Probability analysis of rainfall data for plantation of tree species in Himalayan mid-hills

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ABSTRACT: Uneven distribution of rainfall and its considerable variation from area to area and time to time, is not be very useful in predicting the time of planting of tree species in an area on the basis of average rainfall. The plantation of tree species will be of much more practical to when planted on the basis of weekly rainfall. In the present study, the weekly rainfall data of 19 years (1985-2003) of Hill Campus, Ranichauri was analysed at various probability levels and expected rainfall frequency to estimate and work out the suitable weeks for plantation of evergreen and deciduous species in mid Himalayan region. In general, the evergreen species are planted during the month of June to first fortnight of September and the deciduous species during December to February but monthly mean of rainfall does not ensure the proper establishment of seedlings planted due to its erratic distribution. Hence, weekly plan of plantation was found to be more suitable to ensure the higher survival of plants. The analysis revealed that survival performance of evergreen species would be higher if planted during 26th to 37 ^{the} Standard Meteorological Week (SMW) as chance of rainfall occurrence in these weeks is almost 70 per cent. On other hand, 6th to 8th SMW were found more suitable for plantation of deciduous tree species as probability of rainfall occurrence during this period is more than 60 per cent.

Key words: Hydrology, Plantation strategy, Tree species, Wet spell.

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1. INTRODUCTION

The knowledge of total rainfall and its distribution throughout the year is important for efficient planning of tree species plantation for an area. The rainfall distribution in India is most uneven and varies considerably from region to region and year to year. Average annual rainfall is not very helpful for planning, for example a heavy abnormal rainfall storm or total rain in a week or even in a month may still show that particular year as a year of average rainfall or a normal year although the temporal distribution is uneven, but it may completely damage the plants due to heavy rainfall at improper time. Similarly a dry spell may again damage the tender plants even then that particular year may be of average rainfall. Therefore, analysis of weekly rainfall may be more useful in better prediction of proper time of plantation for different seasons.

Sharma *et. al.* (1979) analyzed the rainfall data of Pantnagar to determine weekly, monthly, seasonal and annual rainfall at different probabilities for the normal, abnormal and drought months. They concluded that the weekly rainfall data could be effective for its use to plan cropping programme and to decide the time of different agricultural operations. *Ray et. al. (1980)* also suggested that prediction of weekly rainfall at different levels of probability can help in crop planning for rainfed situations. This study aimed at probability and frequency analysis on the basis of weekly rainfall data for a period of 19 years to suggest proper time of planting tree species in the Himalayan Mid-hills.

2. MATERIALS AND METHODS

The rainfall data of 19 years (1985-2003) were collected from College of Forestry & Hill Agriculture, Hill Campus, Ranichauri, Tehri Garhwal, Uttarakhand. The campus is located at the 30^0 15' North latitude and 78^0 30' East longitudes and at the elevation 2000 m MSL. Daily rainfall data were converted into standard meteorological weekly rainfall data starting from 1st week of January to last week (52nd) of December as standardized by Indian Meteorological Department (IMD). The weekly rainfall at various probability levels and expected rainfall frequency were estimated to work out the water requirement for the plants during particular week. Probability of rainfall occurrence was worked out by using following procedure given by Weibull's method:

i) The weekly rainfall data were arranged in descending order.

ii) The probability of occurrence of each rainfall value was computed.

$$P = M / (N+1) \quad \ldots(1)$$

Where, P = chance that the rainfall of given amount or equaled or exceeded,

M = rank number from the highest values, and

N = total numbers of years of record.

iii) The recurrence interval, (T) was worked out by using the following relationship:

$$T = 1/P \quad \ldots(2)$$

3. RESULTS AND DISCUSSION

The average annual rainfall at Hill Campus was 1241.24 mm from recorded rainfall data of 19 years. The standard deviation and coefficient of variation were 276.05 mm and 22.24%, respectively. The maximum annual rainfall of 1840.2 mm was recorded during the year 1988 and the minimum of 719.10 mm during the year 2001 (Table 1). The annual rainfall showed high standard deviation and coefficient of variation indicating the variation in collected average rainfall data was to help in proper plantation planning. Therefore, any plantation schedule requires analysis of weekly rainfall in order to ensure higher survival percentage of plants during wet weeks in rainy and winter seasons. The average weekly rainfall based on 19 years rainfall data has been presented in Fig. 1.

The expected rainfall at various probability levels for different standard weeks was computed to assess the possibility of plantation in various weeks (Fig. 2). It is clear that at 90% probability weekly rainfall is expected in 27th to 37th week and at 70% chance the weekly rainfall is expected in 18th to 37th week and 7th to 13th week of a calendar year. At 50% chance, the rainfall covers a wide range of weeks. On the basis of expected weekly rainfall the total rainfall expected in a year at 50% 60%, 70%, 80% and 90% chance are 749.60 mm, 519 mm, 347.50 mm, 218.0 mm and 52.70 mm, respectively. Considering 70% probability, it is observed that an appreciable amount of rainfall is available from 18th to 37th week and the maximum rainfall of 39.2 mm is expected in 28th week during monsoon season, while maximum rainfall of 10.4 mm is expected in 8th week. During winter season, weeks from 7th to 13th represented a wet period.

Generally the plantation work of tree species are

Table 1. Monthly and annual statistical parameters of rainfall (1983-2003)

	Rainfall, mm				
Months	Average	Maximum	Minimum	S.D.	C.V. (%)
January.	59.26	126.60	0.00	35.82	60.45
Febuary	98.69	229.10	13.60	66.10	66.98
March	83.49	186.00	1.80	56.68	67.89
April	50.10	186.60	0.00	41.74	83.31
May	77.47	201.80	7.90	49.23	63.55
June	114.46	263.20	26.10	63.56	55.53
July	260.23	470.80	24.40	120.24	46.20
August	260.66	430.70	54.30	90.40	34.68
September	134.35	382.40	7.00	89.09	66.31
October	41.78	331.80	0.00	86.13	206.15
November	16.26	88.00	0.00	29.21	179.69
December	44.48	189.90	0.00	56.46	126.93
Annual	1241.24	1840.20	719.10	276.05	22.24

S.D: Standard deviation, C.V. : Coefficient of variation

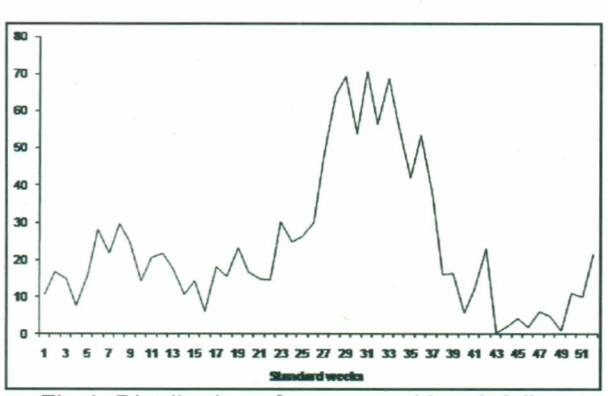

Fig.1. Distribution of mean weekly rainfall at Hill campus

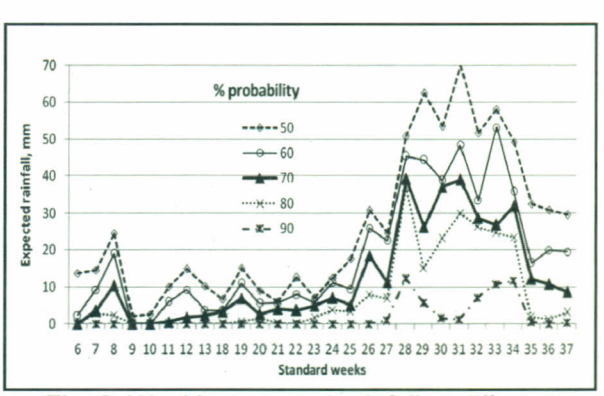

Fig. 2. Weekly expected rainfall at different probability levels based on 1985-2003

taken in the rainy season from the 2nd fortnight of June to the 1st fortnight of September i.e. during 25th to 37th SMW or in the winter season between December to February i.e. during 51st to 52nd SMW and 1st to 9th SMW (Anon., 1985). Generally the evergreen species are planted in rainy season with earth ball because the seedlings have full leaves and require more moisture for their establishment. On the other hand, the deciduous species are planted either with earth ball or bare root in winter season when their seedlings are leafless, and the plant has minimum requirement for survival and establishment. The seedlings of deciduous species are also planted in rainy season when there is higher probability of rainfall occurrence. Seedlings planted during the recommended period may suffer mortality where there is deficit of soil moisture due to long dry spell. The other reasons for to the extent of more than 50 % the mortality would be due to use of unhealthy and less hardy seedlings, unsuitable planting sites, faulty method of planting, damaged seedlings during transportation etc. Table 2 shows that 60 to 70% chance of rainfall occurrence is expected during 26th to 37th SMW in the rainy season, whereas in the winter season 60 to 70% chance of rainfall occurrence is expected during 6th to 8th SMW. At 50% probability the planting work may succeed with excessive risk because there is less than 50% chance of plant survival. The 50% chance of

Table 2. Suggested weeks for plantation of various tree species in Himalayan Mid-hills

Type of species	Prevailing Weeks	Rainfall probability (mm) 60%	70%	weeks for plantation	Suggested weeks for Plantation
A. Deciduous species					
Toona ciliata, Fraxinus micrantha, Aesculus indica, Melia	51-52	1	0	0	
azedarach, Celtis australis, Robinia pseudoacacia,	&	2	0	0	
Dalbergia sissoo, Alnus nepalensis, Bauhinia retusa,	1 - 9	3	0	0	
B. variegata, Betula alnoides, Bombax ceiba, Jacaranda	(Dec. - Feb.)	4	0	0	
mimosaefolia, Juglans regia, Morus alba, M. .serrata,		5	0	0	6-8
Populus deltoids, P. nigra, P. ciliata, Salix alba,		6	2.4	0	
S. tetrasperma, Acer caesium		7	9.2	3.6	
		8	19.0	10.4	
		9	0	0	
		51	0	0	
		52	0	0	
B. Evergreen Species					
Conifers, *Acacia mearnsii, Alstonia scholaris,*		25	9.4	5.1	
Cinnamomum camphora, Grevilea robusta,		26	25.9	18.5	
Grewia optiva, (semi evergreen) Quercus dilatata,		27	22.5	11.3	
Q. leucotrichophora, Q. semicarpifolia	25 - 37	28	45.5	39.2	
	(June-Sept.)	29	44.4	26.2	
		30	38.8	37.1	26 - 37
		31	48.3	39.0	
		32	33.5	28.7	
		33	53.2	26.9	
		34	35.7	32.0	
		35	16.5	12.2	
		36	19.9	10.8	
		37	19.5	8.7	

rainfall also shows that the survival of tree species may not be possible without irrigation. Water harvesting structure can be designed for life saving irrigation of planted seedlings on the basis of different recurrence interval of rainfall occurrence. Amount of annual rainfall in 2, 5 and 10 years of recurrence interval is shown in the Fig. 3. The rainfall at 5-year recurrence interval shows that 20 mm or more rainfall is expected in the most of the weeks except in 6th, 14th, 16th, 41st to 50th weeks. Hence planning of forest seedlings plantation can be designed on the basis of 5-year recurrence period so as the water harvesting plan can be

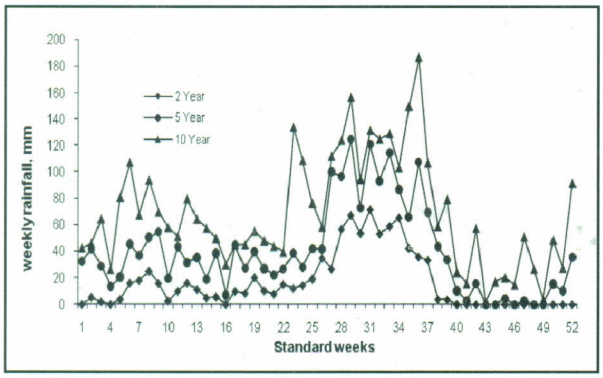

Fig.3. Weekly expected rainfall occurrence at different recurrence interval

managed for supplemental irrigation to the planted seedlings in case of no rainfall condition or under dry spells. In case of 2 years recurrence period, most of weeks receive less than 20 mm rainfall except 27th to 36th week. Hence only few species can be planned under 2 years recurrence period.

4. CONCLUSION

Considering the above facts, a forest manager could plan the planting work of various forest species for their successful plantation during those standard meteorological weeks when chance of occurrence of rainfall is 60 to 70% or more. The plantation programme for evergreen forest species should be conducted during 26th to 37th SMW of rainy season, while deciduous forest species should be planted during 6th to 8th SMW of winter season and during 26th to 37th week of rainy season, too.

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