yield of this harvest. Similarly logarithm of minimum temperature throughout the six weeks pwh had a significant negative correlation with logarithm of yield. Logarithm of relative humidity, during the third and fourth weeks pwh however had a significant positive correlation with logarithm of yield.

4.3.5.1. Two stage of regression models:

Two stage model obtained for six weeks pwh using Model I (Table 27) indicated that a very high predictability of 91 % ($\bar{R}^2 = 0.90$) was obtained for the model developed for sixth week pwh. However, model obtained for the remaining weeks pwh were found to be same as that of the sixth week pwh.

Two stage model using Model II also revealed the same picture. As it could be seen from Table 29 that, model obtained for sixth week pwh had a coefficient of determination of 0.93 ($\bar{R}^2 = 0.93$) and models for remaining weeks pwh were same as that obtained for sixth week pwh.

Two stage model obtained for sixth week pwh using Model III (Table 31) had a predictability of 82 % ($\bar{R}^2 = 0.81$). Model obtained for fifth week pwh was same as that of the sixth week pwh. Predicted values of fourth and sixth weeks pwh were the explanatory variables of the model obtained for fourth week pwh. The coefficient of determination of this model was 0.84 ($\bar{R}^2 = 0.82$). On the other hand, model obtained for third week pwh had a predictability of 86 % ($\bar{R}^2$ = 0.83), with predicted values of third, fourth and sixth weeks pwh as the explanatory variables of this model. Model obtained for second week pwh had a coefficient of determination of 0.86 ($\bar{R}^2$ = 0.83). The predictors of the model being predicted values of second, fourth and fifth weeks pwh. However model obtained for first week pwh was same as that obtained for the second week pwh.

4.3.5.2. Influence of fortnightly weather variables:

Minimum temperature and its logarithm had significant negative correlation with oil yield throughout the three fortnights (Table 32). Relative humidity and its logarithm two fortnights pwh had a significant positive correlation with yield.

Similarly logarithm of minimum temperature had a significant negative correlation with logarithm of oil yield throughout the three fortnights (Table 33). Logarithm of relative humidity, during second and third fortnights pwh had a significant positive correlation with logarithm of yield.

Model obtained for third fortnight pwh to predict oil yield of fifth harvest using Model I (Table 34) had a coefficient of determination of 0.59 ($\bar{R}^2$ = 0.56). Minimum temperature pertaining to the same fortnight was explanatory variable of this model. In the second fortnight, predictability of the model obtained had gone up to 75 % ($\bar{R}^2$ = 0.72). Minimum temperature pertaining to third fortnight and relative humidity of the second fortnight and relative humidity of the second fortnight were the independent variables of this model. However, prediction model obtained for first fortnight pwh was same as that obtained for the second fortnight.

Model obtained for third fortnight pwh using Model II (Table 35) had a predictability of 77% ($\bar{R}^2 = 0.72$). Minimum temperature and its logarithm and logarithm of relative humidity were the independent variables of this model. The coefficient of determination of the model obtained for second fortnight pwh was 0.88 ($\bar{R}^2 = 0.81$). In addition to the weather variables of the model obtained for third fortnight, minimum temperature and its logarithm and logarithm of relative humidity pertaining to second fortnight were the independent variables of the model obtained for second fortnight pwh. However maximum predictability was obtained for the model developed for first fortnight pwh. The predictability of this model was 89% ($\bar{R}^2 = 0.82$). In addition to the explanatory variables of the model obtained for third fortnight pwh, logarithms of minimum temperature and relative humidity pertaining to second fortnight, and logarithm of relative humidity pertaining to first fortnight pwh were the explanatory variables of the model obtained for first fortnight pwh.

Prediction models developed for three fortnights pwh using Model III (Table 36) revealed that the coefficient of determination of the model obtained for third fortnight pwh was 0.76 ($\bar{R}^2 = 0.73$). Logarithms of minimum temperature and relative humidity pertaining to the third fortnight were the explanatory variables of this model. Model obtained for second fortnight pwh was same as that of the model developed for the third fortnight pwh. The predictability of the model obtained for first fortnight pwh was 86 % ($\bar{R}^2 = 0.81$). Logarithms of minimum temperature and relative humidity pertaining to first and third fortnight and logarithm of maximum temperature pertaining to first fortnight pwh were the independent variables of this model.

Model obtained for third fortnight using Model IV (Table 42) had a coefficient of determination of 0.84 ($\bar{R}^2$ = 0.79). The predictability of the model obtained for second fortnight pwh was found to be 0.85 ($\bar{R}^2$ = 0.81). However, model obtained for first fortnight pwh had the maximum predictability of 87 % ($\bar{R}^2$ = 0.82).

Discussion

5. DISCUSSION

The present investigation was carried out to forecast yield (grass yield and oil yield) of lemongrass (*Cymbophogon flexuous*) based on weather parameters. The results obtained for various order of harvests:

5.1. First Harvest (During first fortnight of May):

5.1.1. Grass yield:

Number of rainy days during first, third and fourth week pwh had significant positive correlation with yield of first harvest. Further number of rainy days and its logarithm two fortnights pwh also had significant positive correlation with yield. This indicated that an increase in number of rainy days during these three- weeks growth period and also for the corresponding fortnights was found to be beneficial for grass yield. Total rainfall also was found to be having significant influence during one-week pwh. No other weather parameter was found to have any influence on grass yield of first harvest, probably because they were relatively steady during this period.

Among the three models used for arriving at two stage regression models at each of the six weeks pwh and also for fortnightly predictions Model II was found to be promising. In the case of two stage models obtained for sixth week pwh using Model II, a substantial degree of precision was obtained. The predictability of this model was found to be 73 % ($\bar{R}^2 = 0.71$). The predictability of the models obtained for fourth and fifth weeks pwh were 77 % ($\bar{R}^2 = 0.74$). Predicted values of fifth and sixth week's pwh were the explanatory variables of this model. Model obtained for third week pwh, had a coefficient of determination of 0.81 ($\bar{R}^2 = 0.79$). In this model, predicted values of third and sixth weeks pwh were the explanatory variables. Predicted values of second, third and sixth week pwh were the independent variables of the model obtained for two weeks pwh. The predictability of this model was 0.85 ($\bar{R}^2 = 0.81$). However maximum predictability was obtained for the model one-week pwh. It had a coefficient of determination of 0.89 ($\bar{R}^2 = 0.85$).

Model obtained for third fortnight pwh had a coefficient of determination of 0.71 ($\bar{R}^2 = 0.58$). Total rainfall, relative humidity and logarithms of number of rainy days, maximum temperature and minimum temperature were the independent variables of this model. It could be noted that while total rainfall and logarithm of maximum temperature was found to have beneficial effects on grass yield, relative humidity, logarithms of number of rainy days and minimum temperature were detrimental to the yield. On the other hand predictability of the model obtained for second fortnight pwh was 75% ($\bar{R}^2 = 0.68$). In this model, number of rainy days, minimum temperature, logarithm of number of rainy days were the explanatory variables pertaining to the second fortnight pwh. Logarithm of minimum temperature pertaining to third fortnight pwh was an additional variable in this model. Model revealed that number of rainy days pertaining to second fortnight was beneficial for grass yield whereas the remaining weather variables in the model had adverse effect on grass yield. The predictors of model obtained for one fortnight pwh were number of rainy days pertaining to first and second fortnight pwh, total rainfall and its logarithm pertaining to first fortnight pwh and logarithm of number of rainy days pertaining to second fortnight pwh. The coefficient of determination of this model was 0.76 ($\bar{R}^2$ = 0.65). Among these weather variables total rainfall pertaining to first fortnight and logarithm of number of rainy days pertaining to first fortnight pwh had adverse effect on grass yield.

Prediction model arrived at using Model IV for three fortnights pwh for yield of first harvest revealed that, model obtained for third fortnight pwh had a low predictability of 23 % ($\bar{R}^2$ = 0.18). Beneficial effects of total rainfall on grass yield increased with a decrease in maximum temperature. Model obtained for second fortnight pwh had a substantial predictability of 77 % ($\bar{R}^2$ = 0.65). It could be noted that among the explanatory variables, joint effects of:

(i) Number of rainy days and relative humidity till the second fortnight

(ii) Total rainfall and maximum temperature during the third fortnight

(iii) Total rainfall and maximum temperature till the second fortnight

were found to be beneficial, while the increase in other variables in the model were detrimental for the crop. Beneficial effects of number of rainy days on grass yield for this harvest increased with an increase in relative humidity. On the other hand, beneficial effects of total rainfall during the second and third fortnight increased with a decrease in maximum temperature pertaining to that fortnight. However the predictability of model obtained for first fortnight pwh was 88 % ($\bar{R}^2$ = 0.78). In this case, the explanatory variables of the model having pronounced effect on grass yield were joint effects of:

(i) Number of rainy days and maximum temperature till the first fortnight

(ii) Total rainfall and maximum temperature till the second fortnight

(iii) Number of rainy days and minimum temperature till the first fortnight

(iv) Number of rainy days and relative humidity till the second fortnight

Joint effect of number of rainy days and maximum temperature till first fortnight pwh indicated that an increase in the individual effects of these weather variables led to an increase in their joint effects. However an increase in total rainfall till second fortnight pwh was found to beneficial for grass yield with a decrease in maximum temperature till that fortnight, as revealed by their combined effect. Further an increase in number of rainy days during first fortnight pwh along with a corresponding decrease in minimum temperature was also enhanced the grass yield. Beneficial effects of number of rainy days till the second fortnight pwh increased with an increase in relative humidity till that fortnight. All the remaining explanatory variables in the model were found to adversely affect the yield.

5.1.2. Oil yield:

Number of rainy days during sixth week pwh, maximum temperature and its logarithm pertaining to third, fourth and fifth week pwh, relative humidity and its logarithm during one week pwh were the weather variables having significant negative correlation with oil yield of this harvest. Minimum temperature pertaining to first, second and sixth week's pwh had significant positive correlation with oil yield. Number of rainy days and its logarithm during third fortnight pwh had significant negative correlation with oil yield. Minimum temperature and its logarithm however had significant positive correlation with oil yield throughout the three fortnights. Relative humidity and its logarithm one fortnight pwh had a significant negative correlation with yield.

Negative relation ship of rainy days reveals that an increase in number of rainy days during these weeks would decrease the oil yield pertaining to this harvest. Guenther (1972) also reported that oil yield per acre in Honduras was low when the grass was cut during heavy rains. Shai and Singh (1981) also noted that rainfall is the only feature for significant reduction in oil content of Jammu lemongrass. Adverse effect of relative humidity on yield may be due to the fact that as relative humidity increases evapo-transpiration decreases and hence the nutrient and water uptake by the crop is adversely affected which in turn affects the oil yield of this harvest. On the other hand positive correlation of minimum temperature throughout the three fortnights reveals that the crop prefers cooler nights.

Two-stage model obtained for sixth week pwh using Model II had a predictability of 78 % ($\bar{R}^2$ = 0.77). Predicted values of fifth and sixth week's pwh were the explanatory variables of the model obtained for fifth week pwh. The coefficient of determination of the model for fifth week pwh was 0.81 ($\bar{R}^2$ = 0.78). In the case of fourth week pwh, model obtained had a predictability of 82 % ($\bar{R}^2$ = 0.80). Predicted values of fourth and sixth weeks pwh were the independent variables of this model. Model obtained for third week pwh with predicted values of third and sixth weeks pwh had a coefficient of determination of 0.88 ($\bar{R}^2$ = 0.87). However models obtained for first and second weeks pwh were the same as that of model for third week pwh.

Model obtained for third fortnight pwh had a predictability of 44 % ($\bar{R}^2$ = 0.37). Logarithm of number of rainy days and minimum temperature were the predictors of this model. The coefficient of determination of the model obtained for second fortnight pwh was 0.70 ($\bar{R}^2$ = 0.59). Number of rainy days, total rainfall, minimum temperature and logarithm of maximum temperature pertaining to second fortnight were the explanatory variables of the model in addition to logarithm of number of rainy days pertaining to the third fortnight pwh. However maximum predictability was obtained for the model developed for first fortnight pwh. It had a coefficient of determination of 0.88 ($\bar{R}^2$ = 0.75). Logarithm of minimum temperature pertaining to third fortnight, number of rainy days, total rainfall and minimum temperature pertaining to the second fortnight, number of rainy days, logarithm of maximum temperature pertaining to first fortnight, relative humidity and its logarithm pertaining to first fortnight pwh were the explanatory variables of this model.

Model obtained for third fortnight using Model IV had a predictability of 42 % ($\bar{R}^2$ = 0.38). Combined effect of number of rainy days and relative humidity pertaining to this fortnight was the independent variable of this model and it was found to be detrimental for oil yield of this harvest. In the second fortnight, model obtained had a coefficient of determination of 0.51 ($\bar{R}^2$ = 0.45). Individual effect of maximum temperature, joint effects of number of rainy days and relative humidity pertaining to the second fortnight pwh were the predictors of this model, both of which had adverse effect on oil yield. Model obtained for first fortnight pwh had a coefficient of determination of 0.61 ($\bar{R}^2 = 0.53$). In addition to the explanatory variables of model developed for second fortnight, joint effects of maximum and minimum temperature pertaining to the first fortnight pwh were the independent variables of this model. However unlike in the earlier fortnight, the joint effect of maximum and minimum temperature was found to be beneficial for oil yield of this harvest.

5.2. Second Harvest (By second fortnight of June) :

5.2.1.Grass yield:

Number of rainy days and its logarithm five weeks pwh had significant positive correlation with grass yield. The probable reason for this could be that, the period five weeks pwh coincides with second fortnight of May during which the pre-monsoon showers are received, and so uniform distribution of rainfall during this period was found to be beneficial for the grass Minimum temperature and its logarithm during second and fourth weeks pwh also had a significant positive correlation with yield. Total rainfall during first week pwh also had a significant positive correlation with yield.

Two stage models obtained for sixth week pwh had a coefficient of determination of 0.33 ($\bar{R}^2 = 0.29$). The predictability of the model obtained for fifth week pwh was 57% ($\bar{R}^2 = 0.51$). Predicted values of fifth and sixth week's pwh were the explanatory variables of this model. Model obtained for fourth week pwh had a coefficient of determination of 0.70 ($\bar{R}^2$ = 0.63). Predicted values of fourth, fifth and sixth week's pwh were the independent variables of this model. Model obtained for first, second and third weeks pwh were same. The predicted values of third, fifth and sixth week's pwh were the explanatory variables of this model. The coefficient of determination of this model was 0.85 ($\bar{R}^2$ = 0.82). In other words the weather during last two weeks did not have profound influence on grass yield of second harvest.

Model obtained for third fortnight pwh had a predictability of 49% ($\bar{R}^2$ = 0.38). Number of rainy days, total rainfall and minimum temperature were explanatory variables of the model. Increase in these variables was found to be beneficial for the yield of second harvest. Predictability of the model obtained for second fortnight pwh was 51% ($\bar{R}^2$ = 0.40). Maximum and minimum temperature pertaining to the second fortnight and number of rainy days pertaining to the third fortnight were the independent variables of the model. While increase in number of rainy days of the third fortnight pwh and minimum temperature of the second fortnight pwh were found to be beneficial, increase in maximum temperature of the second fortnight was detrimental for grass yield. However by first fortnight pwh, coefficient of determination had gone up to 95% ($\bar{R}^2$ = 0.88). Number of rainy days pertaining to first and third fortnights pwh, total rainfall and minimum temperature, pertaining to third fortnight pwh, minimum temperature and relative humidity pertaining to first fortnight pwh, logarithms of number of rainy days, total rainfall and relative humidity pertaining to one fortnight pwh were the independent variables of this model. Among these variables, number of rainy days pertaining to third fortnight and logarithms of number of rainy days pertaining to third fortnight and relative humidity pertaining to one fortnight pwh were found to be in excess of the crop requirement.

Model obtained for second and third fortnights pwh using Model IV were same and had a coefficient of determination of 0.45 ($\bar{R}^2 = 0.37$). Joint effects of number of rainy days with minimum temperature and number of rainy days with relative humidity were the independent variable of the model. In the case of model obtained for second fortnight, joint effects of number of rainy days with minimum temperature pertaining to second fortnight and joint effects of number of rainy days with relative humidity pertaining to third fortnight pwh were the explanatory variable of the model. Model obtained for first fortnight pwh had a moderate coefficient of determination of 0.77 ($\bar{R}^2 = 0.68$). Joint effects of number of rainy days and minimum temperature till first fortnight, total rainfall and minimum temperature till first fortnight, number of rainy days with total rainfall and individual effect of number of rainy days were the predictors of the model.

5.2.2. Oil yield:

Minimum temperature one, two, three and four week's pwh had significant positive correlation with oil yield of second harvest. Maximum temperature three weeks pwh also had a significant positive correlation with oil yield of this harvest.

Two-stage model obtained for sixth week pwh had a low predictability of 20% ($\bar{R}^2 = 0.15$). In the fifth week pwh, the coefficient of determination of 0.31 ($\bar{R}^2 = 0.22$) was obtained. Predicted values of fifth and sixth week's pwh were the explanatory variables of this model. However predicted values of fourth week alone was sufficient in explaining about 79 % ($\bar{R}^2$ = 0.77) of variation in yield based on model obtained for fourth week pwh. On the other hand, model obtained for third week pwh had a predictability of 83 % ($\bar{R}^2$ = 0.80) and the predicted values of third and fourth weeks pwh were the independent variables of this model. However, model obtained for two weeks pwh was same as that of the model for third week pwh. The coefficient of determination of 0.89 ($\bar{R}^2$ = 0.87) was obtained for the model one-week pwh. The explanatory variables of this model were predicted values of first and fourth week pwh.

Model obtained for third fortnight pwh had number of rainy days and logarithm of minimum temperature as its explanatory variables. The coefficient of determination of this model was 0.46($\bar{R}^2$ = 0.39). Increase in both these weather variables was found to be beneficial to the crop. Number of rainy days of the third fortnight, total rainfall of second fortnight, logarithm of number of rainy days pertaining to second fortnight and logarithm of minimum temperature pertaining to third fortnight, were the explanatory variables of the model obtained for second fortnight pwh. The predictability of this model was 60 % ($\bar{R}^2$ = 0.48). On the other hand, model obtained for one fortnight pwh had a predictability of 75 % ($\bar{R}^2$ = 0.64). Number of rainy days and its logarithm, logarithm of total rainfall and minimum temperature of first fortnight pwh, logarithm of minimum temperature pertaining to third fortnight pwh were the predictors of this model.

Composite regression model obtained for third fortnight pwh had a very low coefficient of determination of 0.16 ($\bar{R}^2$ = 0.10). Combined effect of maximum and minimum temperature was the independent variable of this model. This indicated that an increase in minimum temperature with a corresponding decline in maximum temperature led to beneficial effect of their combined action. However models obtained for first and second fortnights pwh was same. The predictability of this model was 72 % ($\bar{R}^2$ = 0.66). The explanatory variables of this model were joint effects of:

(i) Maximum temperature and minimum temperature till the second fortnight

(ii) Minimum temperature and relative humidity till the second fortnight

(iii) Number of rainy days and total rainfall during till the second fortnight

Among these variables, first two had beneficial effects on oil yield. While an increase in both the variables of (i) led to an increase in oil yield, beneficial effects of minimum temperature till the second fortnight increased with a decrease in relative humidity of the same fortnight.

5.3. Third Harvest (By mid August):

5.3.1. Grass yield:

Number of rainy days and its logarithm five and six week's pwh and during third fortnight pwh had significant negative correlation with yield. The probable reason for this may be that the period during which it had a negative correlation is the period when intensity of rainfall is high and so its increase in distribution over the aforesaid weeks adversely affects the grass yield. The reason for negative correlation of total rainfall during second and third weeks pwh could also be attributed to the same reason.

Two-stage prediction model obtained for sixth week pwh had a coefficient of determination of 0.33 ($\bar{R}^2 = 0.28$). The predictability of the model obtained for fifth week pwh was 57% ($\bar{R}^2 = 0.51$). Predicted values of fifth and sixth weeks pwh were the independent variables of this model. Predicted values of fourth, fifth and sixth week's pwh were the independent variables of the model obtained for third week pwh. The coefficient of determination of this model was 0.70 ($\bar{R}^2 = 0.63$). Model obtained for three weeks pwh had a predictability of 85 % ($\bar{R}^2 = 0.82$). Predicted values of third, fifth and sixth week's pwh were the explanatory variables of this model. However models obtained for first and second weeks pwh were same as that obtained for three weeks pwh.

Prediction model obtained for third fortnight pwh had a predictability of 48% ($\bar{R}^2 = 0.41$). Number of rainy days and logarithm of minimum temperature were the explanatory variables of this model. Both these variables were found to adversely affect grass yield of this harvest. Predictability of the model obtained for second fortnight pwh was 87 % ($\bar{R}^2 = 0.77$). The explanatory variables of this model were minimum temperature, logarithm of number of rainy days, total rainfall and its logarithm and relative humidity pertaining to second fortnight, in addition to the weather variables of the model obtained for third fortnight pwh. Among these explanatory variables, minimum temperature, total rainfall and logarithm of number of rainy days, all pertaining to second fortnight pwh were found to have beneficial effects on herbage yield of this harvest. However model obtained for one fortnight pwh had a coefficient of determination of 0.88 ($\bar{R}^2 = 0.78$). There is no appreciable increase in predictability of this model at first fortnight pwh over that at second fortnight pwh. In other words, a satisfactory prediction can be done at the second fortnight pwh.

The coefficient of determination of the model obtained for third fortnight pwh using Model IV was 0.69 ($\bar{R}^2 = 0.62$). Individual effect of number of rainy days during the third fortnight, joint effects of number of rainy days and minimum temperature, number of rainy days and maximum temperature were the explanatory variables of this model. Individual effect of number of rainy days was found to be beneficial for grass yield of this harvest. Model obtained for second fortnight pwh had a substantial predictability of 82 % ($\bar{R}^2 = 0.74$). In this model, the independent variables comprised of individual effects of number of rainy days till the second and third fortnight pwh, joint effects of number of rainy days and minimum temperature pertaining to the third fortnight pwh, joint effects of number of rainy days and maximum temperature till the second fortnight and joint effects of number of rainy days and relative humidity till the second fortnight pwh. Among these variables, individual effect of number of rainy days during the third fortnight and joint effect of number of rainy days and relative humidity till the second fortnight pwh enhanced the herbage yield. Joint effect of number of rainy days and relative humidity revealed that beneficial effects of relative humidity on grass yield increased with a decrease in number of rainy days. On the other hand predictability of the model obtained for first fortnight pwh was 88 %($\bar{R}^2 = 0.80$). In this case too individual effect of number of rainy days till first fortnight pwh was beneficial for grass yield. Further joint effects of weather variables namely: number of rainy days and minimum temperature during the third fortnight, total rainfall and relative humidity till the first fortnight pwh, total rainfall and relative humidity till first fortnight pwh were also found to enhancing the grass yield of this harvest.

5.3.2. Oil Yield:

Minimum temperature and its logarithm were found to have a significant negative correlation with oil yield. This could be because the conversion of nutrients to oil increases as minimum temperature decreases. Relative humidity and its logarithm four weeks pwh had a significant positive correlation with yield.

Two-stage model obtained for sixth week pwh had a coefficient of determination of 0.42 ($\bar{R}^2 = 0.39$). Predictability of the model obtained for fifth week pwh was 48 % ($\bar{R}^2 = 0.45$). The coefficient of determination of the model obtained for fourth week pwh was 0.61 ($\bar{R}^2 = 0.56$). Predicted values of fourth and fifth weeks pwh were the explanatory variables of this model. Predictability of the model obtained for third week pwh was 69 % ($\bar{R}^2 = 0.65$). Predicted values of third and fourth weeks pwh were the predictors of this model. Predicted values of second, fourth and sixth weeks pwh were the independent variables of the model obtained for two weeks pwh. The coefficient of determination of this model was 0.80 ($\bar{R}^2 = 0.76$). Predictability of the model obtained for one-week pwh was 84 % ($\bar{R}^2 = 0.79$). Predicted values of first, second, fourth and sixth weeks pwh were the explanatory variables of this model.

Models obtained for third fortnight pwh had a predictability of 46 % ($\bar{R}^2 = 0.39$). Logarithms of minimum temperature and relative humidity pertaining to third fortnight pwh were the explanatory variables of this model. The coefficient of determination of model obtained for second fortnight pwh was 0.74 ($\bar{R}^2 = 0.63$). Maximum temperature pertaining to second fortnight, logarithms of number of rainy days and maximum temperature pertaining to second fortnight pwh and the explanatory variables of the model obtained for third fortnight pwh were the predictors of the model obtained for second fortnight pwh. Maximum temperature and logarithm of number of rainy days pertaining to the second fortnight were the weather variables among these having beneficial effects on oil yield. On the other hand, predictability of the model obtained for one fortnight pwh was 82 % ($\bar{R}^2 = 0.72$). The explanatory variables of this model were maximum temperature and logarithms of number of rainy days, maximum temperature and minimum temperature pertaining to first fortnight pwh, maximum temperature pertaining to the second fortnight and logarithm of relative humidity pertaining to the first fortnight pwh. Among these weather variables it could be noted that as maximum temperature pertaining to second fortnight and logarithms of number of rainy days and maximum temperature pertaining to first fortnight pwh increases, herbage yield for this harvest also increases.

Model obtained for third fortnight pwh had a predictability of 41% ($\bar{R}^2 = 0.38$). Minimum temperature pertaining to the third fortnight was the explanatory variable of this model and it was found to have adverse effect on oil yield of this harvest. The coefficient of determination of the model obtained for second fortnight pwh was 0.44 ($\bar{R}^2 = 0.41$). Individual effect of maximum temperature till the second fortnight was the predictor of this model. However, model obtained for first fortnight pwh had a moderate predictability of 59 % ($\bar{R}^2 = 0.51$). The explanatory variables of this model were, individual effect of minimum temperature till first fortnight for the three levels of j (0,1,2). Among these variables, minimum temperature till the first fortnight pwh with levels 0,1 was found to be beneficial for yield.

5.4. Fourth Harvest: (By second fortnight of October):

5.4.1. Grass yield:

Minimum temperature had a significant negative correlation throughout the six weeks and also for three fortnights pwh with grass yield of this harvest. The probable reason for this could be that, during this harvest, more photo assimilates get accumulated in stubbles directed a quicker production of leaves which can contribute higher herbage yield.. Relative humidity four weeks pwh had a significant positive correlation with yield. A significant positive correlation for relative humidity four weeks pwh may be due to the fact that, the period of crop growth experiences moisture scarcity and so an increase in relative humidity reduces the rate of transpiration and maintain a favorable relative water content in the crop which would increase the grass yield of this harvest.

Two stage regression models obtained for sixth week pwh had a coefficient of determination of 0.86 ($\bar{R}^2 = 0.85$). The predictability of the model obtained for fifth week pwh had increased up to 88 % ($\bar{R}^2 = 0.86$). Predicted values of fifth and sixth week's pwh were the explanatory variables of this model. On the other hand, predicted values of fourth, fifth and sixth week's pwh were the independent variables of the model obtained for four weeks pwh. The model had a coefficient of determination of 0.93 ($\bar{R}^2 = 0.91$). Model obtained for third week pwh had a predictability of 94 %

($\bar{R}^2$ = 0.91). Predicted values of third, fourth, fifth and sixth week's pwh were the independent variables of this model. However, model obtained for second week pwh was same as that obtained for third week pwh. The predictability of model obtained for one-week pwh was 95 % ($\bar{R}^2$ = 0.94). Predicted values of first, third and fifth weeks pwh were the explanatory variables of this model.

Model obtained for third fortnight pwh had a coefficient of determination of 0.90 ($\bar{R}^2$ = 0.84). Maximum temperature and its logarithm, minimum temperature and its logarithm, relative humidity and its logarithm pertaining to the same fortnight were the explanatory variables of this model. Among these variables, while maximum temperature and relative humidity had beneficial effects on yield, their logarithms were found to be detrimental to the crop. This revealed that, rate of change in yield increased with an increase in the aforesaid weather parameters. On the other hand, while minimum temperature was found to adversely affect the yield, its logarithm was found to be beneficial. However model obtained for first fortnight had a coefficient of determination of 0.96($\bar{R}^2$ = 0.94). Minimum temperature and its logarithm, relative humidity and its logarithm pertaining to third fortnight pwh, number of rainy days and minimum temperature pertaining to first fortnight were the explanatory variables of this model.

Model obtained for third fortnight pwh to predict grass yield of fourth harvest using Model IV had a coefficient of determination of 0.76 ($\bar{R}^2$ = 0.73). Individual effect of minimum temperature during the third fortnight and its joint effect with relative humidity were the explanatory variables of this model, both of which had adverse effect of grass yield. The predictability of the model obtained for second fortnight pwh was 0.80 ($\bar{R}^2$ = 0.88). In this model, the independent variables comprised of individual effect of minimum temperature till the second fortnight for levels of 1 and 2 respectively, in addition to joint effect of minimum temperature and relative humidity during the third fortnight. Among these variables, minimum temperature at level 1 had beneficial effects on the yield. However the predictability of the model obtained for first fortnight was 98 %($\bar{R}^2$ = 0.97). In this model, individual effect of number of rainy till first fortnight, minimum temperature till second fortnight, joint effects of number of rainy days with maximum temperature and relative humidity and combined effect of minimum temperature with relative humidity were found to enhance the grass yield.

5.4.2. Oil yield:

Maximum temperature and its logarithm one week and six weeks pwh had a significant positive correlation with yield, this could be due to the reason that the diurnal variation i.e. though the temperature is maximum, its duration of availability is less during this period and hence an increase in maximum temperature would increase the oil yield for this harvest. Minimum temperature one, two, three and four week's pwh had a significant negative correlation with yield. The probable reason for negative correlation of minimum temperature with yield during these weeks may be due to the longer cooler nights available during the period, which provides a short span photosynthesis and longer period of photo assimilates destruction by respiration which favors an increase in precursors for the formation of oil content.

Two-stage model obtained for sixth week pwh had a coefficient of determination of 0.65 ($\bar{R}^2 = 0.63$). Model obtained for fifth week pwh was same as that obtained for the sixth week. Predicted value of sixth week was the explanatory variable of this model. Prediction model for fourth week pwh with predicted values of fourth and sixth weeks pwh as independent variables, had a predictability of 97 % ($\bar{R}^2 = 0.96$). Model obtained for third week pwh were the explanatory variables of this model. However, models obtained for first and second weeks pwh was same as that obtained for the third week pwh.

Prediction model obtained for third fortnight pwh had a coefficient of determination of 0.55 ($\bar{R}^2 = 0.46$). Total rainfall, logarithms of maximum temperature and minimum temperature pertaining to the third fortnight were the explanatory variables of this model. In the second fortnight, model obtained had a predictability of 85 % ($\bar{R}^2 = 0.81$). Logarithm of maximum temperature pertaining to third fortnight, minimum temperature of second fortnight, relative humidity and its logarithm pertaining to second fortnight were the independent variables of the model for second fortnight. However, predictability of the model obtained for first fortnight pwh was 94% ($\bar{R}^2 = 0.87$). The explanatory variables of this model were minimum temperature pertaining to second fortnight, maximum temperature and its logarithm pertaining to firs fortnight, relative humidity and its logarithm pertaining to second fortnight, logarithm of maximum temperature pertaining to third fortnight, logarithm of total rainfall pertaining to first fortnight, logarithm of minimum temperature pertaining to third fortnight and logarithm of minimum temperature pertaining to first fortnight pwh.

The predictability of the model obtained for third fortnight was 43 % ($\bar{R}^2 = 0.36$). Joint effect of maximum temperature with relative humidity for levels 1 and 2 were the explanatory variables of this model. While the former had beneficial effect on oil yield, latter was detrimental for yield. Model obtained for first and second fortnights pwh had a coefficient of determination of 0.82 ($\bar{R}^2 = 0.78$). Model obtained for second fortnight pwh comprised of joint effect of minimum temperature with relative humidity till the second fortnight pwh as explanatory variable in addition to the variables of the model obtained for third fortnight. On the other hand, model obtained for first fortnight pwh had joint effect of minimum temperature with relative humidity till the first fortnight pwh was the other explanatory variable in addition to the variables of the model obtained for third fortnight pwh.

5.5. Fifth Harvest (By first fortnight of December):

5.5.1.Grass Yield:

Minimum temperature and its logarithm throughout the six weeks six weeks pwh had a significant correlation with grass yield of this harvest.

Maximum temperature and its logarithm one, two and six weeks pwh however had a significant positive correlation with yield. In addition to this, logarithm of minimum temperature had a significant negative correlation with logarithm of grass yield.

Two stage model obtained for sixth week pwh using Model I had a coefficient of determination of 0.75 ($\bar{R}^2 = 0.73$). Models obtained for fourth and fifth weeks pwh were same as that obtained for sixth week pwh. Predicted value of fifth week pwh was found to be the independent variable of this model. Predictability if this model was found to be 81 % ($\bar{R}^2 = 0.80$). The coefficient of determination of the model obtained for third week pwh was 0.86 ($\bar{R}^2 = 0.85$). The explanatory variables of this model were predicted values of third and fifth weeks pwh. Model obtained for first week pwh had a coefficient of determination of 0.92 ($\bar{R}^2 = 0.91$). Predicted values of fourth and fifth weeks pwh were the explanatory variables of this model.

Model obtained for third fortnight pwh had a coefficient of determination of 0.74 ($\bar{R}^2 = 0.71$). On the other hand predictability of the model obtained for second fortnight pwh was found to be 85% ($\bar{R}^2 = 0.78$). The independent variable of this model comprised of explanatory variables of model obtained for third fortnight pwh, in addition to the minimum temperature pertaining to the second fortnight pwh, number of variables and its logarithms pertaining to the second fortnight. However, the model obtained for the first fortnight pwh had a predictability of 88% ($\bar{R}^2 = 0.80$).

Model obtained for third fortnight pwh using Model IV had a coefficient of determination of 0.68 ($\bar{R}^2$= 0.64). The explanatory variables of this model were individual effect of minimum temperature pertaining to three levels i.e., j = 0, 2. The predictability of the model for the second fortnight were found to be 69% ($\bar{R}^2$ = 0.67). In this case too individual effect of minimum temperature pertaining to the same fortnight for the level j = 2 was the explanatory variable of the model. The model obtained for first fortnight pwh had a predictability of 79% ($\bar{R}^2$ = 0.75). Individual effect of minimum temperature pertaining to second fortnight pwh, and joint effects of number of rainy days, total rainfall pertaining to the first fortnight pwh and joint effects of maximum temperature and minimum temperature pertaining to the first fortnight were the independent variables of the model.

5.5.2. Oil yield

Minimum temperature and its logarithm was found to have a significant negative correlation throughout the six weeks pwh. Further logarithm of the minimum temperature was found to have a significant negative correlation with logarithm of oil yield. However, logarithm of relative humidity during the third and fourth weeks pwh had a significant positive correlation with logarithm of yield.

Two stage model obtained for sixth week pwh using Model II had a coefficient of determination of 0.93 ($\bar{R}^2$ = 0.93), indicating that an advance estimate of oil yield could be done as early as by the sixth week.

Model obtained for the third fortnight using Model II had a predictability of 77% ($\bar{R}^2 = 0.72$) minimum temperature and its logarithm, logarithm of relative humidity were independent variables of this model. The coefficient of determination of model obtained for second fortnight pwh was 0.88 ($\bar{R}^2 = 0.81$). However, maximum predictability was obtained for the model developed for first fortnight pwh. Predictability of this model being 89% ($\bar{R}^2 = 0.82$).

Model obtained for third fortnight pwh using Model IV had a coefficient of determination of 0.84 ($\bar{R}^2 = 0.79$). Individual effect minimum temperature and joint effect of maximum temperature with relative humidity and minimum temperature were the explanatory variables of this model. In the case of second fortnight pwh the predictability of the model obtained has gone up to 85% ($\bar{R}^2 = 0.81$). The influencing weather variables during this fortnight were again the same as that obtained for the earlier fortnights, for levels of $j = 0$ and 2. The model obtained for first fortnight pwh had coefficient of determination of 0.87 ($\bar{R}^2 = 0.82$). Individual effect of minimum temperature and joint effect of maximum temperature with minimum temperature pertaining to third fortnight along with joint effects of maximum temperature with relative humidity pertaining to three fortnights pwh were found to be the explanatory variables of this model.

Summary

SUMMARY

A study on forecasting of lemongrass yield, using weather variables was undertaken using yield data from comparative yield trials conducted at the Aromatic and Medicinal Plants Research Station, Odakkali for the period 1965-1989.Observations on various climatic variables such as number of rainy days, total rainfall (mm), maximum temperature (°C), minimum temperature (°C) and relative humidity were gathered from the meteorological observatory located at the station. Yield data on the largely cultivated variety namely OD-19 was used for the investigation. The grass is grown as rain-fed.

Coefficients of correlation of weekly weather variables and their logarithms pertaining to growing period (six weeks or three fortnights pwh) with grass and oil yields for various orders of harvest were worked out. Models were developed using weekly and fortnightly weather variables to forecast grass and oil yield of lemongrass for five orders of harvest.

Grass Yield:

Number of rainy days and total rainfall were the significant weather variables influencing the grass yield of first harvest, as revealed by their significant correlation coefficients. On the other hand number of rainy days, total rainfall, minimum temperature were the weather variables influencing grass yield of second harvest. However for grass yield of third harvest, number of rainy days and total rainfall were

the influencing weather variables. Minimum temperature was found to influence the yield of fourth and fifth harvests. In addition to this, maximum temperature also had a significant influence on the grass yield of fifth harvest.

Two stage regression models obtained for six weeks pwh for grass yield of various orders of harvest, using weather variables pertaining to each week as explanatory variables revealed that, for first, second and third harvests, though a higher predictability was obtained for model fitted for one week pwh, no substantial predictability was obtained for models fitted for earlier weeks pwh. However, models obtained for sixth week pwh of fourth and fifth harvest had a higher predictability i.e. 84 % ($\bar{R}^2 = 0.83$) and 72 % ($\bar{R}^2 = 0.70$) respectively.

Models obtained to predict logarithm of grass yield using logarithms of weather variables pertaining to six weeks pwh also revealed similar trend. Predictability of the model obtained for sixth week pwh for fourth and fifth harvest were found to be 89 % ($\bar{R}^2 = 0.88$) and 82 % ($\bar{R}^2 = 0.81$).

However advance estimates of grass yield could be made using weather variables and their logarithms pertaining to six weeks pwh as explanatory variables. This was revealed by a very high predictability of the models obtained for first, second, fourth and fifth harvests. The coefficient of determination of the model obtained for sixth week pwh for first, second, fourth and fifth harvests were found to be 0.73 ($\bar{R}^2 = 0.71$), 0.71 ($\bar{R}^2 = 0.70$), 0.86 ($\bar{R}^2 = 0.85$) and 0.75 ($\bar{R}^2 = 0.73$) respectively. The coefficient of determination of model obtained for sixth week pwh to predict grass yield of third harvest, however had a lower predictability of 33 % ($\bar{R}^2$ = 0.29). Model obtained for fifth week pwh had a predictability of 57 % ($\bar{R}^2$ = 0.51).

Model obtained for grass yield of various orders of harvest using weather variables pertaining to three fortnights pwh as explanatory variables revealed that a moderate predictability was obtained for the models developed for third fortnight pwh to predict yields of first, third, fourth and fifth harvests. The predictability of these models were, 70%, 67%, 80% and 67% for first, third, fourth and fifth harvests respectively. However, by second fortnight pwh, the prediction models obtained for these harvests had a substantial predictability.

Models obtained for various orders of harvest using weather variables and their logarithms pertaining to three fortnights pwh revealed that, predictions could be made well a ahead of each of the five harvests i.e. by the third fortnight, with a very high predictability. In this case too, models obtained for the second and third fortnights pwh of second harvest had a moderate predictability. The inference made based on this model was that an increase in weather variables led to an increase in yield (grass or oil).

Models obtained for third fortnight pwh using logarithms of weather variables to predict logarithm of grass yields of first, fourth harvests also had a substantial predictability. The predictability of the models for these harvests during this fortnight was found to be 76 % ($\bar{R}^2$ = 0.63), 74 % ($\bar{R}^2$ = 0.68) respectively.

Model obtained for three fortnights pwh to predict grass yield using generated weather variables proposed by Agrawal *et al.* (1980) indicated that a substantial predictability was obtained for the model developed for second fortnight pwh, to predict grass yield of first, third and fourth harvest. However in the case of grass yield of second and fifth harvest, maximum predictability was obtained for the model developed for first fortnight pwh.

Oil yield

Number of rainy days was found to have a significant negative correlation with oil yield of first harvest, in addition to maximum temperature and relative humidity. However by second harvest, maximum temperature was found to have a significant positive correlation with oil yield. Minimum temperature was found to have a significant negative correlation with oil yield of third, fourth and fifth harvest. Relative humidity was found to have a significant positive correlation with oil yield of third and fifth harvest.

Two stage regression models obtained for six weeks prior to the week of harvest (pwh) for oil yield of various orders of harvest using weather variables pertaining to each week as explanatory variables revealed that, advance estimates of oil yield i.e, by sixth week pwh was obtained only for oil yield of fourth and fifth harvest. However for the first and third harvest, models obtained for first fortnight pwh was found to have a moderate predictability.

Substantial predictability was obtained for the two stage regression models developed for sixth week pwh of first and fifth harvest using weather variables and their logarithms . However for oil yield second and fourth harvest, models obtained for fourth week pwh had a higher predictability, when compared to those obtained for fifth and sixth week pwh. Model obtained for fourth week pwh of third harvest had moderate predictability.

Two stage regression models developed using logarithms of weather variables to predict logarithms of weather variables to predict logarithm of oil yield for various orders of harvest were also developed. While a moderate predictability was obtained for models developed for fourth week pwh to predict oil yield of first and third harvest, a higher predictability was obtained for the models pertaining to the same week to predict oil yields of second, and fourth harvest. However advance estimate i.e., by sixth week pwh with a higher predictability was obtained for the models developed to predict oil yield of fifth harvest.

Models obtained for oil yield of various orders of harvest using weather variables pertaining to three fortnights pwh as explanatory variables revealed that, a substantial predictability was obtained for the models developed for third fortnight pwh to predict yields of first, fourth and fifth harvest. On the other hand, a substantial predictability was obtained for the model developed for first fortnight pwh, to predict oil yields of remaining harvest.

Models obtained for various orders of harvest, using weather variables and their logarithms pertaining to three fortnights pwh revealed that, by second fortnight pwh estimates of oil yield of first, third, fourth harvest could be obtained with a sufficient degree of precision. However for oil yield of fifth harvest, prediction was possible as early as by sixth week pwh with a substantial predictability.

Model obtained for three fortnights pwh to predict logarithm of oil yield of various orders of harvest using logarithms of weather variables indicated that, a moderate predictability was obtained for the models developed for second and third fortnights pwh to predict logarithms of oil yield of first, second and third harvest. However a substantial predictability was obtained for the model developed for first fortnight pwh to predict logarithm of oil yield for first, second and third harvest. In the case of oil yield of fourth and fifth harvest, advance estimate of logarithms of oil yield of these harvest was possible i.e., by the third fortnight pwh using logarithm of weather variables pertaining to this fortnight.

Prediction models were developed for three fortnights pwh using generated weather variables. Models developed for first fortnight pwh was found to have maximum predictability for all orders of harvest. However for fifth harvest, model developed for third fortnight pwh could explain about 84% of variation in oil yield of this harvest, thus giving an advance estimate of oil yield for this harvest.

In general it was noted that among the various prediction models developed, model using weather variables and their logarithms as explanatory variables was promising and hence it could be recommended for forecasting both grass and oil yield of lemongrass. Two stage regression models developed using weather variables and their logarithms as predictors had a relatively higher predictability when compared to the models obtained for three fortnights pwh, using the same set of independent variables.

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FORECASTING OF LEMONGRASS (*Cymbopogon flexuosus* Nees ex. Steud Wats) YIELD BASED ON WEATHER PARAMETERS

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ABSTRACT OF THE THESIS

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ABSTRACT

The grass and oil yield obtained from comparative yield trials conducted at Aromatic and Medicinal Plants Research Station from 1965-1989 and the weather observations corresponding to the same period have been analysed in order to evaluate the effect of different climatic factors on lemongrass yield and to develop suitable prediction models for the pre-harvest forecasting of grass yield with sufficient degree of precision. The variety viz., OD-19 (Sugandhi) was considered and the crop was raised as rainfed for the entire period of investigation. The meteorological variables included in the study were number of rainy days, total rainfall (mm), maximum temperature (°C), minimum temperature (°C) and relative humidity (%).

Coefficients of correlation of weather variables and their logarithms with grass and oil yield for the growing period of the crop (six weeks or three fortnights) were worked out. Two stage regression models for each week of the growing period were developed to predict grass and oil yield using observations on weather variables up to the week of forecast as the explanatory variables. Predictability of model obtained for earlier week of crop growth were over 70 % for first, second, fourth and fifth harvests.

Fortnightly prediction models were also developed making use of weather variables and their logarithms. In addition to these, logarithms of weather variables were also used as explanatory variables to predict logarithm of grass and oil yields. In the case of fortnightly weather variables composite regression model proposed by *Agrawal et al.* (1980) was also developed.

Appendix

Appendix

Weather data pertaining to six weeks prior to the week of harvest for various orders of harvest

Ordes of harvest	No.of weeks prior to the week of harvest	Total Rainfall (mm)	Maximum Temperature(^{0}C)	Minimum Temperature(^{0}C)	Relative Humidity(%)
1	1	67.78	26.84	22.62	91.80
	2	91.21	26.39	22.47	91.90
	3	51.29	26.78	22.72	91.87
	4	43.22	25.56	21.41	85.96
	5	34.14	26.83	22.70	97.02
	6	31.75	27.03	22.86	90.44
2	1	117.32	28.91	23.66	87.73
	2	79.28	32.87	24.10	88.64
	3	87.74	29.76	24.25	88.21
	4	63.41	30.27	24.39	86.60
	5	65.96	31.01	24.47	85.66
	6	44.23	31.65	24.44	85.67
3	1	111.28	27.04	22.72	91.78
	2	157.43	26.51	22.51	91.94
	3	148.34	26.92	22.63	91.44
	4	129.31	27.14	22.82	91.39
	5	146.06	26.61	22.64	90.06
	6	160.06	26.54	22.44	91.72
4	1	74.93	28.72	22.99	88.83
	2	77.41	28.64	22.80	89.61
	3	101.53	28.32	23.42	89.17
	4	74.73	28.58	23.76	89.00
	5	65.49	28.43	23.46	89.44
	6	50.64	28.24	23.53	89.94
5	1	9.86	30.36	21.59	83.89
	2	14.86	29.86	21.99	85.72
	3	20.64	29.58	21.14	87.50
	4	62.86	29.07	22.64	88.83
	5	32.64	29.27	22.81	88.06
	6	49.39	29.33	22.93	89.44