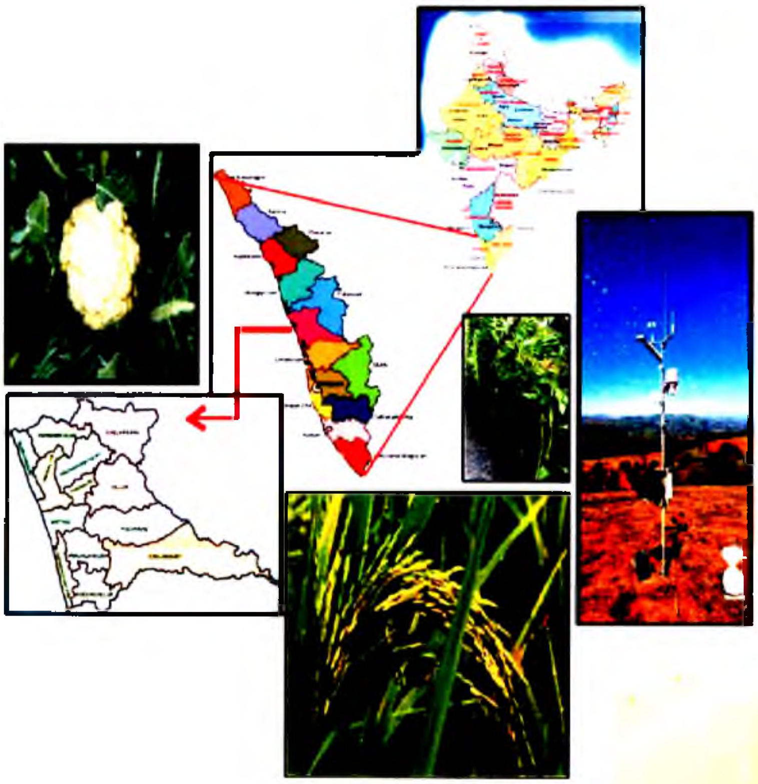
All India Co-ordinated Research Project on Agrometeorology



ANNUAL PROGRESS REPORT

1.4.2012 - 31.3.2013

Department of Agricultural Meteorology
College of Horticulture
Kerala Agricultural University
Vellanikkara- Thrissur 680 656
Kerala

All India Co-ordinated Research Project
On
Agrometeorology

अखिल भारतीय कृषि अनुसंधान परिषद
ICAR

Funded By
Indian Council of Agriculture Research

Annual Progress Report
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CONTENTS

All India Co-ordinated Research Project on Agrometeorology
Thrissur Centre

1. Title of the project	: All India Co-ordinated Research Project on Agrometeorology
2. Location of the co- ordinating	: Department of Agricultural Meteorology College of Horticulture Kerala Agricultural University Vellanikkara, Thrissur 680 656, Kerala
3. Geographical Co-Ordinates of the Location	: Latitude - 10°31'N Longitude - 76°13'N Altitude - 25 m amsl
4. Sanction Number	: No.F.1 (2)/92 AFC dt.15-4-95 of ICAR R2/71377/94 dt.28-4-95 of KAU
5. Date of start	: 01-04-1995
6. Report period	: 2012-2013

7. **Objectives**

a. To characterize climatic resources and crop growing environments of Kerala
b. To develop crop weather relationships of major crops in Kerala

8. Ongoing research projects

1. Agroclimatic resources characterization
2. Crop weather relationships studies of major crops
3. Agromet Advisory Services

Agroclimatic resources characterization

9. Progress of research

9.1 Agro-climatic resources characterization

9.1.1 Mean annual rainfall over Kerala

The mean annual rainfall of the State is 2824 ± 41 mm over a period of 142 years (1871 - 2012). The coefficient of variation of annual rainfall is only 14.26%, indicating that it is highly stable and dependable.

The season-wise rainfall distribution over Kerala indicated that 68 per cent of annual rainfall is received during the monsoon, followed by post-monsoon (17%) and pre-monsoon (14 %). The least (1 %) is seen in winter (**Table 1**). The seasonal rainfall during monsoon is dependable as the CV is 19.2%. At the same time, the rainfall during winter and summer is undependable as the CV is 96.36% and 40.72 %, respectively.

Table1. Season-wise normal rainfall (1871-2011) and its percentage contribution

Season	Normal Rainfall (1871-2012)	Percentage contribution to annual	Standard Deviation	CV (%)
Monsoon (June-Sept)	1921.22	68	367.97	19.15
Post-monsoon (Oct-Nov)	484.47	17	146.76	30.29
Winter (Dec-Feb)	27.92	1	26.90	96.36
Summer (Mar-May)	390.46	14	159.00	40.72
Annual	2824.06	100	402.83	14.26

9.1.2 Onset of monsoon over Kerala

The southwest monsoon set over Kerala was on 5th June 2012, four days delayed its normal onset date. It advanced rapidly along the west coast covering coastal Karnataka, Goa, Southern parts of Konkan and Madhya Pradesh on 6th June. The monsoon covered across the entire country by 11th July, 4 days earlier than it normal date of July 15th. The monsoon directory of Kerala indicated that the earliest onset of monsoon was on 11th May in 1918 while belated monsoon on 18th June in 1972.The trend in onset of monsoon appeared to be before 1st June rather after 1st June (**Fig. 1**)

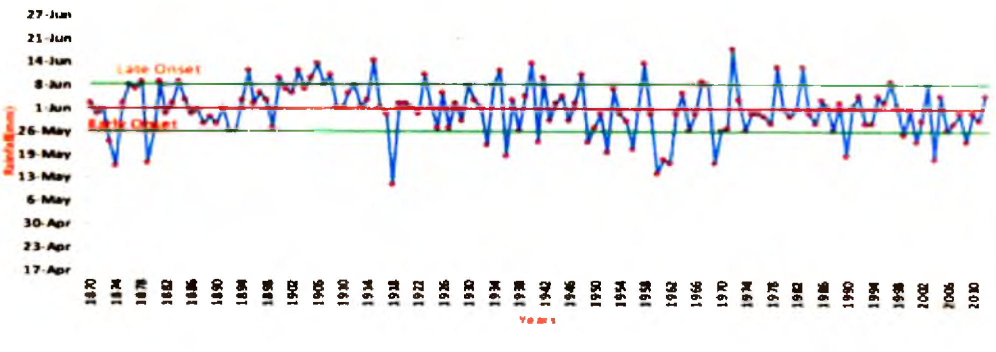

Fig. 1 Onset of monsoon over Kerala from 1870 to 2012 (142years)

For the last 30 years, the onset of monsoon was early on 18th May, 21st May and 24th May in 2004 ,2001and 1999, respectively. It was late in 2003 (13th June) and 1983 (11th June). All the remaining years fell under normal monsoon years (June 1+/-7 days). The earlier studies showed that if the monsoon is early (i.e. before 25th May), the total monsoon rainfall is likely to be below normal or normal. Similarly, it is also true when the monsoon was delayed (i.e. on or after 8th June). But during 2012 the onset was on 5th June and the state experiences a drought condition.

10. Rainfall Trends over Kerala

10.1. Annual Rainfall Trend

Mean annual rainfall over Kerala shows a long term insignificant decreasing trend (Fig. 2). The rainfall data from 1871 to 1975 shows an increasing trend (Fig 3). Whereas the rainfall from 1975 to 2012 shows a decreasing trend (Fig. 4).

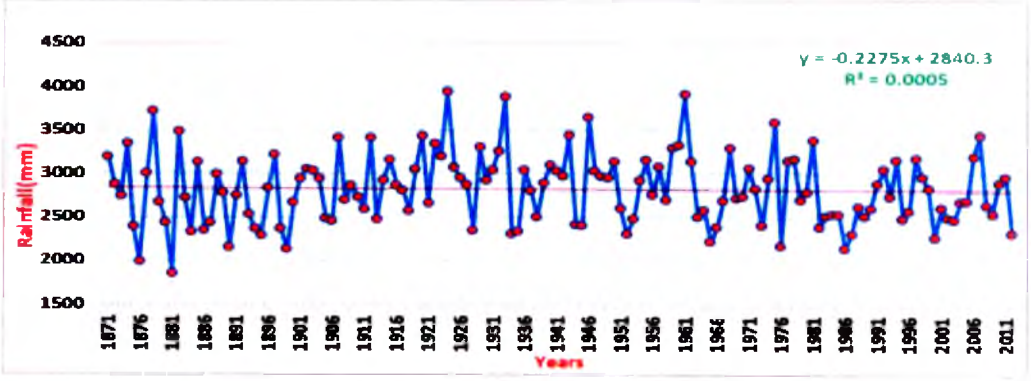

Fig.2. Annual Rainfall Trends over Kerala from 1871-2012

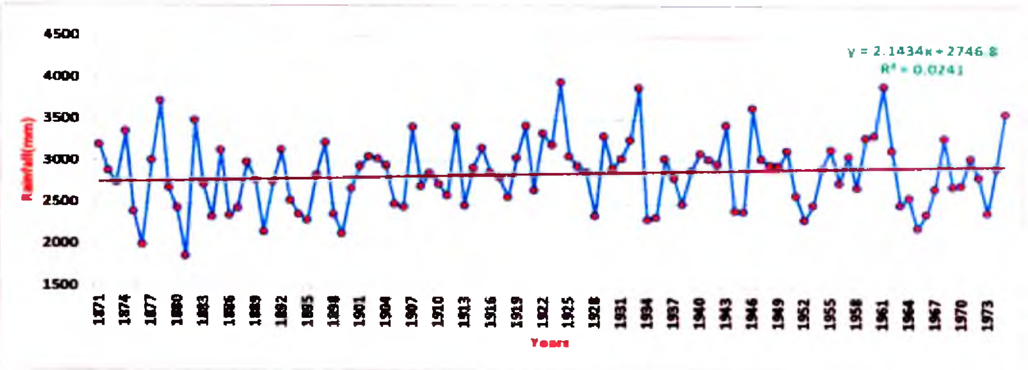

Fig.3. Annual Rainfall Trends over Kerala from 1871-1975

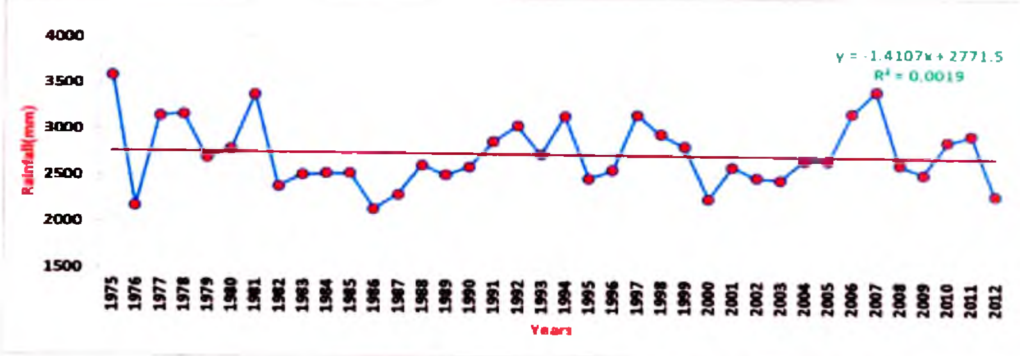

Fig.4. Annual Rainfall Trends over Kerala from 1975-2012

10.2. Seasonal Rainfall Trends

10.2.1 South West Monsoon (June-September)

Mean rainfall during south west monsoon over Kerala shows a long term decreasing trend (Fig 5). The rate of decrease of SWM is about 1.22mm per year.

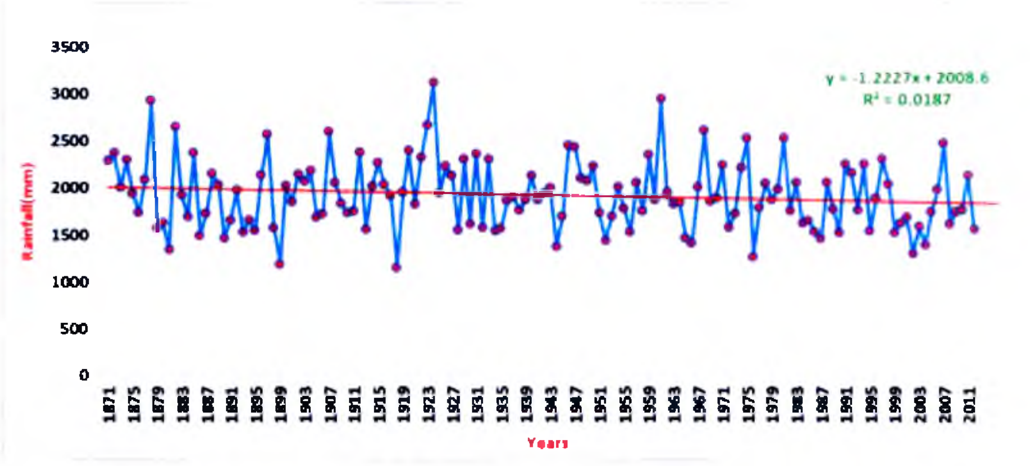

Fig.5. SW monsoon Rainfall Trends over Kerala from 1871-2012

10.2.2 Post Monsoon(October-December|

Post monsoon rainfall shows an increasing trend. Such trend was more evident since 1975 onwards. Post monsoon rainfall was increasing 0.72mm per year during 1871-2012 periods.

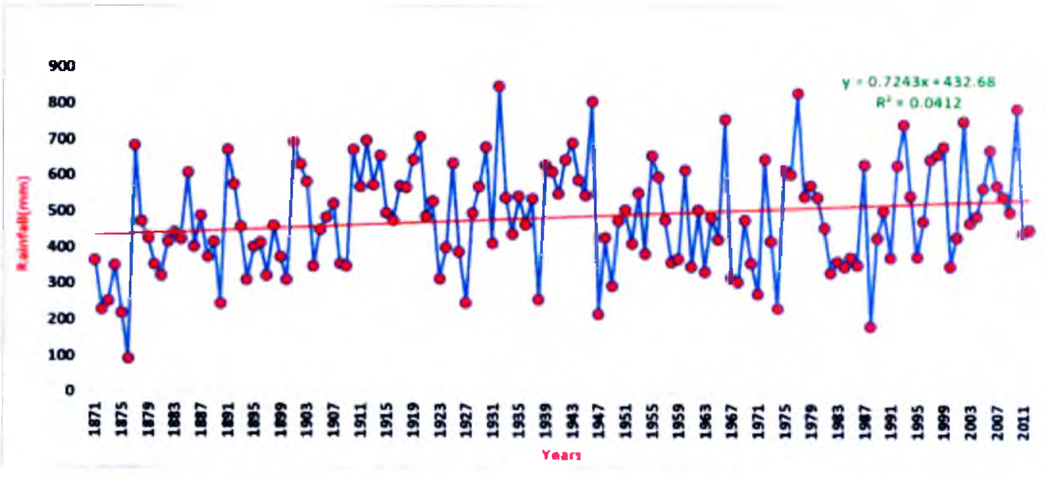

Fig.6. Post Monsoon Rainfall Trends over Kerala from 1871-2012

10.2.3 Winter Monsoon(January-February)

Winter rainfall had an increasing trend. Increase in rainfall during the season is beneficial to the plantation crops. However, high variability of rainfall lead to uncertainty and the crops need assured irrigation.

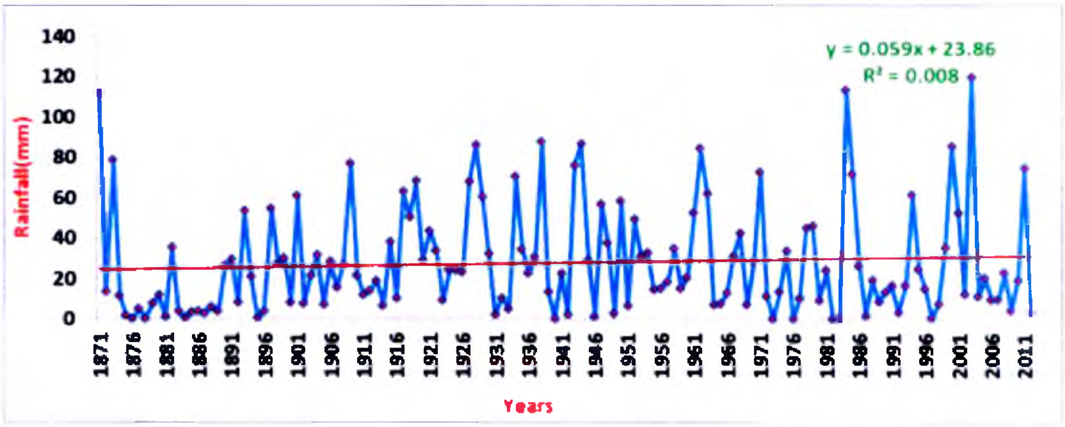

Fig.7. Winter Monsoon Rainfall Trends over Kerala from 1871-2012

10.2.4 Summer Monsoon(March-May)

There was an overall increasing trend which is statistically insignificant during our study period.

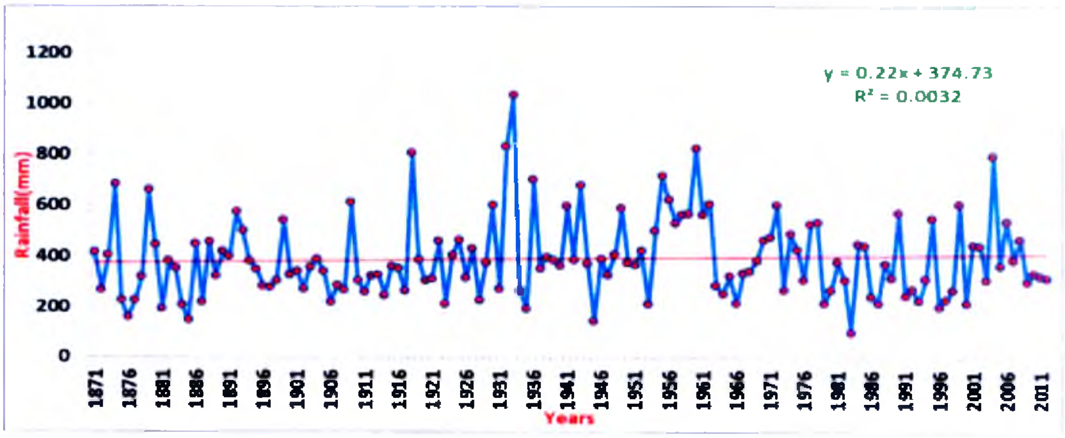

Fig.8. Summer Monsoon Rainfall Trends over Kerala from 1871-2012

11. Onset of monsoon over Thrissur (1980 to 2012) and monsoon rainfall

The onset of monsoon was normal (5th June) at Thrissur in 2012, which was similar to that of onset of monsoon over Kerala though the onset was on 5th May, further advancement was weak and it is clear from the rainfall pentads (Table 2). The monsoon rainfall was less during the period from 26th May to 15th June (204.3 mm) during active onset of monsoon. Thereafter, the monsoon was weak and the pentad rainfall was relatively less.

Table 2. Pentad rainfall (16th May to 15th June) in mm at Vellanikkara from 1980 to 2012

Year	16-20 May	21-25 May	26-31 May	1-5 June	6-10 June	11-15 June	Date of onset of monsoon
1980	3.0	85.3	10.3	220.7	96.1	20.0	1st June
1981	19.4	0.0	105.8	301.6	121.8	255.2	30th May
1982	120.7	12.8	27.4	65.0	122.8	79.0	30th May
1983	3.5	3.2	0.9	0.0	26.1	90.6	11th June
1984	20.4	0.0	19.0	193.0	54.2	186.1	31st May
1985	26.4	48.8	128.0	127.7	62.0	121.9	28th May
1986	7.0	0.4	31.0	0.8	27.5	108.2	3rd June
1987	4.1	73.9	0.8	165.4	30.0	157.1	2nd June
1988	0.0	8.0	159.2	154.6	177.2	27.7	26th May
1989	28.8	30.6	12.9	11.7	128.9	183.0	3rd June
1990	81.2	141.0	160.7	23.9	66.8	178.9	28th May
1991	0.0	36.3	17.2	240.6	241.3	217.2	2nd June
1992	45.0	0.6	3.6	11.4	306.7	168.5	5th June
1993	31.9	5.4	89.4	23.4	228.2	208.1	28th May
1994	0.8	2.1	28.3	247.9	177.0	188.4	29th May
1995	12.0	0.6	2.0	2.8	67.7	253.0	8th June
1996	16.2	1.0	10.2	1.4	41.2	116.1	3rd June
1997	0.0	0.0	28.0	103.2	30.2	48.0	9th June
1998	88.0	11.0	0.4	37.6	52.1	68.4	2nd June
1999	44.4	169.6	137.3	65.1	127.8	141.7	24th May
2000	45.2	18.6	48.5	86.4	305.5	46.9	1st June
2001	2.0	72.8	52.3	36.6	171.5	227.0	21st May
2002	325.3	2.8	44.6	110.6	40.0	209.5	1st June
2003	26.8	0.0	2.0	0.5	58.9	52.9	13th June
2004	115.3	97.2	51.8	351.9	126.5	114.8	18th May
2005	0.0	0.0	67.4	54.4	60.9	44.9	8th June
2006	84.8	55.6	520.3	57.5	2.2	37.4	26th May
2007	0.0	19.6	141.1	1.4	92.3	177.4	28th May
2008	0.3	1.6	6.6	30.1	140.6	93.4	31st May
2009	41.8	101.9	26.0	86.3	151.9	26.9	23rd May
2010	46.5	1.0	32.1	24.7	16.4	307.5	31st May
2011	0.0	3.2	82.1	254.0	135.5	122.7	29th May
2012	26	0	2.5	28.2	92.7	54.9	5th June

The monsoon was weak over the District during June, July and September while it was strong in August. The onset phase was active on August and hence the rainfall received during August was 72% above normal. The rainfall was deficient in June (20%), July (55%) and September (67%) when compared to normal and hence the monsoon rainfall during 2012 was 15.4% deficient than normal. It was a weak monsoon (Table 3) year after 2008 (19.6% deficient) since last 11 years and it has affected the first season rice crop very badly.

Table 3.Rainfall at Vellanikkara during Southwest monsoon from 2001 to 2012

Year	Monthly monsoon rainfall (mm)				Total	% deviation from over normal
	June	July	August	September		
2001	676.2	477.7	256.2	206.1	1616.2	-24.7
2002	533.5	354.2	506.6	124	1518.3	-29.2
2003	570.6	492.6	490.1	53.7	1607	-25.1
2004	786.0	369.6	386.9	208.8	1751.3	-18.4
2005	711.4	727.5	346.5	416.1	2201.5	2.6
2006	608.6	519	550.6	522.2	2200.4	2.5
2007	826.5	1131.9	549.7	765.9	3274	52.6
2008	636.7	416.3	321.9	314.2	1689.1	-19.6
2009	565.0	985.8	421.4	276.0	2248.2	-14.4
2010	700.4	552.0	224.1	326.7	1803.2	-6.3
2011	799.6	588.2	713.8	435.2	2536.8	21.1
2012	551.5	375.8	616.5	191.8	1735.6	-15.4

12. Annual Rainfall over vellanikkara

The data on mean annual rainfall, deviation from normal, coefficient of variation, standard deviation and its classification are given in Table 4 and 5. The mean annual rainfall of this region was 2781.8mm spread with coefficient of variation 17.72 %. The maximum rainfall was 3964.2 mm in 2007 followed by 3626.4 mm in 1992 and the minimum was 2140.7 mm in 2012. The normal range *i.e.* between ± 19 of mean annual rainfall was 2401.9 to 3178.4 mm. Out of 30years, six years *viz.*, 1992, 1994, 1998, 2006, 2007 and 2011received excess of rainfall (19.0 – 30 %). Whereas years 2000 & 2012 received less than -26 to -49% rainfalls than the normal range and declared as moderate drought year.

The rainfall of 30 years (Table 4) ranged from 1770.8 mm to 3962.4 mm with a mean of 2781.8 mm. The standard deviation (SD) was moderately less (492.33) with a coefficient of variation (CV) of 17.72 per cent, indicating moderate variability and dependability on rainfall. The 5 years analysis (Table 5) indicated that, the mean annual rainfall was more or less normal with a moderate coefficient of variation (<25 %). During better rainfall years, 2003-2007 (5 years) mean rainfall was 3039.24 mm with CV (22.4 %).

Year	Mean	%RF departure from Normal	Situation
1983	2418.2	-15.036	N
1984	2594.7	-7.211	N
1985	2617	-6.297	N
1986	2349.5	-18.400	N
1987	2462.9	-12.948	N
1988	2923.7	4.853	N
1989	2630.4	-5.756	N
1990	2532.4	-9.848	N
1991	3182.3	12.585	N
1992	3626.7	23.297	E
1993	2439.3	-14.041	N
1994	3579.6	22.287	E
1995	2809.7	0.993	N
1996	2241.4	-24.110	SLD
1997	3044.4	8.626	N
1998	3435.7	19.033	E
1999	2619.6	-6.192	N
2000	2173.9	-27.964	MD
2001	2400.1	-15.904	N
2002	2303.6	-20.759	SLD
2003	2223	-25.137	SLD
2004	2895.2	3.917	N
2005	2662.9	-4.465	N
2006	3460.3	19.608	E
2007	3962.4	29.795	E
2008	2401.9	-15.817	N
2009	2852.3	2.472	N
2010	3004.9	7.425	N
2011	3465.3	19.724	E
2012	2140.7	-29.948	MD

Table.4. Year wise mean rainfall and % rainfall departure from normal at Thrissur district of Kerala

IMD Classification: E= Excess RF (>19%), N = Normal RF (± 19%), SLD = Slight Drought (> -19 to -25%), MD = Moderate Drought (-26 to -49%) and SD = Severe Drought (-50% & above)

Table .5. Annual Rainfall (mm) variability between 1983to 2012(30 years)

Period	Mean Rainfall(mm)	%Departure from Normal	SD	CV (%)
1983-1987	2418.2	-14.55	114.79	4.75
1988-1992	2979.1	7.02	442.97	14.87
1993-1997	2822.88	1.87	526.10	18.64
1998-2002	2586.58	-7.09	501.81	19.40
2003-2007	3040.76	8.90	681.57	22.41
2008-2012	2773.02	0.11	518.86	18.71

13. Seasonal Rainfall

The data on mean seasonal rainfall, standard deviation, coefficient of variation and percentage contribution of seasonal rainfall are presented in Table 6. Highest amount of 2050.643 mm of rainfall was received in south-west monsoon contributing to 73.71% to total amount of rainfall with coefficient of variation of 9.21% indicating its dependability. For post-monsoon season, the rainfall received was 427.76 mm and thus contributing 15.38% to the total with coefficient of variation of 33.699%. Winter monsoon rainfall also contributed substantially 13.49 mm), 0.48% of the total with 53.13% coefficient of variation, in summer the rainfall was 289.91 mm are thus contributing 10.42% to the total with coefficient of variation of 29.85%.

Table.6. Mean seasonal rainfall, standard deviation, coefficient of variation and percentage contribution of seasonal rainfall

Month	Mean	SD	CV	% of total
Jan	1.68	4.60	274.21	0.060
Feb	11.81	32.93	278.76	0.425
March	20.68	43.10	208.39	0.744
April	78.36	62.55	79.82	2.817
May	190.86	164.20	86.03	6.861
June	691.22	174.61	25.26	24.848
July	639.04	232.42	36.37	22.972
Aug	439.74	132.55	30.14	15.808
Sep	280.64	190.08	67.73	10.088
Oct	302.56	132.68	43.85	10.877

Nov	102.40	96.16	93.90	3.681
Dec	22.79	41.16	180.60	0.819
Seasonal Rainfall				
Winter	13.49	7.17	53.13	0.485
Summer	289.91	86.55	29.85	10.422
SWM monsoon	2050.64	188.86	9.21	73.716
Post monsoon	427.76	144.15	33.70	15.377
Total	2376.83	244.79	8.80	100

14. Weekly distribution of rainfall at Vellanikkara during Southwest monsoon of 2012

The weekly monsoon rainfall distribution pattern showed that the rainfall was active during June while it was comparatively weak in July. Weekly distribution was weak on the third week of August. But a sharp increase was observed on to the end of August. But total rainfall was high during August. Rainfall was weak from the second week of September toward the end of season. (Fig.9). Agriculture drought was there in 2012 from 27th standard week to 31st standard week shows in Fig.10.

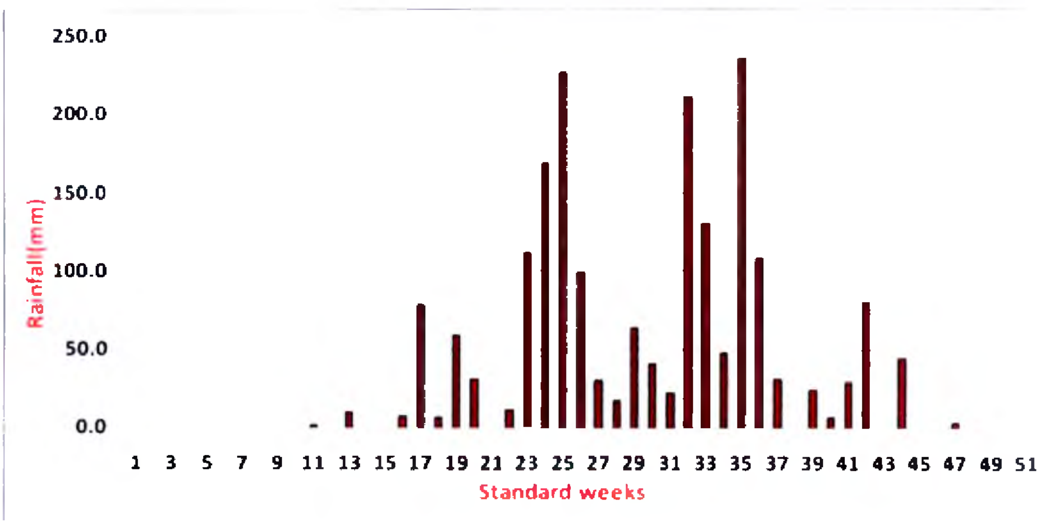

Fig.9. Weekly distribution of monsoon rainfall over Vellanikkara

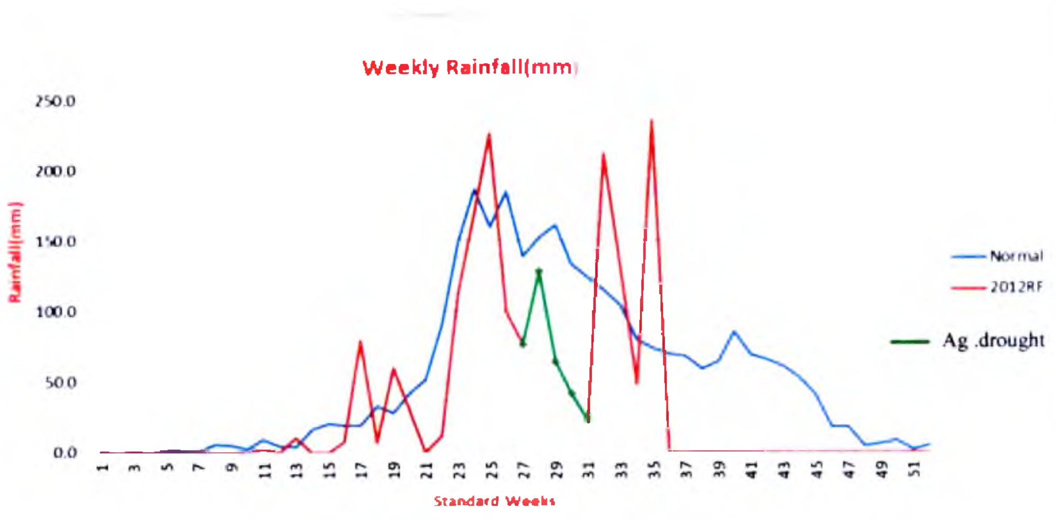

Fig.10. Weekly distribution of monsoon rainfall over Vellanikkara (green line showing Agriculture Drought during 2012)

15. Weekly soil moisture (%) from January to September at Vellanikkara during 2012

There was a sharp increase in soil moisture storage on 17th standard week. After that, there is a slight decrease in soil moisture due to decrease in rainfall. Since the onset of monsoon was on 5th June and the rainfall was normal except in July, soil moisture storage was also good during the initial weeks later it was decreased drastically due to poor rainfall. With the progress of monsoon soil moisture storage increased and reached to the field capacity. The soil moisture status was low in cropped field when compared to that of bare soil mainly from 27th to 38th standard week. This has created an agricultural drought situation in all most all the part of the districts.

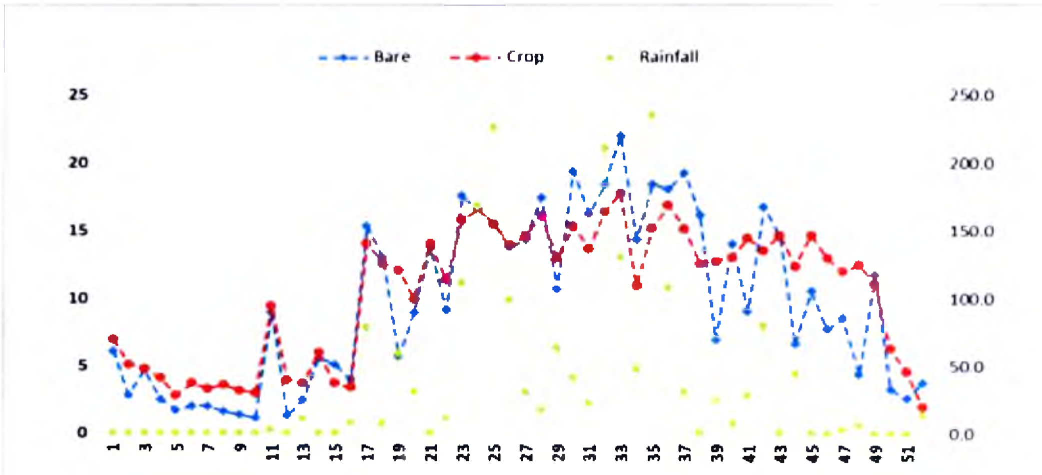

Fig.11. Weekly soil moisture variation in bare and cropped field from January to September 2012

Crop weather relationship studies of major crops



Crop weather relationships of cauliflower
(*Brassica oleracea* var. *Botrytis* L.)



16. Crop weather relationships of cauliflower (*Brassica oleracea* var. *Botrytis* L.)

Objectives:

The main objectives are to study the effect of weather on growth and yield of cauliflower and to assess the suitability of cauliflower under various crop growing environments

16.1. Plant height

The weekly plant heights differed significantly for the different times of planting and the pattern was found to be dissimilar for the two years. But during the harvest-time, the plant height was higher in the delayed plantings in 2010-11 (Fig. 12.1), that higher temperatures increased plant height in cauliflower. The maximum height was found in the 1st December planting in 2010-11 (14.0 cm), since the crop duration was long in that crop compared to other plantings which allowed the plant to get exposed to higher temperatures for more number of days and thereby the plant height increased.

But in 2011-12, the higher plant height was observed in the 1st November planted crop (14.8 cm) because of the active vegetative growth during the curd initiation phase favoured by the low mean and minimum temperatures and higher forenoon and afternoon relative humidity compared to the first year. Reduction in plant height with respect to delay in planting time as observed in 2011-12.

The plant height was observed to be similar in both Basant and Pusa Kartik Sankar indicating that these genotypes had similar responses to the weather parameters influencing plant height. Even though, there were differences in plant height with respect to time of planting in both the years, pooled analysis showed that times of planting were similar (11.2-13.5 cm) because of the high variability between the two years. The year-to-year variation for the same planting time may be attributed by the fluctuation in the minimum temperature in both the years during the experimental period.

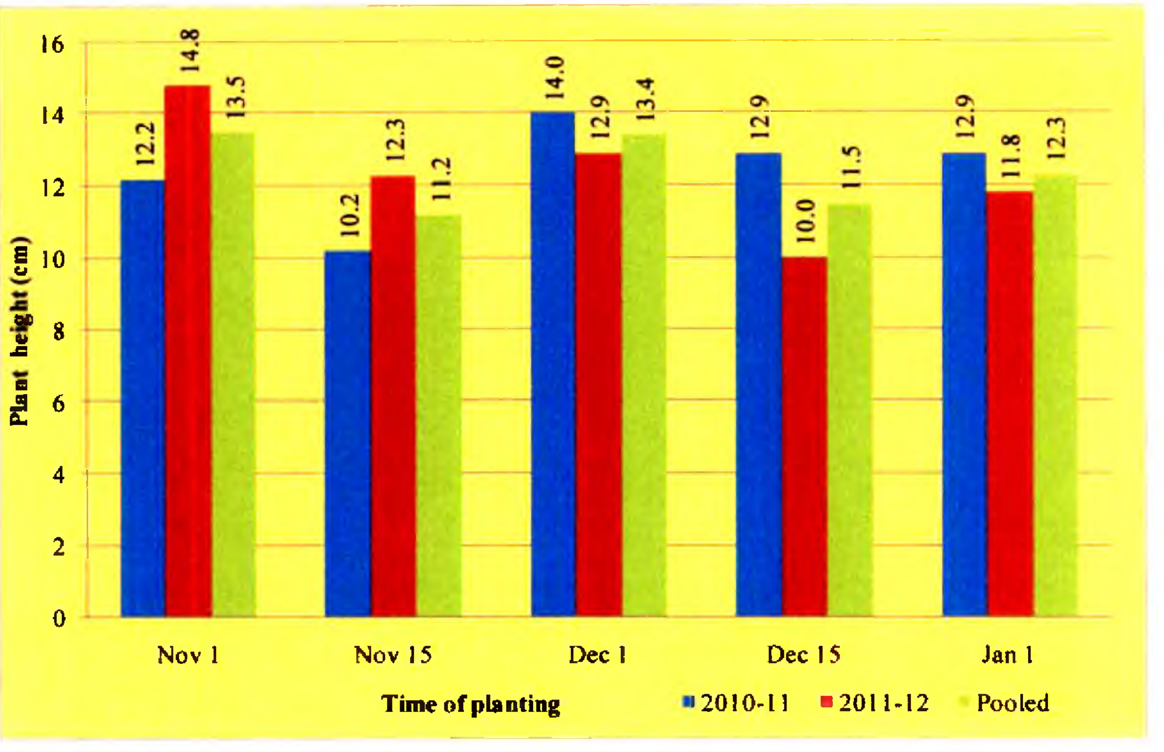

Fig.12.1. Plant height of different times of planting at the time of harvest

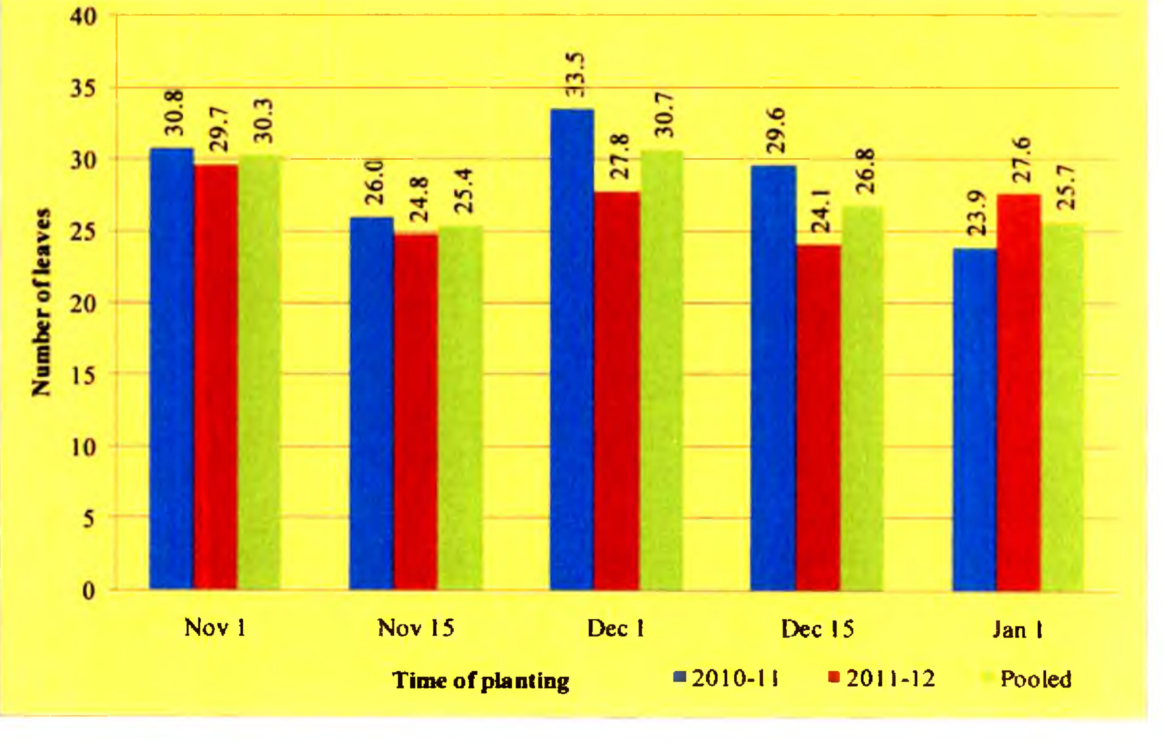

Fig.12.2. Number of leaves of different times of planting at the time of harvest

The maximum, minimum and mean temperatures showed positive correlation with plant height until curd initiation and after that increase in temperature exhibited negative effect on harvest-time plant height, but the diurnal temperature range exhibited negative effect on plant height. Increase in forenoon and afternoon vapour pressure deficit in response to decrease in the corresponding humidity also favoured enhanced plant height. Bright sunshine hours, solar radiation and wind speed also showed positive effect on plant height..

16.2. Number of leaves

Number of leaves showed variation with respect to prevailing weather conditions because at the time of transplanting the number of leaves was 3.8-4.4 for the different times of planting in 2010-11, but at the time of harvest it ranged between 23.9 and 33.5.

Compared to first year, leaf production was less in the second year (Fig. 12.2) because of the higher temperature and solar radiation along with lower humidity and higher vapour pressure deficit experienced by the crop. Even though, variation with respect to leaf number was observed in individual years for different planting times, no significant difference was noticed in the pooled analysis (25.4-30.3 leaves) because of the considerable variation observed between the same planting times in both the years. The year-to-year variation for the same planting time may be attributed by the fluctuation in minimum temperature during the experimental period in both the years. Though, no specific pattern in leaf production was noticed with respect to planting time in this study.

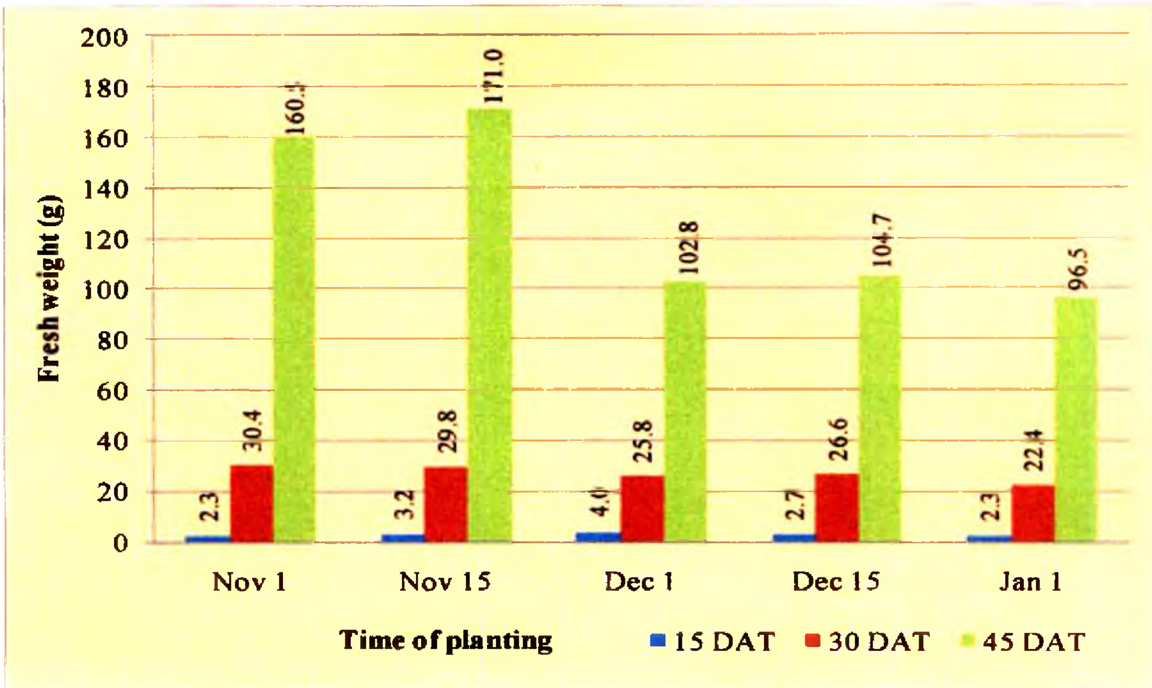

Fig.12.3. Plant fresh weight of different times of planting at 15 DAT, 30 DAT and 45 DAT

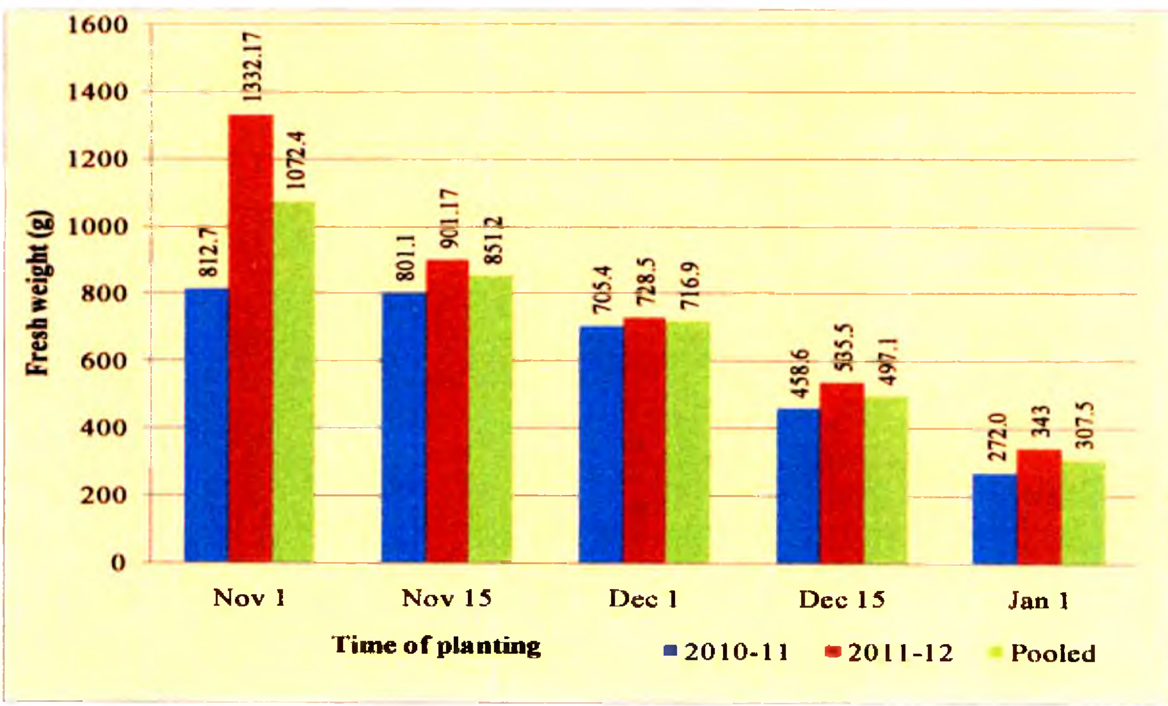

Fig.12.4. Plant fresh weight of different times of planting at the time of harvest

The correlation analysis revealed that the production of leaves decreased with increase in maximum temperature and diurnal temperature range. In the initial weeks after transplanting increase in relative humidity enhanced the leaf production, but as the crop approached to curd initiation, relative humidity showed a negative influence until the curd development is over.

The number of leaves at the time of harvest was more in the 1st November planting (29.7 leaves) in 2011-12, because of the active vegetative growth favoured by the weather conditions, especially the lower maximum temperature, but in 2010-11, the highest number of leaf was recorded in 1st December planting (33.5 leaves) because of the lowest minimum temperature experienced by the crop during its crop growth. The number of leaves was observed to be similar for both Basant and Pusa Kartik Sankar indicating that these varieties have similar responses to the weather parameters influencing leaf production.

In delayed plantings, irrespective of the year, plants produced shorter leaves even though the leaf number varied. The high incident solar radiation coupled with high temperature might have resulted in small leaf size.

16.3. Plant weight

The influence of planting time on the whole plant weight was recognized in this study. In the initial crop growth stage, the plant fresh and dry weights were observed to be more in the 1st December plantings in both the years, but at 45 DAT, the 1st November and 15th November planted crops recorded the highest fresh and dry weights (Fig. 12.3) because of the higher vegetative growth. The vegetative stages of these early plantings were observed to be very active in the respective growing environments with low temperature, low incident radiation, high humidity and low vapour pressure deficit. Plant weights were low in the delayed plantings because of the stunted plant growth as a result of higher temperature and solar radiation.

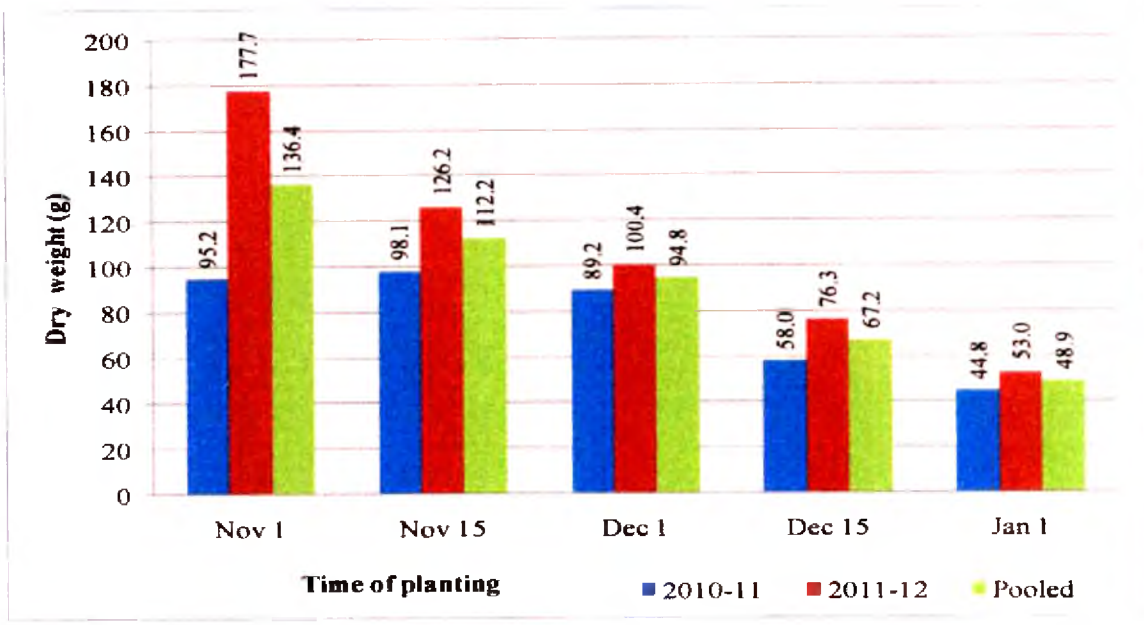

Fig. 12.5. Plant dry weight of different times of planting at the time of harvest

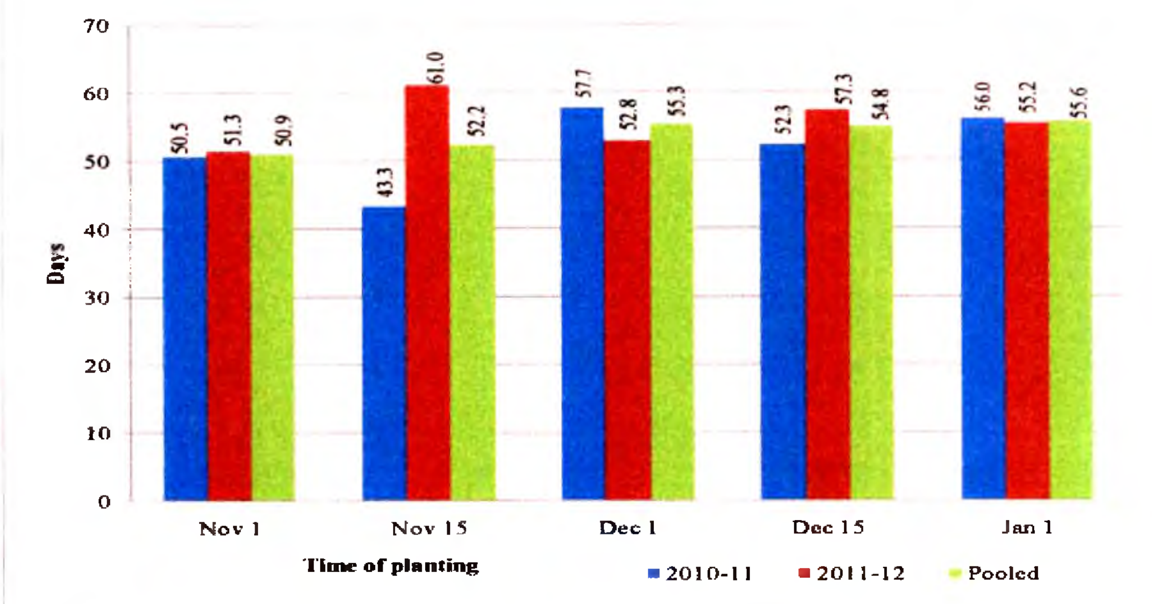

Fig.12.6. Duration of transplanting to curd initiation period in different times of planting

The plant weight was high in early plantings at the harvest time also (Fig. 12.4 and 12.5), which was attributed by the active vegetative growth before the curd initiation phase along with the higher curd weight. The fresh and dry plant weights obtained in 2011-12 were 1332.2g and 177.7g in 1st November planting and 343.0g and 53.0g in 1st January plantings, respectively.

16.4. EFFECT OF WEATHER ON THE DURATION OF DIFFERENT GROWTH STAGES

16.4.1. Duration from transplanting to curd initiation

The duration from transplanting to curd initiation showed considerable variation with respect to time of planting in both the years (Fig. 12.6). The curd yield was observed to be high when the duration of this phase was short. Duration of this growth stage varied between 50.9 days and 55.6 days in the pooled analysis. The shortest duration in 2010-11 was observed in the 15th November planting (43.3 days) because of the low mean temperature experienced by the crop during this period compared to that of 1st November planting which took 50.5 days for curd initiation and the mean temperature experienced (26.4°C) was very low compared to all other planting times. But in the second year 15th November planted crop took more number of days to reach curd initiation phase (61.0 days) because the crop underwent high diurnal variation in temperature (9.3°C) compared to 15th November planting (8.5°C).

From the correlation analysis, it was identified that maximum and mean temperatures and diurnal temperature range exhibited positive influence on the duration of this phase. The bright sunshine hours and solar radiation also showed positive influence on the duration of this phase. The minimum temperature showed an overall negative influence on the duration from transplanting to curd initiation (Fig. 12.7), but for the curd initiation to occur, the minimum temperature should be low in the preceding week.

Relative humidity showed negative influence and VPD showed positive influence on the duration from transplanting to curd initiation. The heat units exhibited positive influence indicating the effect of both temperature and sunshine hours and among the different heat units, growing degree days were appeared to have high correlation with the duration of this phase and the influence of GDD on the duration from transplanting to curd initiation is depicted in (Fig. 12.8).

16.4.2. Duration from curd initiation to harvest

In both the years, the duration to curd maturity was shorter in the earlier plantings (Fig. 12.9) and the shortest duration was observed in the 15th November

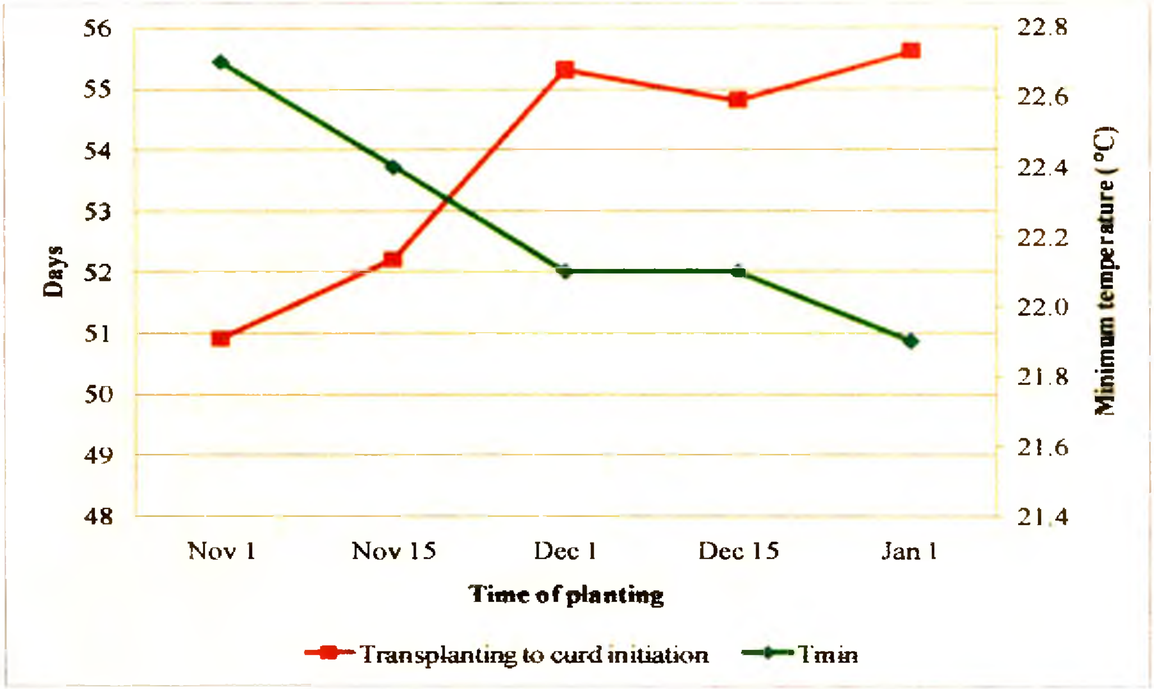

Fig. 12.7. Relationship between minimum temperature and the duration of transplanting to curd initiation phase

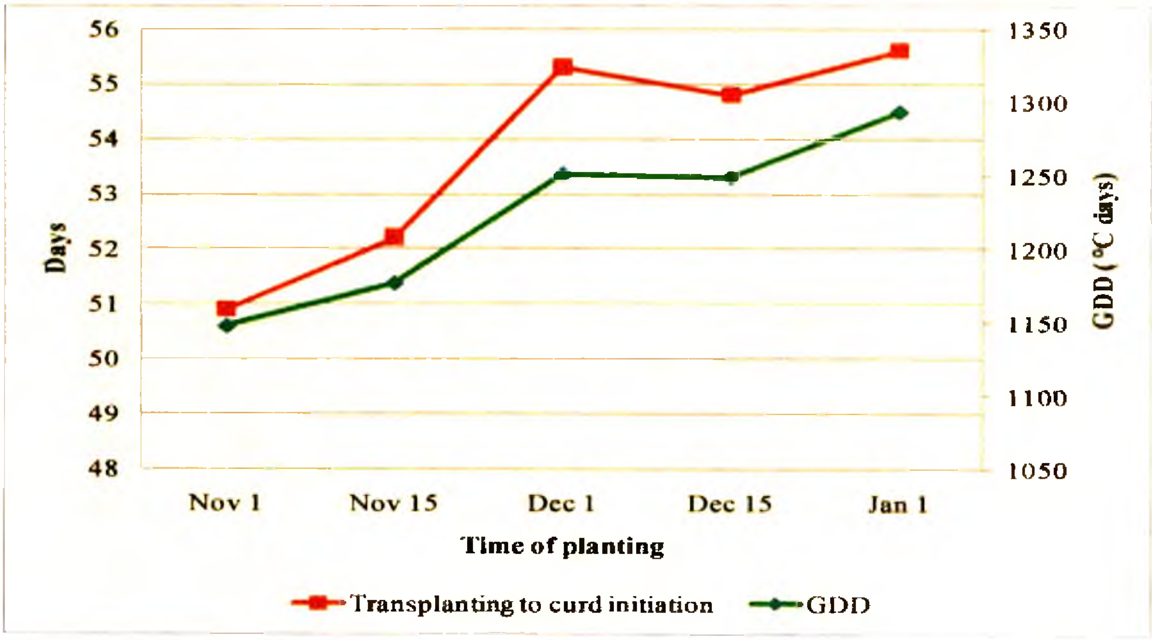

Fig. 12.8. Relationship between growing degree days and the duration of transplanting to curd initiation phase

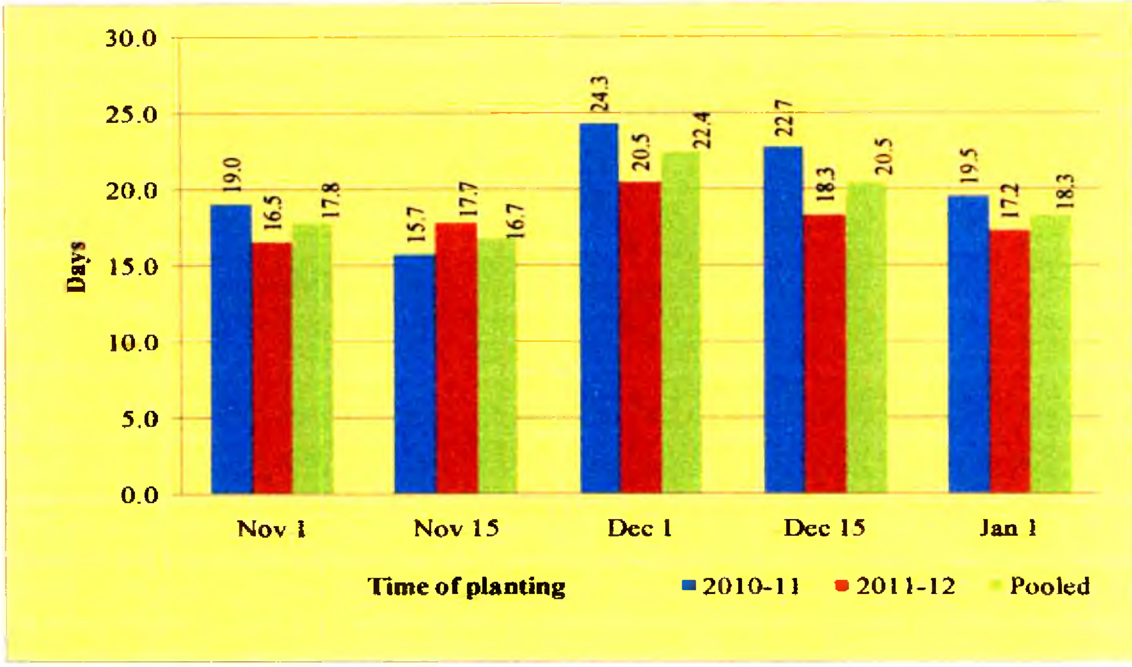

Fig.12.9. Duration of curd initiation to harvest period in different times of planting

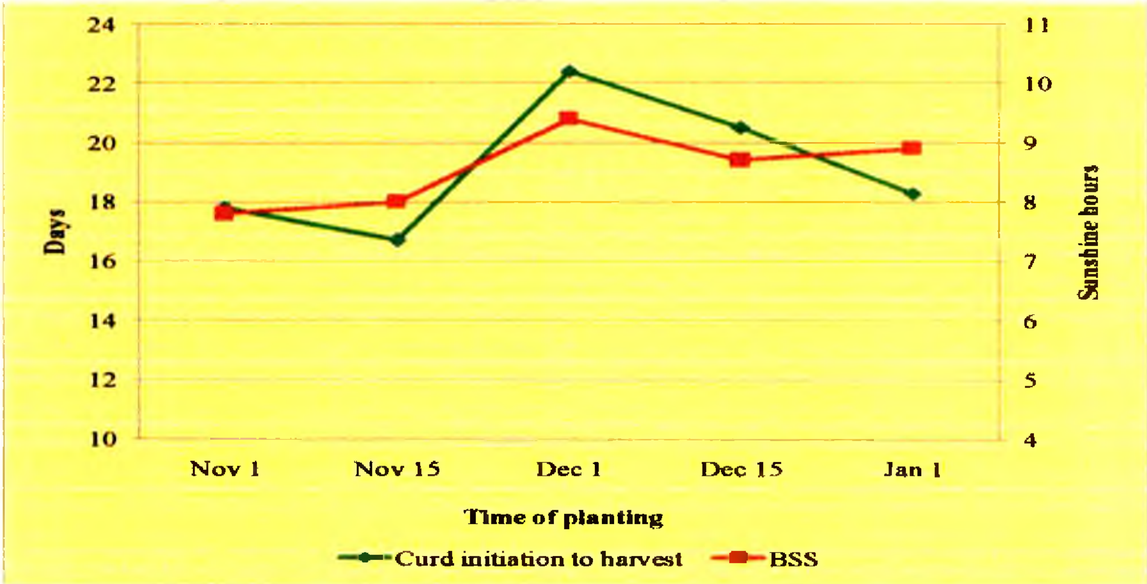

Fig.12.10. Relationship between bright sunshine hours and duration of curd initiation to harvest phase

planting (16.7 days) whereas the longest was noticed in 1st December planting (22.4 days). During this phase, the most critical weather variables influencing the duration were observed to be bright sunshine hours and solar radiation and these were exhibited positive impact. The influence of BSS on the duration of this growth stage is depicted in (Fig.12.10). Maximum and mean temperatures and DTR also showed positive influence on the duration of curd initiation to harvest period.

16.4.3. Duration from transplanting to harvest (crop duration)

The crop duration was observed to be less in the earlier plantings (Fig. 12.11) and this was observed to be influenced by the duration from transplanting to curd initiation. The crop duration varied between 68.7 days in 1st November and 77.7 days in the 1st December planting. The crop duration was positively influenced by maximum and mean temperatures, diurnal variation of temperature, bright sunshine hours and solar radiation. Relative humidity exhibited negative effect on crop duration whereas, vapour pressure deficit and wind speed showed positive effect. Heat units showed positive influence and the effect of growing degree days on the entire crop duration is depicted in (Fig. 12.12).

16.5. CURD WEIGHT

Curd in cauliflower is the prefloral fleshy apical meristem and the formation of curd is the transient stage between vegetative and generative stage which is highly influenced by the prevailing weather conditions.

In the present study, curd weight decreased with each delay in planting time (Fig. 12.13) . Maximum (Fig. 12.14) and mean temperatures and diurnal temperature range showed a negative influence on curd weight and at higher temperatures, the curd yield obtained was very less.. Minimum temperature showed negative relation with curd weight in the correlation analysis and it was observed that the temperature before curd initiation influenced the curd weight more than that after the curd initiation. For better yield, the minimum temperature should be low in the curd development phase compared to that of curd initiation phase. The highest curd yield was observed in 1st November planted crop in 2011-12 which required less heat units and it is illustrated by considering growing degree days (Fig. 12.15).

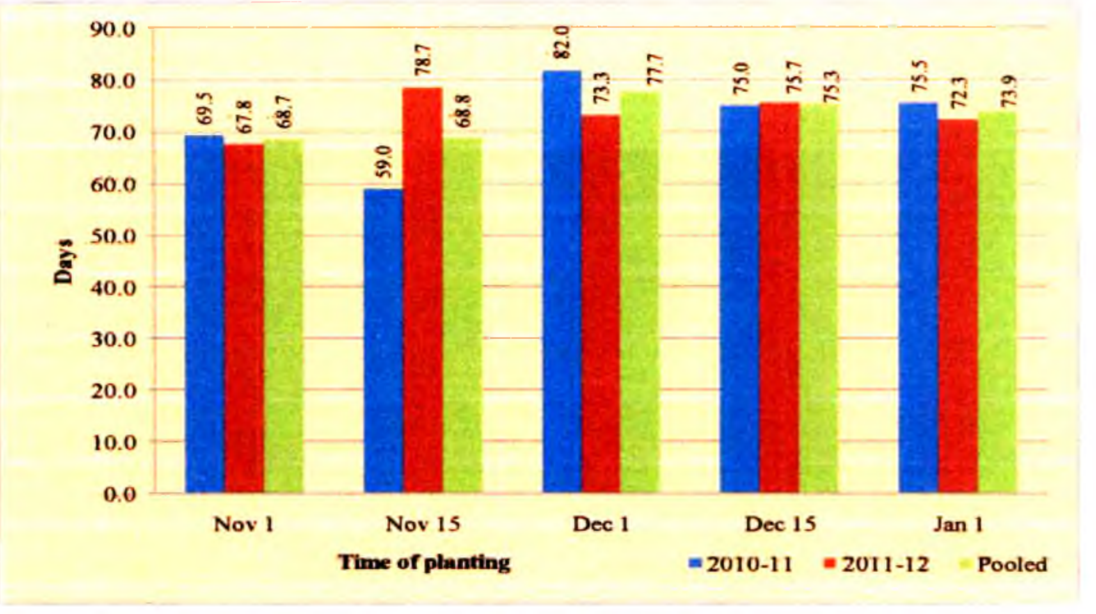

Fig.12.11. Duration from transplanting to harvest in different times of planting

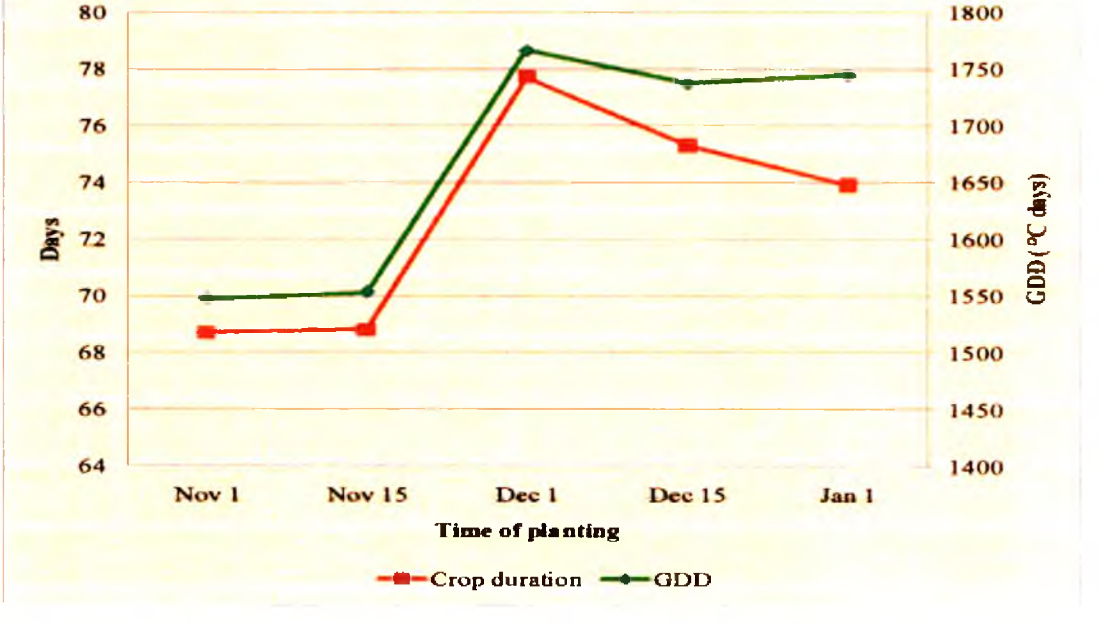

Fig.12.12. Relationship between growing degree days and the crop duration

Afternoon relative humidity showed positive influence and vapour pressure deficit showed negative influence on curd weight. Bright sunshine hours and solar radiation during the early vegetative and curd development stages exhibited negative influence on curd weight. Wind speed during the curd maturation period (one week before harvest) showed significant negative influence on curd weight.

In this study, earlier curd initiation resulted in highest curd weight. Incidence of black rot disease occurred in 2010-11 which resulted in low curd yield in all planting times compared to 2011-12.

It was observed that, in the plains, if weather conditions are favourable, a curd yield of 535.2g can be achieved if planting is done in the first fortnight of November. The optimum weather variables contributing to higher yield were identified as, 31.1-31.4°C, 22.4-22.7°C, and 26.9-27.0°C of maximum, minimum and mean temperatures respectively with low DTR of 8.4-8.9°C, higher humidity of 81.1-83.6% in forenoon and 55.6-59.6% in afternoon, lower vapour pressure deficits of 3.9-4.4 mm Hg in forenoon and 13.6-15.1 mm Hg in afternoon, low bright sunshine hours and solar radiation of 5.9-6.5 hrs and 15.7-16.6 MJ m^{-2} respectively, in the transplanting to curd initiation phase followed by further low minimum temperature of 21.1-22.7 °C in the curd development phase. So planting of tropical cauliflowers can be done when the maximum temperature, mean temperature, DTR, BSS and solar radiation are, less than 31.2°C, 26.8°C, 8.8°C, 6.0 hrs, and 22.3 MJ m^{-2} respectively, with an average minimum temperature of 22.5°C.

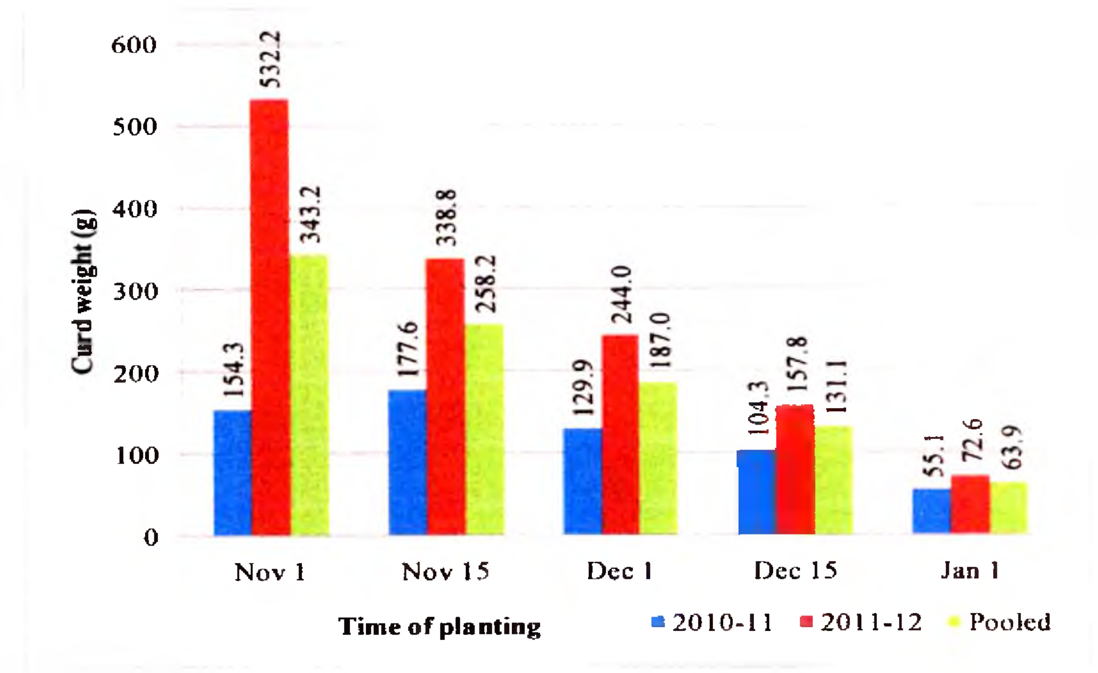

Fig.12.13. Curd weight obtained in different times of planting

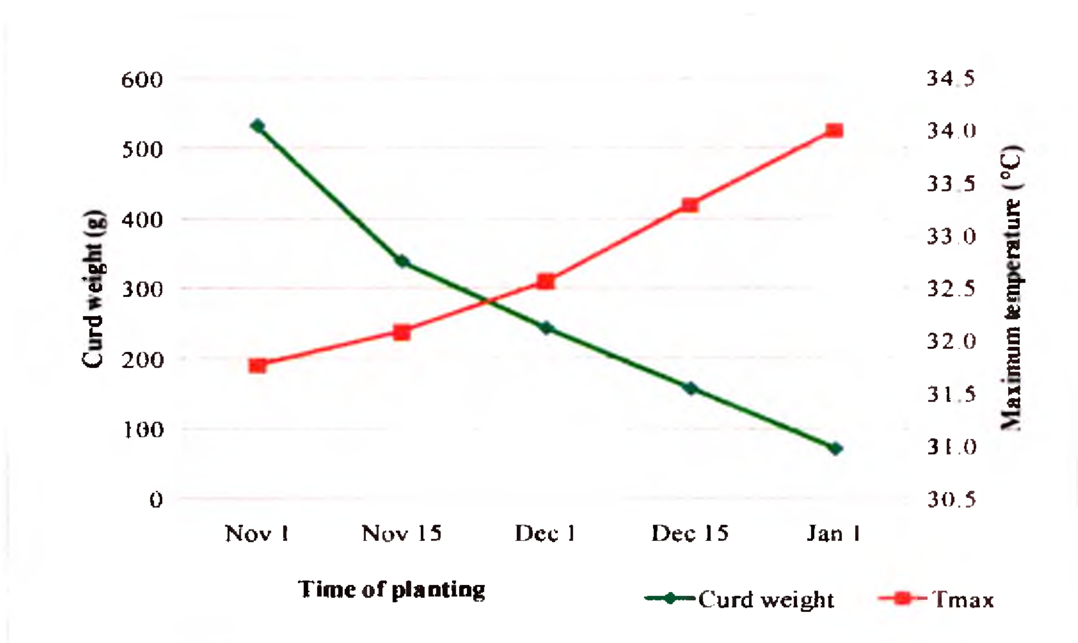

Fig.12.14. Variation in curd weight in different times of planting as influenced by maximum temperature during the entire crop duration

Planting in the first fortnight of November can be adopted in plains of central Kerala for getting good yield and to ensure quality produce by means of curd colour and fewer incidences of physiological disorders. Utmost care must be taken while undertaking cauliflower cultivation in this region during this period, because the environmental conditions existing here depends on the Northeast monsoon which may be favourable for the incidence of bacterial diseases, especially black rot, which can result in considerable yield losses as noticed in 2010-11. Possibility of crop damage by way of mechanical injury and pest and disease incidence as a result of the northeast monsoon rains should be considered in extensive cultivation of cauliflower. Basant was noted as the superior variety with respect to curd weight in this study but this variety was regarded as the most susceptible variety to black rot.

16.6. PREDICTION MODEL FOR CURD WEIGHT

Prediction of the yield of cauliflower based on weather variables prevailed before curd initiation is having utmost practical importance. Hence, multiple linear regression equations were fitted based on different weather variables using stepwise regression method and the best fitting equation was selected based on R^2 value. The equation developed is given below.

Curd weight = 474.743 T_{max} – 569.084 T_{min} + 77.06 RH II – 418.844 BSS – 2547.22

This equation could predict the curd yield of cauliflower with a precision of 95% (Fig.12.16) and this can be used in crop planning in the central zone of Kerala.

16.7. WEATHER INFLUENCE ON THE INCIDENCE OF PESTS, DISEASES AND PHYSIOLOGICAL DISORDERS

Weather plays an important role in the incidence of various pests and diseases in crops. Further, growth and survival of pests and pathogens are influenced by the prevailing weather conditions. If weather is favourable, then serious outbreaks of pests and diseases may occur. Besides, environmental fluctuations at different developmental stages can cause several physiological defects that affect productivity of the crop, as it reduces the market value of the produce.

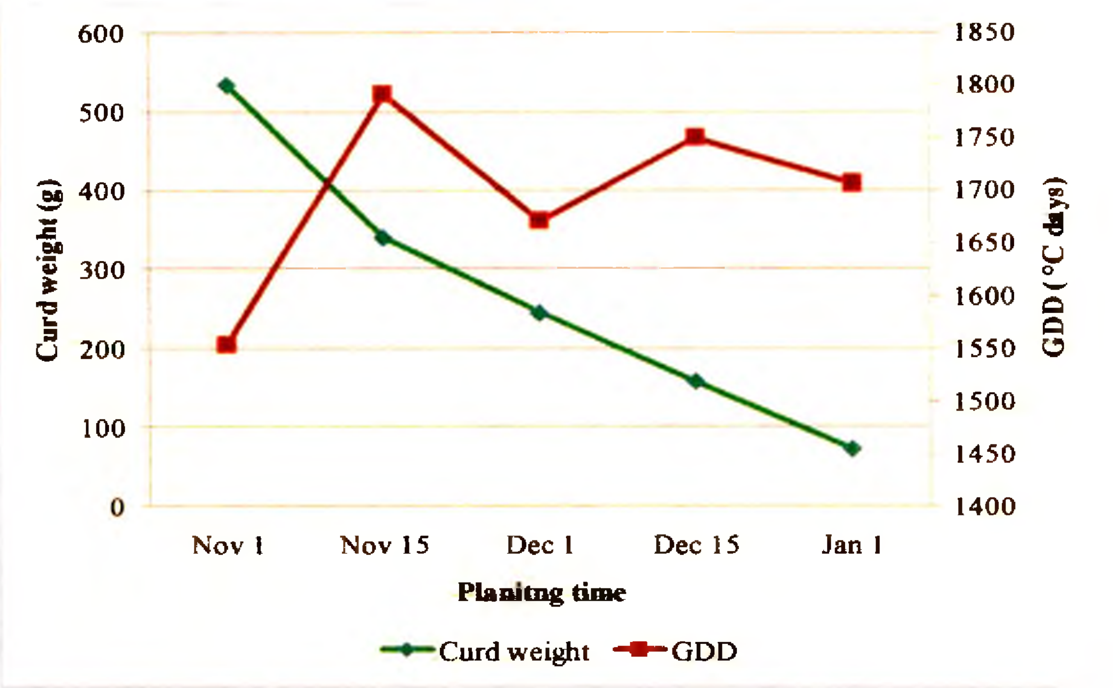

Fig.12.15. Relationship between growing degree days and curd weight

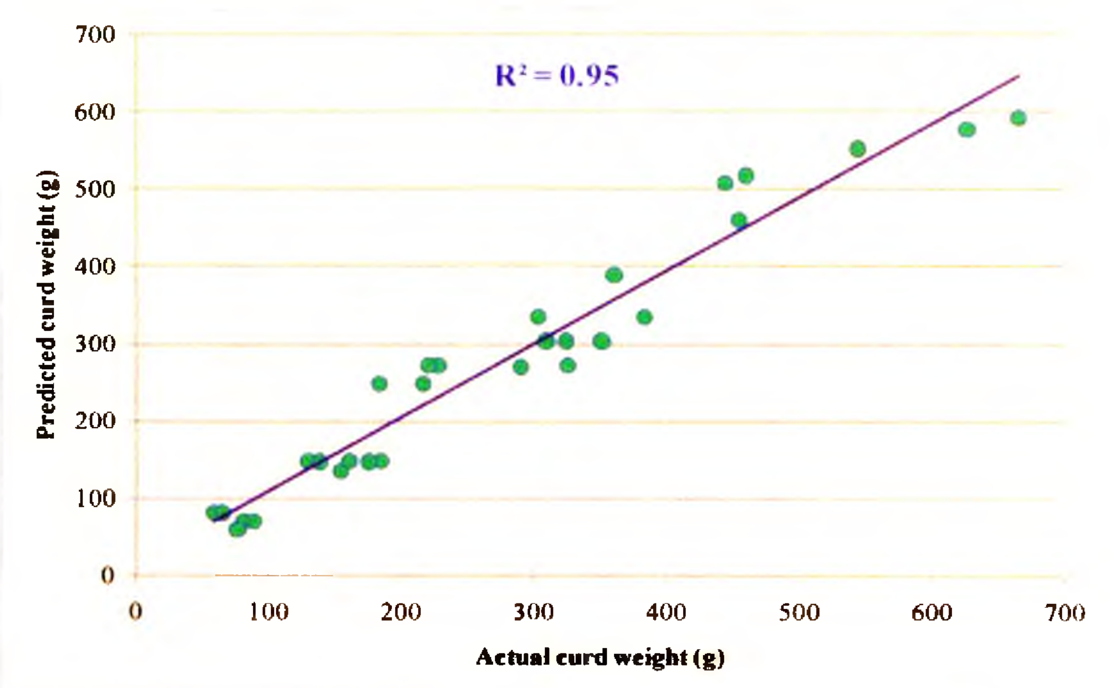

Fig.12.16. Actual and predicted curd weight of cauliflower

16.7.1. Effect of weather on the incidence of pests

The activity of Tobacco caterpillar (*Spodoptera litura*), Cabbage stem borer (*Hellula undalis*), Cabbage semilooper (*Trichoplusia ni*), leaf webber (*Crocidolomia binotalis)* and painted bug (*Bagrada hilaris)* were more in the initial plantings, where the crop life was in the months of November to January. The higher temperature, lower relative humidity and higher VPD in February and March might have resulted in the decreased activity of these pests in the delayed plantings, but these meteorological conditions favoured the activity of aphids and diamondback moth (*Plutella xylostella)*.

The incidence of cabbage borer was found in the earlier plantings. The increased activity of DBM in the delayed plantings and is positively correlated with temperature and negatively related to the amount of rainfall and negatively correlated with relative humidity.

The incidence of painted bug was occurred in the 1st November planting. Incidence of cotton aphid (*Aphis gossypii)* was noticed in both the years for all delayed plantings. The cotton aphid incidence was observed in plantings where the average mean temperature during the entire crop duration was above 27.1°C and that the optimum temperature for the population growth of cotton aphid on cotton was 25-30°C.

16.7.2. Effect of weather on the incidence of diseases

Black rot and soft rots were observed in the curd development period of the earlier plantings. The 1st November planted crop received high rainfall before curd initiation with a total amount of 306.1mm in 13 days in 2010-11 and 240.0mm in 9 days in 2011-12, which resulted in a highly humid atmosphere with less vapour pressure deficit and more soil moisture status creating the favourable conditions for the incidence of these bacterial diseases.

The heavy rainfall in the initial weeks after transplanting caused the incidence of Alternaria leaf spot disease in the 1st November plantings of both the years and 15th November planting of 2010-11. The rainfall that occurred in the 8th and 9th standard weeks with a total of 77.5mm in 3 rainy days caused the incidence of leaf spot in the 1st January planted crop in 2010-11.

16.7.3. Effect of weather on the incidence of physiological disorders

Both bracting and leafiness were observed in the study, even though both of the varieties considered were adapted to higher temperatures. The prevalence of higher temperature might have resulted in the occurrence of bracting and leafiness in this region and the lowerp temperature limit for the incidence of leafiness might be higher than that needed for bracting, since it occurred in the delayed plantings. Riceyness was observed when the minimum temperature before and after the initiation of curd was higher.

Buttoning disorder of cauliflower is marked by the development of small curds when the plants are small and it was observed in the delayed plantings.

16. II. Crop Weather Relationships in Cauliflower (*Brassica oleracea* var. *botrytis* L.)

16.1 Objective

- To study the effect of weather on growth and yield of cauliflower
- To assess the suitability of cauliflower under various crop growing environments

16.2. Experiment layout

Design	:	RBD
Time of planting	:	5
		(1st Nov,15th Nov,1st Dec,15th Dec and 1stJan)
Varieties	:	1 (NS 60N)
Replication	:	3
Year of study	:	2011-12
Plot size	:	3.3 x 2.0 m2

16.3. Results

1^{st} December (D3) planting gave the highest yield compared to other planting.

Proposed work

Crop weather relationship studies in yard long bean

17. Crop weather relationship of Yard long bean (*Vigna unguiculata* subsp. *sesquipedalis*)

17.1 Objective

To determine the crop weather relationship and to study the effect of date of sowing on the growth and yield of yard long bean

17.2 Technical programme

The yard long bean variety Lola will be grown with twelve dates of sowing. The experiment will be conducted in 2013-14. Important morphological observations will be recorded along with yield attributes. Weather will be monitored continuously. The optimum weather requirement of the crop also will be worked out. The cultural and manurial practices will be followed as per the package of practices recommendations of KAU (2011).

Design	: RBD
Treatment	: Date of sowing From 1st May 2013 to 1st April 2014
Replications	: 3
Plot size	: $25m^2$
Number of plants /treatment	: 40
Spacing	: 1m x 0.5 m

17.3. Results: Planting will be initatied on May 1st 2013.

Proposed Work

Crop weather relation studies in rice

(Jyothi and Kanchana varieties of rice)

18. Crop weather relation studies in rice(Jyothi and Kanchana varieties of rice)

18.1. Objective

The main objectives are simulation of phenology, growth and yield of Jyothi and Kanchana varieties of rice, calibrate their genetic coefficient and determine the crop weather relationship.

18.2 .Technical programme

Varieties of rice Jyothi and Kanchana, will be raised at Agricultural Research Station Mannuthy with five different planting dates during the *virippu* season. The crops will be transplanted at a spacing of 15 cm X 10cm. Crop management and crop protection measures will be carried out as per the package of practices (KAU, 2011). Important biometric and phenological observations will be recorded along with yield attributes. Weather will be monitored continuously. All observations (crop, soil, weather) required to run the CERES – Rice model will be recorded as per schedule.

Design	: Split plot in RBD
Main plot	: Five dates of planting
Treatments	5thJune, 20th June, 5th July, 20th July and 5th August (2013)
Sub plot	: Two varieties
Treatments	Jyothi and Kanchana
Replications	: 4
Plot size (sub plot)	: 5 x 4m^2
Spacing	: 15cm X 10cm

18.3 Results:

Sowing of rice varieties of rice Jyothi and Kanchana on coming May 2013.

19. Agro-advisories

Based on the medium range weather forecasting issued by the India Meteorological Department, Govt. of India, New Delhi, weekly agromet advisory bulletins are prepared in consultation with a multi-disciplinary group of scientists and Extension Officers of the Department of Agriculture. These bulletins are disseminated to the farmers through print and e-media. In addition, the bulletins are regularly being disseminated to selected progressive farmers of nearby Panchayaths. It also appears in the University website (www.kau.edu). It is also disseminated through SMS of IFFCO. The IFFCO feedback is that the farmers are benefitted and more number of locations to be covered with AAS for larger benefits. It is well received by the farmers. The farmers' interface is being conducted regularly once in six months to get the feedback from the farmers for the improvement of the agromet advisory bulletins (AABs).

20. Crop weather outlook

The web site developed by ICAR at CRIDA is being updated regularly by providing crop and weather information at Thrissur Centre.

20.1. Salient features

- A sound database is maintained on onset of monsoon and rainfall of Kerala for a period of 143 years (1870-2012). It is communicated to AICRPAM.
- The monsoon rainfall in Kerala was deficit against normal since last 12 years except in 2007 and 2010. The year 2012 experience agricultural drought and medium drough conditions .
- The decline in curd size with the delay in time of transplanting could be attributed to prevalence of high temperature. However, such relationships are not seen with minimum temperature. High temperature in cauliflower causes to elongated stunted vegetative growth with very poor curd size and its quality.
- The best time suited for cauliflower in this central part of Kerala is the first fortnight of November for obtaining better curd size in cauliflower. Thereafter, the curd weight declines if the transplanting is delayed. Hence, the farmers are advised to take up cauliflower cultivation immediately after cessation of North east monsoon, preferably, before 15th November in the central region of Kerala.
- The agro-advisory system is made effective based on the location specific strategies developed under AICRPAM. It should be strengthened and disseminated District – wise as economic impact is realized under NICRA.

20.2. Unfavorable weather events 2012-2013(Reported in newspapers) in Kerala


വില്ലേജ് ഓഫിസിനും രക്ഷയില്ല

അന്തിക്കാട് മേഖല മുങ്ങി

മരം വീണു വൈദ്യുത ലൈനിൽ തീ


തിരി കെടുത്തുന്ന തിരുവാതിര: ആശങ്കയോടെ കർഷകർ

Manorama dated June21&24,2012


വൃശ്ചികക്കാറ്റ് ശക്തമായി; വിളകൾക്ക് ദോഷം

Deshabhimani dated December20, 2012


ജില്ലയിൽ കനത്ത മഴയും മിന്നലും: നഗരത്തിൽ വെള്ളക്കെട്ട്


നെൽ കർഷകർക്ക് കണ്ണീർമഴ

Manorama dated November 08, 2012

Mathrubhoomi dated March 01,2013

വയലുകൾ കരിഞ്ഞു: കർഷകരുടെ പ്രതീക്ഷകളും

കാട്ടൂർ തെക്കുംപാടത്ത് നെൽപ്പാടം വെള്ളത്തിൽ

Manorama dated January13, 2013

വേനൽ രൂക്ഷം; ചെറുതുരുത്തി സ്ഥിരം തടയണ നിർമാണ നടപടികൾ വൈകുന്നു

Mathrubhoomi dated January 31, 2013

വെള്ളം കിട്ടിയില്ല; വിത്തുത്പാദനകേന്ദ്രത്തിൽ നെൽക്കൃഷി നശിച്ചു

Mathrubhoomi dated January 31, 2013

21. Seminars conducted

1. Farmers' Awareness Programme on "Climate Change Impacts on Agriculture" was held at Communication Centre,Mannuthy , Thrissur held on 21th March 2013. 60 farmers participated.
2. Farmers' Awareness Programme on "Climate Change Impacts on Agriculture" was held at A.L.P.S,Karalam , Thrissur held on 22nd March 2013. 60 farmers participated.

22. Publications

22.1. Research articles

Rao, GSLHVP and Gopakumar, C.S and Krishnakumar K.N. 2012 Impact of Climate Change on Agriculture in Kerala. Compendium on Climate Change: Plantations Crops and Spices of Kerala. pp. 91-101

Rao, GSLHVP and Gopakumar, C.S and Krishnakumar K.N. 2012 Impacts of Climate change in horticulture across India. In: Adaptation and Mitigation Strategies for Climate Resilient Horticulture. Pp. 1-11

Rao, GSLHVP and Gopakumar, C.S and Krishnakumar K.N. 2012. Impact of climate change on monsoon onset and monsoon rainfall over Kerala from 1870 to In: Proceedings of OCHAMP 2012 held at IITM Pune during 21-25, February 2012

Karthika, V.P., Prasada Rao, G.S.H.L.V., Ajithkumar, B., Laly John, C. and Pradeepkumar, T. 2012 Influence of Planting time on the curd weight of cauliflower (Brassica oleracea var. botrytis) in the central region of Kerala. 22nd Swadesi Science Congress(Kasargod).A16

V.P Karthika,G.S.H.L.V.Prasada Rao,B.Ajith Kumar,C.Laly John and T.Pradeepkumar. 2013. Influence of weather variables on the curd yield of cauliflower(Brassica oleracea var. botrytis) in the central region of Kerala. : Proceedings of National Symposium on "Climate Change and Indian Agriculture: slicing down the uncertainties during 22-23 January 2013 S3-73

LincyDavis,P and Ajithkumar, B., 2013. Crop weather realationship studies in bitter gourd. : in. Proceedings of National Symposium on "Climate Change and Indian Agriculture: slicing down the uncertainties during 22-23 January 2013 S3-74

22.2 Popular Articles:

V.P,Karthika and B,Ajith Kumar,Profitable Cauliflower Cultivation.Karshakan2012, vol20,Pp.12-15

23. Staff position during 2012-13

Sl. No	Category	Present incumbent	Date of joining	Scale of pay (Rs.)	Remarks
1	Asst.Professor & Head(Agrometeoro-logist)	Dr. B. Ajith Kumar	01.08.2012	15600-39100	Continuing
2	Farm officer Gr. II	Mr. P.M Paulose	01.04.2012	10480-18300	On contract basis
3	Clerical / Lab Assistant	--	vacant	9940-16580	vacant

24. Budget utilization since the beginning of the project

Year	Budget			
	Provision (ICAR share + Uty. Share)	Expenditure	Balance	Percentage utilization
1995-1996	4.6	4.1	0.5	89.6
1996-1997	3.1	3.4	-0.3	100.0
1997-1998	4.4	2.7	1.7	61.2
1998-1999	4.1	3.8	0.2	94.2
1999-2000	5.1	3.6	1.5	71.2
2000-2001	5.9	10.2	-4.3	172.6
2001-2002	8.2	10.2	-2.1	125.2
2002-2003	8.2	6.8	-1.3	83.8
2003-2004	8.7	10.0	-1.3	115.2
2004-2005	11.8	11.2	0.5	95.6
2005-2006	13.9	8.8	5.0	63.6
2006-2007	17.5	11.6	5.9	66.4
2007-2008	18.1	15.9	2.2	87.9
2008-2009	20.2	14.0	6.2	69.5
2009-2010	13.6	16.3	5.2	119.8
2010-2011	7.0	23.45	-16.45	335.0
2011-2012	32.60	32.31	0.29	99.1
2012-2013	22.18	25.05	2.87	112.9

****

MINIMUM DATASET REQUIRED FOR CROP WEATHER RELATIONS AND CROP SIMULATION MODELS - RICE

I. Station details and weather data

Station details 10^{0}32'N Latitude, 76^{0}20'E Longitude and 22 m MSL Altitude

II. Soil data

S. No.	Parameters	Value / Text		
1	Soil colour	Grey		
2	Soil texture	Sandy clay loam		
3	Drainage (Very excessive / Excessive / Some what excessive / Well / Moderately well / Some what poorly / poorly / very poorly	Surface furrows		
4	Soil series name	Laterite		
5	Soil classification	Silty loam		
6	Slope (%)	3%		
7	Electrical conductivity (dS / m)	0.12		
Layer wise / depth wise information (Minimum 3 layers)				
		0-15 cm	15-30 cm	30-60
8	Clay (%)	26	26	26
9	Silt (%)	22.2	22.2	22.2
10	Sand (%)	51.8	51.8	51.8
11	pH	5.7	5.7	5.7
12	Cation exchange capacity (Cmol/kg)	20.5	20.5	20.5
13	Total nitrogen (%)	0.17	0.17	0.17
14	Field capacity (Volume basis)			
15	Wilting Point (Volume basis)			
16	Bulk density (Mg / m^3)	1.54	1.54	1.52
17	Run off potential (Lowest / Moderately low / Moderately high/Highest)	Moderately low	Moderately low	Moderately Low
18	Organic carbon (%)	0.67	0.67	0.67
19	Soil moisture at sowing (Volume basis)	0.23	0.23	0.23
20	NO_3 content at sowing (Kg / ha)			
21	NH_4 content at sowing (Kg /ha)			

III. Experimental data

S. No.	Parameters	Date / Value / Text
1	Variety name	JYOTHI
2	Type of variety (Short / medium / long duration)	Medium
3	Duration of variety (in days)	105
4	Previous season crop	Cowpea
5	Experimental design	RBD
6	Sowing method (Transplanted / direct seeded)	Transplanted
7	Sowing depth.(If, direct seeded)	----
8	Puddling (Yes / No)	Yes
9	Seed rate	85 kg / ha
10	Row to row spacing	15 cm
11	Age of seedlings at transplanting day	29 days
12	No of seedlings / hill	2-3
13	Plant population (No of hill / m^2)	67
12	Sowing date	25 May 12
13	Transplanting date	22Jun 12
14	Panicle Initiation stage	
15	Heading stage	
16	50% flowering / Anthesis	7 Aug 12
17	Beginning of grain filling	
18	End of grain filling	
19	Physiological maturity	
20	Harvesting	3Sep12
21	*No of effective tillers / m^2	
22	*No of grains / ear	97
23	*No of grains / m^2	
24	*Single grain weight (g)	0.0284
25	*Straw yield (Kg / ha)	
26	*Biomass yield (Kg/ha)	
27	*Grain yield (Kg / ha)	4323
28	Harvest index	
	Irrigation details	
29	Irrigation amount (mm)	
30	Date of irrigation (in DAT)	
31	Irrigation method	
	Fertiliser management	
32	Date of fertilizer (N, P and K) application (DAT)	30th day after planting
33	Amount of fertilizer (N, P and K) application	70:35:35 kg / ha
34	Type of fertilizer (N, P and K)	Urea, MOP, Mus. Phos
35	Depth of fertilizer application	
36	Fertilizer application method	Broad casting
	Farmyard manure / green manure applied, if any	
37	Name of green manure crop/FYM	FYM
38	Application date	During the time of planting
39	Amount	5000 Kg/ha

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