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RESEARCH ARTICLE

STUDY OF SPATIO-TEMPORAL ANALYSIS OF ANNUAL RAINFALL VARIABILITY IN UTTAR PRADESH

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Abstract: Uttar Pradesh is Humid subtropical and semi arid climatic region situated between 23° 52' N and 31° 28' N latitudes and 77° 3' and 84° 39'E longitudes. The state is divided into 18 divisions and 71 districts. The statistical analysis of annual rainfall data of past to present 100 years (1915-2014) ranged from 532.7mm in year in 1991 to 1313.1 mm in year 2013 with an average annual rainfall of the area is 929.6 mm. The average rainfall with 2013 showing the highest positive rainfall anomaly (2.26) while the other years show rainfall below normal with 1991 Showing the lowest negative rainfall deviation (-2.34). The calculated value of standard deviation reveals that deviation of rainfall is of 169.7 mm. in a century. The trend analysis in XLSTAT 2014.6.02 ver. observed trend of rainfall, the R^2 value 0.018 means that only 1.8 percent variation is observed in hundred years. The coefficient of skewness has been computed as -0.06 for annual rainfall indicates a negative trend or going to decline pattern. The maximum standard deviation value and CV(%) is observed 210 & 23% in year 1935-44 and minimum standard deviation and CV(%) is observed 80.7 & 10% in year 1995-04. The overall decadal dataset observed decadal maximum rainfall 1328.9 in year 1955-64 whereas minimum rainfall 493.9mm in year 2005-14 observed. In future, expected annual rainfall may be less in year 2025 observed 881.9mm in the state. In the year 2021; expected rainfall may be 893mm. The geostatistical analysis is the ARCGIS 10.3.1 extension used for interpolation and kriging. The prediction map of dataset year 1995-2004 was highest rainfall in east side of some place of Uttar Pradesh. The western part of Uttar Pradesh covered less rainfall the other side cover area. The central part of state decadal map covered maximum area in year 1966-74. The objective of this study is to analyze the recent and future trend of annual rainfall pattern.

Keywords: Anomaly**,** GIS, Geostatistical method, Kriging & Monsoon

INTRODUCTION

The rainfall is the meteorological phenomenon is a major source of water on the earth. It is also one of the most important climatic variables because of its two sided effects one is deficient resource, such as droughts and as a catastrophic agent, such as floods (Alam, 2011). Agriculture is dependent on climatic factors: temperature, rainfall, sunshine hours, relative humidity and air direction. The changing of rainfall pattern in rabi, kharif & zaid seasons are change the cropping pattern if changes are seen for long time. Because water having vital role to agriculture crops growth and crops are having short period for complete life cycle. The change of rainfall pattern is affecting the crops productivity. The Kharif crop is the summer crop or monsoon crop in India. Kharif crops are usually sown with the beginning of the first rains in July, during the south-west monsoon season. The South west monsoon is very important for Uttar Pradesh agriculture. The major socio-economic infrastructures are dependent on rainfall because greater percentages of the peoples are dependent agriculture related work (www.gktoday.in). Rainfall in pre-monsoon and winter season had a decreasing trend whereas it had an increasing trend during monsoon and post monsoon seasons (Rimi *et al*.). The IMD (Indian meteorology Department, New Delhi) divided Indian season in four categories: pre-monsoon (April-June), monsoon (July-September), post-monsoon (October-November) and winter season (December-March). IMD defines a four month period from June to September as Indian summer monsoon (ISM) period (Attri and Tyagi, 2010). The Statistical techniques are essential tools for analyzing large datasets. It also helps us to identify which of the many pieces of information derived from observations of the climate system are worthy of synthesis and interpretation. It is also helpful for testing hypotheses, estimations of parameters and in predictions of the data set (Cobanovic, 2002). The climatic research is complex, large level and long time period's process. The natural or human-induced factors are cause of climates change. Agricultural statistics are needed to provide information used to monitor trends and estimate future prospects. Geostatistics assumes that at least some of the spatial variations of natural phenomena can be modelled by random processes with spatial autocorrelation. Many methods are associated with geostatistics, but they are all in the Kriging family. Ordinary, Simple, Universal, probability, Indicator, and Disjunctive kriging, along with their counterparts in cokriging, are available in the geostatistical analysis. The changing climatic condition has been attributable to rainfall (Adger *et al*. 2003 & Obot *et al.* 2010), studies have also shown that the climate is changing based on the changing pattern of rainfall (Goswami *et al*. 2006 & Adger *et al*. 2003). Prediction of the spatial and

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temporal variability in rainfall is a major problem in an agricultural country like India and particularly in the state U.P. Measurement and prediction of change using statistical methods is a very important tool for decision making.

Objective

The objective of this study is to analyze the recent and future trend of annual rainfall pattern.

Study area

Uttar Pradesh is Humid subtropical (warm summer) and semi arid climatic region situated between 23° 52' N and 31° 28' N latitudes and 77° 3' and 84° 39'E longitudes, this is the fifth largest state in the country after Rajasthan, Maharashtra, Madhya Pradesh and Andhra Pradesh in area (Fig.1). Total geographical area of the state is 24,170 thousand hectare which is 7.33% of total area of India out of which 16,573 thousand hectare is under cultivation **(FSI, 2015).** It is divided into three distinct hypsographical regions: The Himalayan region in the North, The Gangetic plain in the centre & The Vindya hills and plateau in the south. It is lies largely in the plains formed by the Ganges and Yamuna rivers. State climate is subtropical and congenial for agriculture. Uttar Pradesh is largest producer of wheat, potato, sugarcane and milk whereas third largest producer of rice. For administrative purposes, the state is divided into 18 divisions and 71 districts. The state divided into nine agro-climatic zones, namely, Bhabhar & Tarai, Western Plain, Central-Western Plain, South-Western Plain, Central Plain, Bundelkhand, North-Eastern Plain, Eastern Plain, and Vindhyan region. It is also divided into four economic regions, viz., Western, Eastern, Central and Bundelkhand (Guha & Basu, 1996). The western region comprises of 27 districts and the eastern region 27 districts. Ten districts constitute the central region whereas the Bundelkhand region has only 7 districts. Rising of urbanization, populations and de-forestation are causing adverse impacts on the state's biosphere.

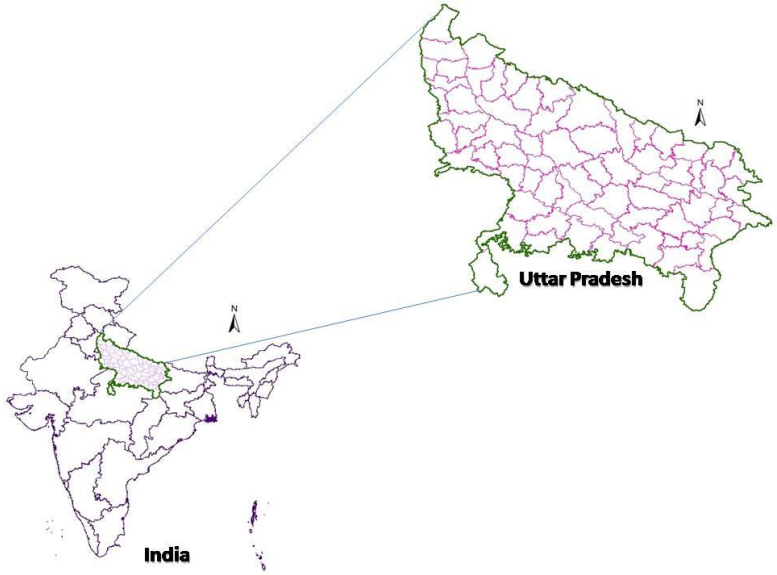

Fig.1 Study area

MATERIAL AND METHOD

The monthly rainfall data were collected from IMD, New Delhi & India water portal for the periods 1915-2014 (India water Portal, IMD New Delhi & NASA/POWER Agrometeorology website). The district wise collected monthly data were converted to annual time scale before statistical and interpolation analysis is done. The rainfall data processed on Excel sheets according to the requirements to obtain critical area maps using ArcGIS 10.2 software. ESRI's Geo-statistical analyst extension has been used for these analyses. The rainfall surfaces were predicted using ordinary kriging method.

METHODOLOGY

Time series analysis of the monthly and annual rainfall values were used to illustrate the trend in the behaviour of rainfall and in estimating seasonal variation. Linear regression analysis was also employed using Microsoft Excel statistical tool as it has proved effective in investigating trends in many climatic time series (Hutchinson, 1985 & Ayoade, 1973). One of the important indices standardized anomalies was evaluated.

Several statistics are applied to monthly rainfall series such as mean, variance, standard deviation, coefficient of variation, and skewness. For

identifying the trend in the rainfall data, the statistical analysis of linear regression was used. All these different analyses constitute the continuity of the study of Uttar Pradesh rainfall, which started about a century ago. The descriptive statistical analyses are:

(i) **Mean** is the arithmetic average of a set of values or distribution and represents the average of the data set.

$$Mean(\bar{x}) = \frac{\sum x}{N}$$

Where x is the rainfall data & N= Number of years

(ii) The **Standard deviation** (STD) is measure of the dispersion of a set of data from its mean.

$$STD = \frac{\sqrt{\sum(x-\bar{x})^2}}{N}$$

(iii) The **median** is the middle value when the data is arranged in order of size.

(iv) The **coefficient of variation** is a normalized measure of dispersion of a probability distribution which is defined as the ratio of the standard deviation σ to the mean $\bar{x}$.

$$CV = \frac{\sigma}{\bar{x}} x100$$

(v) **Deviation score** = $x - \bar{x}$

(vi) **Standardized anomalies**, also referred to as normalized anomalies, are calculated by dividing anomalies by the climatological standard deviation.

$$= \frac{(x-\bar{x})}{STD}$$

Where x is the annual rainfall totals, $\bar{x}$ is the mean of the entire series and STD is the standard deviation from the mean of the series.

(vii) Skewness is a measure of the asymmetry of the probability distribution. The skewness value can be positive or negative, or even undefined. It is a dimensionless quantity.

$$\text{Skewness} = \frac{\text{Mean} - \text{Mode}}{\text{Standard deviation}}$$

Recently, geographic information systems GIS interpolation technique has emerged as a method to map the distribution of evapotranspiration, temperature and precipitation (Haberlandt 2007 & Cheng et al. 2007) and it gives the layout and drawing tools necessary to present the results visually. GIS technique assist researchers and practitioners to understand the natural environment (Jang et al. 2007). That method was successfully used to study spatial distributions of precipitation by Dingman et. al. The Geostatistical analysis provides many tools to help determine which parameters to use, and also provides reliable defaults that can be used to make a surface quickly. The geostatistical analysis is the ARCGIS extension used for interpolation and kriging. There is numerous interpolation methods are used for rainfall data analysis. After detail study of kriging method is observed, two interpolation methods are explained distribution pattern of rainfall for the study area after different decadal dataset study.

RESULT AND DISCUSSION

The annual rainfall data series during the period 1915 to 2014 are analysis using time series analysis. The result shows that over Uttar Pradesh state. South-west rainfall or monsoon season covered almost districts over the state in June to September months. It is a most dominant session of the cyclic rainfall. The Kharif crops production is dependent on this rainfall.

Standardized anomalies of Annual Rainfall

Table 1 depicts the computed annual mean rainfall and standardized anomalies within the year under consideration (1915 to 2014) over Uttar Pradesh State. Fig. 2 shows the standardized rainfall deviations viz; 1915 to 1919, 1922, 1924-25, 1927, 1931, 1933, 1936, 1938,1942-43, 1946 to 1951, 1955-56, 1958, 1960 to 1964, 1967, 1969 to 1971, 1973, 1975, 1977-78, 1980 to 1982, 1985, 1990, 1994, 1996, 2003, 2007 -08 and 2012-13 are years with above average rainfall with 2013 Showing the highest positive rainfall anomaly (2.26) while the other years show rainfall below normal with 1991 Showing the lowest negative rainfall deviation (-2.34).

Table 1. Average Annual rainfall & Standardized rainfall anomaly of Uttar Pradesh (1915-2014)

Year	Average Rainfall (mm)	Standardized rainfall anomaly	Year	Average Rainfall (mm)	Standardized rainfall anomaly
1915	971.5	0.25	1965	650.6	-1.64
1916	1099.9	1.00	1966	736.5	-1.14
1917	1188.1	1.52	1967	1112.4	1.08
1918	611.5	-1.87	1968	641.6	-1.70
1919	954.7	0.15	1969	955.1	0.15
1920	801.3	-0.76	1970	1137.6	1.23
1921	825.1	-0.62	1971	1196.0	1.57
1922	1139.5	1.24	1972	804.1	-0.74

1923	927.0	-0.02	1973	1075.8	0.86
1924	1033.4	0.61	1974	663.1	-1.57
1925	1242.4	1.84	1975	1004.4	0.44
1926	889.2	-0.24	1976	850.9	-0.46
1927	976.7	0.28	1977	976.7	0.28
1928	653.7	-1.63	1978	974.3	0.26
1929	914.6	-0.09	1979	620.5	-1.82
1930	907.5	-0.13	1980	1267.8	1.99
1931	969.1	0.23	1981	1043.8	0.67
1932	763.6	-0.98	1982	1088.9	0.94
1933	1065.2	0.80	1983	921.6	-0.05
1934	864.0	-0.39	1984	800.7	-0.76
1935	925.6	-0.02	1985	1041.2	0.66
1936	1309.2	2.24	1986	882.9	-0.28
1937	837.8	-0.54	1987	567.7	-2.13
1938	972.4	0.25	1988	913.5	-0.09
1939	873.9	-0.33	1989	772.7	-0.92
1940	804.7	-0.74	1990	1085.6	0.92
1941	626.8	-1.78	1991	532.7	-2.34
1942	1052.1	0.72	1992	628.4	-1.77
1943	983.5	0.32	1993	799.1	-0.77
1944	914.1	-0.09	1994	997.0	0.40
1945	880.7	-0.29	1995	849.4	-0.47
1946	952.0	0.13	1996	985.0	0.33
1947	1025.8	0.57	1997	755.2	-1.03
1948	1179.3	1.47	1998	874.2	-0.33
1949	1122.6	1.14	1999	825.0	-0.62
1950	971.9	0.25	2000	683.8	-1.45
1951	934.6	0.03	2001	690.9	-1.41
1952	884.5	-0.27	2002	685.2	-1.44
1953	924.8	-0.03	2003	1038.6	0.64
1954	885.7	-0.26	2004	810.8	-0.70
1955	1123.2	1.14	2005	907.5	-0.13
1956	1145.3	1.27	2006	887.4	-0.25
1957	907.2	-0.13	2007	981.1	0.30
1958	991.4	0.36	2008	1274.4	2.03
1959	892.8	-0.22	2009	838.3	-0.54
1960	1057.5	0.75	2010	841.7	-0.52
1961	1115.4	1.09	2011	892.1	-0.22
1962	990.2	0.36	2012	971.4	0.25
1963	1115.9	1.10	2013	1313.1	2.26
1964	1035.0	0.62	2014	881.4	-0.28
Average Rainfall (mm) 929.6					

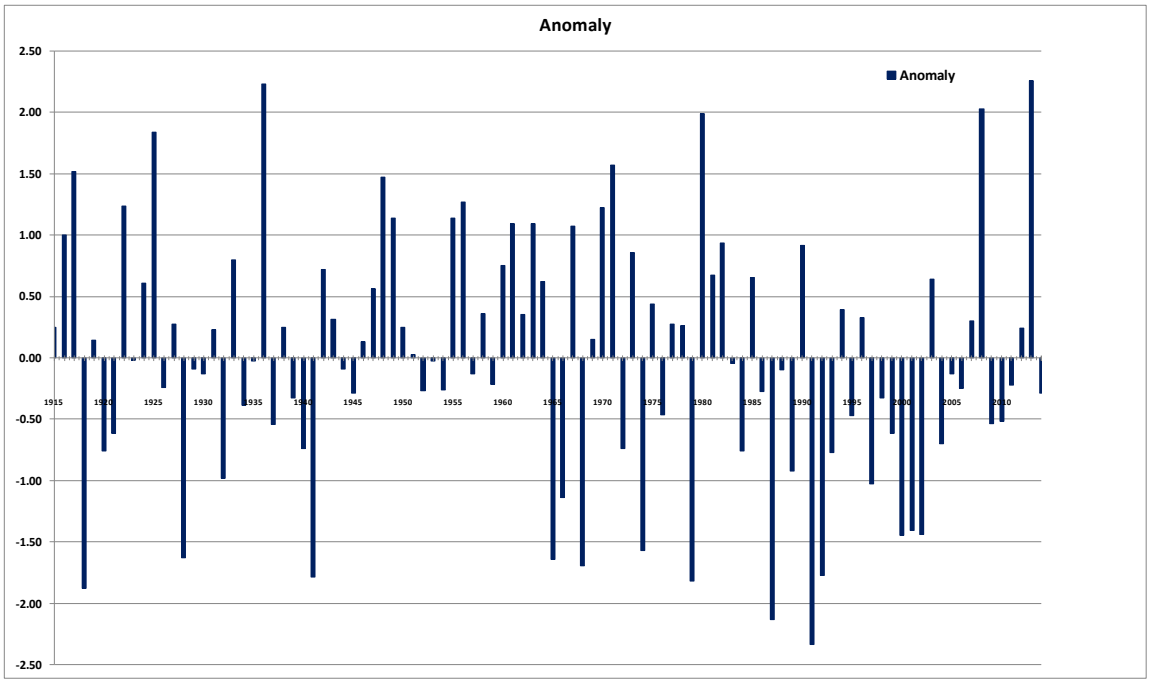

Fig. 2. Standardized rainfall anomaly of Uttar Pradesh from 1915-2014

Rainfall departure and cumulative departure of rainfall

The departure and cumulative departure from average rainfall for the study area has been depicted in Table.2. The trend of annual departure from the computed value of average annual rainfall reveals that;

(a) Years showing annual positive departure with respect to average annual rainfall were 1915-17, 1919, 1922, 1924-25, 1927, 1931, 1933, 1936, 1938, 1942-43, 1946-51, 1955-56, 1958, 1960-64, 1967, 1969-71, 1973, 1975, 1977-78, 1980-82, 1985, 1990, 1994, 1996, 2003, 2007-08 & 2012-13. The positive trend of rainfall shows the favourable conditions for recharge.

(b) Years showing annual negative departure with respect to average annual rainfall were 1918, 1920-21, 1923, 1926, 1928-30, 1932,1934-35,1937,1939-1941,1944-45,1952-54,1957, 1959, 1965-66,1968,1972, 1974, 1976, 1979,1983-84,1986-89,1991-93, 1995, 1997-02, 2004-06, 2009-11 & 2014. The negative trend of rainfall shows the unfavourable conditions for recharge.

(c) Years showing negative annual cumulative departure from average rainfall were observed in a centum data 1915, 1920-21, 1941 and 2000 to 2014.

Table 2. The annual rainfall data and its departure and cumulative departure from average rainfall in Uttar Pradesh (1915-2014)

Year	Annual rainfall (mm)	Departure from average rainfall	Cumulative departure from average rainfall	Year	Annual rainfall (mm)	Departure from average rainfall	Cumulative departure from average rainfall
1915	971.5	41.9	-42	1965	650.6	-279.0	1389
1916	1099.9	170.3	128	1966	736.5	-193.1	1196
1917	1188.1	258.5	387	1967	1112.4	182.8	1379
1918	611.5	-318.2	69	1968	641.6	-288.0	1091
1919	954.7	25.1	94	1969	955.1	25.4	1116
1920	801.3	-128.3	-35	1970	1137.6	208.0	1324
1921	825.1	-104.6	-139	1971	1196.0	266.4	1590
1922	1139.5	209.8	71	1972	804.1	-125.6	1465
1923	927.0	-2.6	68	1973	1075.8	146.2	1611

1924	1033.4	103.8	172	1974	663.1	-266.6	1344
1925	1242.4	312.8	485	1975	1004.4	74.8	1419
1926	889.2	-40.5	444	1976	850.9	-78.8	1341
1927	976.7	47.1	491	1977	976.7	47.1	1388
1928	653.7	-276.0	215	1978	974.3	44.7	1432
1929	914.6	-15.1	200	1979	620.5	-309.1	1123
1930	907.5	-22.1	178	1980	1267.8	338.2	1461
1931	969.1	39.4	218	1981	1043.8	114.2	1576
1932	763.6	-166.0	52	1982	1088.9	159.3	1735
1933	1065.2	135.5	187	1983	921.6	-8.0	1727
1934	864.0	-65.6	121	1984	800.7	-128.9	1598
1935	925.6	-4.1	117	1985	1041.2	111.6	1709
1936	1309.2	379.6	497	1986	882.9	-46.7	1663
1937	837.8	-91.8	405	1987	567.7	-361.9	1301
1938	972.4	42.7	448	1988	913.5	-16.1	1285
1939	873.9	-55.7	392	1989.0	772.7	-156.9	1128
1940	804.7	-125.0	267	1990.0	1085.6	156.0	1284
1941	626.8	-302.8	-36	1991	532.7	-396.9	887
1942	1052.1	122.5	87	1992	628.4	-301.3	586
1943	983.5	53.8	141	1993	799.1	-130.5	455
1944	914.1	-15.5	125	1994	997.0	67.4	522
1945	880.7	-48.9	76	1995	849.4	-80.2	442
1946	952.0	22.4	99	1996	985.0	55.4	498
1947	1025.8	96.1	195	1997	755.2	-174.4	323
1948	1179.3	249.7	444	1998	874.2	-55.4	268
1949	1122.6	193.0	637	1999	825.0	-104.7	163
1950	971.9	42.3	680	2000	683.8	-245.9	-83
1951	934.6	4.9	685	2001	690.9	-238.8	-322
1952	884.5	-45.1	639	2002	685.2	-244.4	-566
1953	924.8	-4.8	635	2003	1038.6	108.9	-457
1954	885.7	-43.9	591	2004	810.8	-118.8	-576
1955	1123.2	193.6	784	2005	907.5	-22.1	-598
1956	1145.3	215.6	1000	2006	887.4	-42.3	-640
1957	907.2	-22.4	977	2007	981.1	51.5	-589
1958	991.4	61.8	1039	2008	1274.4	344.8	-244
1959	892.8	-36.8	1002	2009	838.3	-91.4	-335
1960	1057.5	127.8	1130	2010	841.7	-87.9	-423
1961	1115.4	185.8	1316	2011	892.1	-37.5	-461
1962	990.2	60.5	1377	2012	971.4	41.7	-419
1963	1115.9	186.2	1563	2013	1313.1	383.5	-36
1964	1035.0	105.3	1668	2014	881.4	-48.2	-84
Annual average rainfall (mm) = 929.6							

Statistical parameters of Annual rainfall

The statistical analysis of annual rainfall data of past to present 100 years (1915-2014) ranged from 532.7mm in year in 1991 to 1313.1 mm in year 2013 with an average annual rainfall of the area is 929.6 mm (Table -3).

Table 3. Mann-Kendall trend tests of rainfall data (1915-2014)

XLSTAT 2014.6.02 - Mann-Kendall trend tests - on 14-11-2015 at 16:20:43							
Time series: Workbook = up100.xlsx / Sheet = Sheet1 / Range = Sheet1!$B$1:$B$101 / 100 rows and 1 column							
Date data: Workbook = up100.xlsx / Sheet = Sheet1 / Range = Sheet1!$A$1:$A$101 / 100 rows and 1 column							
Significance level (%): 5							
Summary statistics:							
Variable	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation
UP	100	0	100	532.739	1313.112	929.637	169.736
Mann-Kendall trend test / Lower-tailed test (UP):							
Kendall's tau	-0.096						
S	-474.00						
Var(S)	112750.00						
p-value (one-tailed)	0.079						
alpha	0.05						
The exact p-value could not be computed. An approximation has been used to compute the p-value.							
Test interpretation:							
H0: There is no trend in the series							
Ha: There is a negative trend in the series							
As the computed p-value is greater than the significance level alpha=0.05, one cannot reject the null hypothesis H0.							
The risk to reject the null hypothesis H0 while it is true is 7.95%.							
The continuity correction has been applied.							
Sen's slope:	-0.84						
Confidence interval:	] -33.383 ,	32.960 [					

The computed value of the median 925.2mm indicates ideal rainfall of the area. The coefficient of variation (%) was found to be 18.26. The calculated value of standard deviation reveals that deviation of rainfall is of 169.7 mm. in a century. The coefficient of skewness has been computed as -0.06 for annual rainfall indicates a negative trend. The trend analysis was done in XLSTAT 2014.6.02 ver. Fig.3 &4 shows that the trend of rainfall, the R^2 value 0.018 means that only 1.8 percent variation is observed in hundred years.

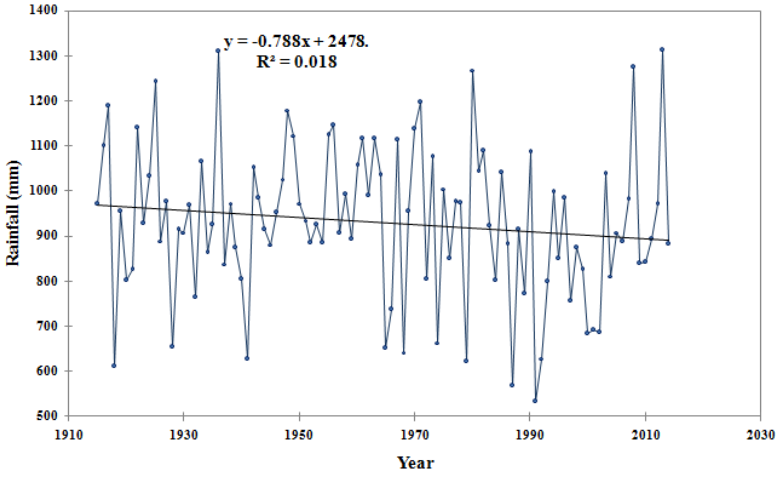

Fig. 3 Trend analysis of Average rainfall of Uttar Pradesh

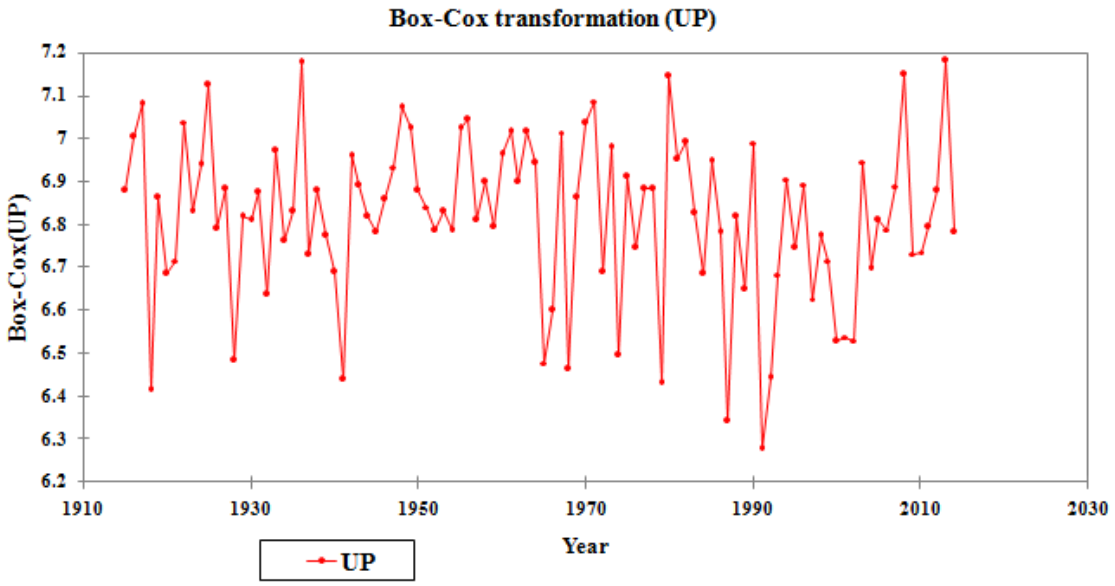

Fig.4. Box-Cox analysis of Average rainfall of Uttar Pradesh

Table 4. Computation of statistical parameters of Uttar Pradesh

Statistical parameters	**Computed value**
	Annual Rainfall (mm)
Mean	929.6 mm
Min	532.7 mm
Max	1313.1 mm
Median	925.2 mm
Std. Dev.	169.7
CV%	18.26
Coefficient of skewness	-0.06

Trend analysis of annual rainfall

A trend analysis of the average south west rainfall of Uttar Pradesh state for 100 year period from 1915 to 2014 was statistical test MS Excel in Table 5. Trend analysis was also performed on seasonal scale to examine if there are trends in the data at this scale. The trend analysis helps to measure the deviation from the trend and also provides information pertaining to the nature of trend. The analysis can be used as a tool to forecast the future behaviour of the trend. The method of least square fit for straight line has been used for trend analysis of the behaviour of annual rainfall. After trend analysis of data observed rainfall trend is going to decline pattern.

Table 5. Time series analysis of South-west rainfall (mm) data of Uttar Pradesh

Year	**X**	**Y**	**X2**	**XY**	**Trend value**	**Year**	**X**	**Y**	**X2**	**XY**	**Trend value**
1915	-49	971.5	2401	-47605.2	968.7	1965	1	650.6	1	650.6	929.2
1916	-48	1099.9	2304	-52795.4	967.9	1966	2	736.5	4	1473.0	928.5
1917	-47	1188.1	2209	-55841.7	967.1	1967	3	1112.4	9	3337.3	927.7
1918	-46	611.5	2116	-28127.5	966.3	1968	4	641.6	16	2566.4	926.9
1919	-45	954.7	2025	-42962.9	965.5	1969	5	955.1	25	4775.3	926.1
1920	-44	801.3	1936	-35256.7	964.7	1970	6	1137.6	36	6825.7	925.3

1921	-43	825.1	1849	-35478.1	963.9	1971	7	1196.0	49	8372.2	924.5
1922	-42	1139.5	1764	-47857.4	963.2	1972	8	804.1	64	6432.5	923.7
1923	-41	927.0	1681	-38006.9	962.4	1973	9	1075.8	81	9682.2	922.9
1924	-40	1033.4	1600	-41337.2	961.6	1974	10	663.1	100	6630.5	922.1
1925	-39	1242.4	1521	-48453.2	960.8	1975	11	1004.4	121	11048.8	921.4
1926	-38	889.2	1444	-33788.7	960.0	1976	12	850.9	144	10210.4	920.6
1927	-37	976.7	1369	-36139.1	959.2	1977	13	976.7	169	12697.2	919.8
1928	-36	653.7	1296	-23531.8	958.4	1978	14	974.3	196	13640.8	919.0
1929	-35	914.6	1225	-32009.7	957.6	1979	15	620.5	225	9307.9	918.2
1930	-34	907.5	1156	-30856.6	956.8	1980	16	1267.8	256	20285.0	917.4
1931	-33	969.1	1089	-31979.3	956.1	1981	17	1043.8	289	17744.9	916.6
1932	-32	763.6	1024	-24436.6	955.3	1982	18	1088.9	324	19600.0	915.8
1933	-31	1065.2	961	-33020.6	954.5	1983	19	921.6	361	17510.7	915.0
1934	-30	864.0	900	-25920.7	953.7	1984	20	800.7	400	16014.3	914.3
1935	-29	925.6	841	-26841.0	952.9	1985	21	1041.2	441	21865.9	913.5
1936	-28	1309.2	784	-36658.0	952.1	1986	22	882.9	484	19424.4	912.7
1937	-27	837.8	729	-22620.7	951.3	1987	23	567.7	529	13058.2	911.9
1938	-26	972.4	676	-25281.2	950.5	1988	24	913.5	576	21924.8	911.1
1939	-25	873.9	625	-21848.4	949.7	1989.0	25	772.7	625	19318.5	910.3
1940	-24	804.7	576	-19312.1	949.0	1990.0	26	1085.6	676	28226.2	909.5
1941	-23	626.8	529	-14416.4	948.2	1991	27	532.7	729	14384.0	908.7
1942	-22	1052.1	484	-23146.4	947.4	1992	28	628.4	784	17594.1	908.0
1943	-21	983.5	441	-20652.5	946.6	1993	29	799.1	841	23173.7	907.2
1944	-20	914.1	400	-18282.1	945.8	1994	30	997.0	900	29910.5	906.4
1945	-19	880.7	361	-16733.7	945.0	1995	31	849.4	961	26332.5	905.6
1946	-18	952.0	324	-17136.7	944.2	1996	32	985.0	1024	31521.1	904.8
1947	-17	1025.8	289	-17438.1	943.4	1997	33	755.2	1089	24922.0	904.0
1948	-16	1179.3	256	-18869.5	942.6	1998	34	874.2	1156	29723.4	903.2
1949	-15	1122.6	225	-16838.9	941.9	1999	35	825.0	1225	28873.6	902.4
1950	-14	971.9	196	-13606.5	941.1	2000	36	683.8	1296	24615.5	901.6
1951	-13	934.6	169	-12149.3	940.3	2001	37	690.9	1369	25561.7	900.9

1952	-12	884.5	144	-10614.0	939.5	2002	38	685.2	1444	26037.9	900.1
1953	-11	924.8	121	-10173.1	938.7	2003	39	1038.6	1521	40503.6	899.3
1954	-10	885.7	100	-8857.3	937.9	2004	40	810.8	1600	32431.9	898.5
1955	-9	1123.2	81	-10108.9	937.1	2005	41	907.5	1681	37209.1	897.7
1956	-8	1145.3	64	-9162.3	936.3	2006	42	887.4	1764	37269.9	896.9
1957	-7	907.2	49	-6350.4	935.6	2007	43	981.1	1849	42188.2	896.1
1958	-6	991.4	36	-5948.4	934.8	2008	44	1274.4	1936	56073.9	895.3
1959	-5	892.8	25	-4464.0	934.0	2009	45	838.3	2025	37722.3	894.5
1960	-4	1057.5	16	-4229.9	933.2	2010	46	841.7	2116	38718.3	893.8
1961	-3	1115.4	9	-3346.2	932.4	2011	47	892.1	2209	41929.7	893.0
1962	-2	990.2	4	-1980.4	931.6	2012	48	971.4	2304	46626.4	892.2
1963	-1	1115.9	1	-1115.9	930.8	2013	49	1313.1	2401	64342.5	891.4
1964	0	1035.0	0	0.0	930.0	2014		881.4			890.6
							Σ=0	**Σy= 92963.7**	**Σx2= 80850**	**Σx2= - 63298.2**	

Forecasting of annual rainfall

On the basis, the future forecast of rainfall for a period of ten years from 2016 to 2025 has been made (Table 6), which shows a negative trend for the coming years. In future, expected annual rainfall may be less in year 2025 observed 881.9mm in the state. In the year 2021; expected rainfall may be 893mm. The trend analysis gives the scenario of current to expected future situation. So in view of future rainfall is going tobe decline. It will also affect the production of rabi and Kharif season crops.

Table 6. Expected future Annual rainfall (mm) trend

Expected future rainfall trend (mm)	
Year	**Annual Rainfall (mm)**
2016	889.0
2017	888.2
2018	887.4
2019	886.7
2020	885.9
2021	893.0
2022	884.3
2023	883.5
2024	882.7
2025	881.9

The statistical data of hundred years (1915 to 2014) rainfall dataset of Uttar Pradesh was divided in ten decadal datasets *viz.* 1915-24, 1925-34, 1935-44, 1945-54, 1955-64, 1965-74, 1975-84, 1985-94, 1995-04 & 2005-14 were analyzed (Table 7) and observed 5th decadal dataset (1955-64) having

maximum rainfall 1037.4mm whereas in 8th dataset observed minimum rainfall 822.1mm. The maximum standard deviation value and CV(%) is observed 210 & 23% in year 1935-44 and minimum standard deviation and CV(%) is observed 80.7 & 10% in year 1995-04. The overall decadal dataset observed decadal maximum rainfall 1328.9 in year 1955-64 whereas minimum rainfall 493.9mm in year 2005-14 observed. The highest coefficient of skewness observed negative value -0.49 in year 1945-54. The highest median value of decadal dataset is observed 1060.4.

Table 7. Decadal Computation of statistical parameters of Uttar Pradesh

Parameters	Mean Decadal Uttar Pradesh									
	1915-24	**1925-34**	**1935-44**	**1945-54**	**1955-64**	**1965-74**	**1975-84**	**1985-94**	**1995-04**	**2005-14**
Mean	955.2	924.6	930.0	976.2	1037.4	897.3	955.0	822.1	819.9	977.3
SD	191.4	179.5	210.0	178.0	142.7	135.0	143.9	94.1	80.7	174.3
CV	0.20	0.19	0.23	0.18	0.14	0.15	0.15	0.11	0.10	0.18
CV%	20.0	19.4	22.6	18.2	13.8	15.0	15.1	11.4	9.8	17.8
MIN	541.5	543.1	502.0	569.1	684.8	601.9	713.4	626.3	660.2	493.9
MAX	1291.6	1256.7	1263.5	1311.5	1328.9	1107.1	1266.9	1049.8	973.9	1283.1
MEDIAN	1015.5	977.2	989.7	1006.4	1060.4	937.8	995.9	819.3	815.2	980.8
COFF OF SKEWNESS	-0.48	-0.37	-0.44	-0.49	-0.41	-0.44	-0.12	0.29	-0.09	-0.33

GIS anlysis of time series data

Spatial interpolation s of decadal study

Geographical Information System (GIS) plays a vital role in interpolating and displaying various attributes of rainfall. It is effectively used in this attempt to compute and produce maps. ArcGIS Geostatistical Analyst is an interactive tools are use for generate optimal surfaces from sample data and evaluate predictions for better decision making **(**http://www.esri.com).

Geostatistical methods (krigings) are widely used in spatial interpolation from point measurement to continuous surfaces. Spatial interpolation with the geostatistical and Inverse Distance Weighting (IDW) algorithms outperformed considerably interpolation with the Thiessen polygon that is commonly used in various hydrological models.

ESRI's Geo-statistical analyst extension has been used for these analyses. The rainfall surfaces were predicted using ordinary kriging method. The co-kriging analysis has been done to improve the accuracy of prediction, by including the elevation as a covariate. (Mesnard, 2013). It is applied to study Spatio-temporal distributions of the annual rainfall in Uttar Pradesh.

In this research, the spatial distribution of rainfall for different decadal pattern in a century, and the prediction of rainfall have been made using geostatistical analysis in geographic information system (GIS) software. ESRI's ArcGIS Geostatistical Analyst generate optimal surfaces from sample data and evaluate predictions for better decision making & used for decadal datasets analyses. The spatial temporal decadal maps are generated and observed trends and pattern of rainfall. The prediction map of dataset year 1995-2004 was highest rainfall in east side of some place of Uttar Pradesh. The western part of Uttar Pradesh covered less rainfall the other side cover area. The central part of state decadal map covered maximum area in year 1966-74 (Fig.5).

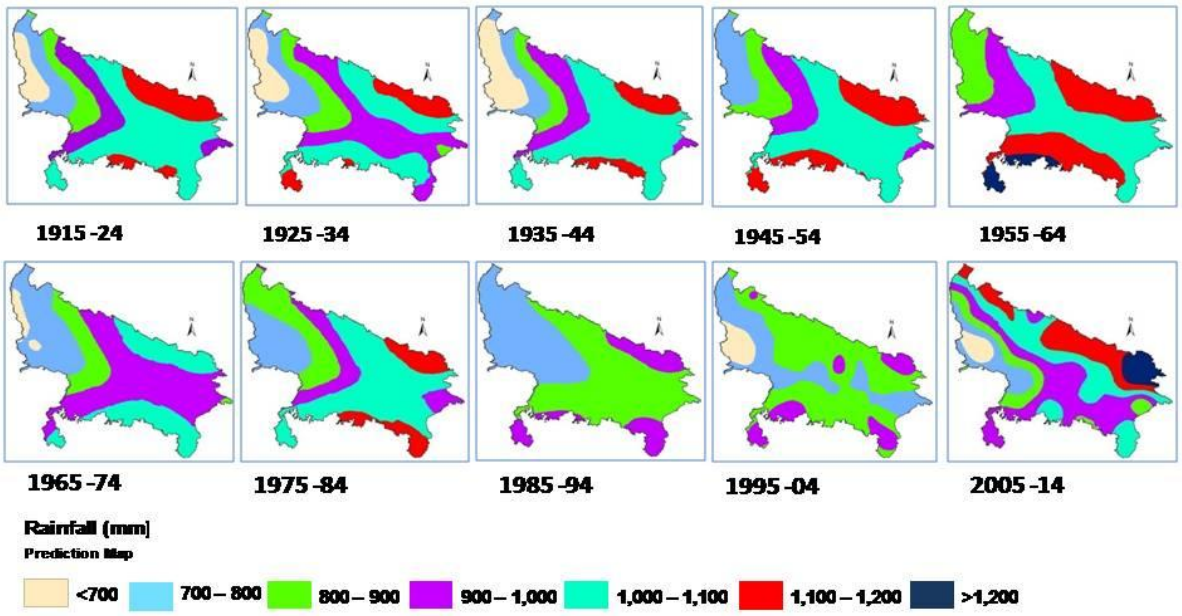

Fig.5. Geostatistical analysis of decadal rainfall (mm) pattern in Uttar Pradesh

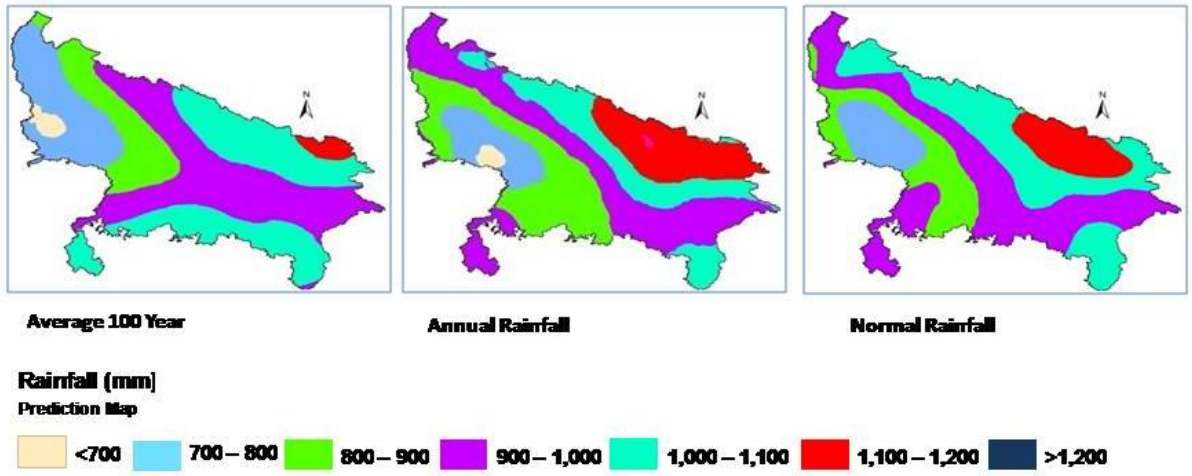

Fig.6. Geostatistical analysis of a centum (average), annual and normal rainfall (mm) pattern in Uttar Pradesh

The prediction map shown in Fig. 6 observed the pattern of rainfall of a century based average data study the lowest rainfall observed in western part of the Uttar Pradesh but maximum rainfall (1100-1200 mm) covered part in red tone observed in small areas of eastern Uttar Pradesh. The central part of the Uttar Pradesh covered rainfall range 900-1000 mm in violet color. The annual rainfall map study the maximum rainfall 1000 to 1100mm covered in eastern part of U.P. The normal rainfall pattern is like to annual rainfall.

CONCLUSION

Normal rainfall of region during 1915-2014 is 929.6.mm. The maximum rainfall recoded 1313.1mm in year 2013 and lowest rainfall recoded 532.7mm in year 1991. The south west monsoon plays a vital role in rainfall for water cycle. It contributes the highest percentage of rainfall and kharif season crops are most of dependent on rainfall. The average rainfall with 2013 showing the highest positive rainfall anomaly (2.26) while the other years show rainfall below normal with 1991 Showing the lowest negative rainfall deviation (-2.34). The calculated value of standard deviation reveals that deviation of rainfall is of 169.7 mm. in a century. The trend analysis in XLSTAT *2014.6.02* ver. observed trend of rainfall, the R^2 value 0.018 means that only 1.8 percent variation is observed in hundred years. The coefficient of skewness has been computed as -0.06 for annual rainfall indicates a

negative trend or going to decline pattern. In future, expected annual rainfall may be less in year 2025 observed 881.9mm in the state. In the year 2021; expected rainfall may be 893mm. The trend analysis gives the scenario of current to expected future situation. Geographical Information System (GIS) plays a vital role in interpolating and displaying various attributes of rainfall. The spatial temporal decadal maps are generated and observed trends and pattern of rainfall. The prediction map of dataset year 1995-2004 was highest rainfall in east side of some place of Uttar Pradesh. The western part of Uttar Pradesh covered less rainfall the other side cover area. The central part of state decadal map covered maximum area in year 1966-74.

The statistical data of hundred years (1915 to 2014) rainfall dataset of Uttar Pradesh was divided in ten decadal datasets; and observed 5^{th} decadal dataset (1955-64) having maximum rainfall 1037.4mm whereas in 8^{th} dataset observed minimum rainfall 822.1mm. Water is a vital component for agricultural crops and in abnormal period crops are irrigated by available source *viz.* tube well, submersible, canal, irrigation channels and other sources. Today rainfall is not regular fashion so farmers are not more dependent much more on rainfall. The source of irrigation, mechanization and knowledge of current situation of weather and climate change related pattern and adaptation of technology is maintend to crops yield trend. The precise technologies are use for fast and reliable information for proper future management. The spatial temporal decadal maps are generated and observed trends and prediction of rainfall patterns. The geostatistical methods are use for pattern of rainfall study. The statistical and geostatistical methods for temporal data studies are helpful for planning and efficient use of agriculture water resources. Techniques of geostatistics are used to perform traditional statistical analysis and spatial analysis with ArcGIS, geostatistical software and statistical software XLSAT in order to obtain the knowledge of characteristics of distribution and spatial variability of rainfall in different parts of Uttar Prdesh.

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RESEARCH ARTICLE

INSIGHT INTO SEQUENCE-STRUCTURE-FUNCTION RELATIONSHIP OF *CATHARANTHUS ROSEUS* RNA BINDING PROTEIN USING *INSILICO* APPROACH

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Abstract: RNA binding protein regulates numerous aspects of RNA metabolism such as pre-mRNA processing, transport and translation. This study describes sequence-structure-function relationship between the *Catharanthus roseus* and their homologs plant species through computational approach. After using sequence analysis techniques, it was observed that only 11 plant species showed higher similarity with RNA binding protein of *C. roseus.* Also, multiple sequence alignment illustrate only two conserve regions between *C. roseus* and their respective homologs plant species. Hence, the structural molecular model of the RNA binding protein was developed through homology modeling using the software MODELLER (9v5). Using PROCHECK and VERIFY-3D, the energy of constructed models was minimized and qualities of each models were evaluated. The corresponding Ramachandran plot specify 93.70% amino acid residues were in the most favoured regions. Final predicted model structure was submitted to Protein Model Database having deposition number PM0080432.

Keywords: RNA binding protein; *Catharanthus roseus*, Homology modeling, RNA recognition motif

INTRODUCTION

RNA binding proteins (RBPs) are key players in aspects of post-translational gene regulation and their involvement in regulating several development processes, a large body of evidence is supporting their key function in plant adaptation to various environmental conditions (Lorkovic, 2009). RBPs are involved in a variety of hetrogenic proteins and included in diverse aspects of post-translation regulation by direct interaction with single/double strand molecule. mRNA maturation events such as splicing, capping, polyadenylation and export from the nucleus are essential for mediating their interation with proteins. RBPs also promote to post-transcriptional regulatory events in the cytoplasm, such as mRNA localization, mRNA stability, decay and translation (Burd and Dreyfuss, 1994; Kim *et al.*, 2002). Despite the diversity of their function in fascinating with RNA and regulating post-translational events, most RBPs were constructed in versatile modular structure with multiple repeats of few conserve domains and arranged in a variety of ways to complete their diverse functional requirement (Lunde *et al.*, 2007). The RBPs are unique members of hetrogenous superfamily of glycine-rich proteins (GRPs) and contains a RNA binding domain at the N-terminal, which is the form of RNA recognation motif (RRM). This is pursued by a C-terminal glycine-rich domain (Ambrosone *et al.*, 2012).

With the innovation in sequencing technologies, it is now significantly easier to obtain the uncharacterized function of protein in the plant. Still, there are the protein sequences with their functions yet to be discovered or experimentally confirmed. These uncharacterized proteins show a enormous undetermined field with various opportunities. *Insilico* analysis help in determining of the protein functions, which can be divide into three broad categories: sequence, expression and interaction based methods. Sequence based methods rely on the ability to construct alignment between protein sequences. The sequence analysis approach was used for the prediction of protein domain family and their identification was based on the amino acid sequence similarity (Oany *et al.*, 2014). However, structural analysis and comparitive study allow to confirm the function of the protein and all these predictions are based on the sequence analysis.

Hence, the *insilico* study of *C. roseus* RNA binding protein with respect to its homologs species is very interesting task to understand the molecular evolution of this protein among the species. Hence forward, the present study affirmed the sequence-structure-function relationship between *C. roseus* and their respective homologs species. Besides, the phylogenetic relationship and motif discovery between *C. roseus* RNA binding protein and their identified homologs species were also established.

MATERIAL AND METHOD

In present analysis, initially full length of 137 amino acid sequence of *C. roseus* RNA binding protein (Accession no AAF31402) was retrived from the Genbank, a protein sequence database of National Center for Biotechnology Information (NCBI).

Homology prediction

In this context, homology prediction technique was performed to identify existence of the similar regions

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among the sequences of different plant species. The smith-waterman algorithm based program BLASTp (Altschul *et al.*, 1997) was used to predict the homologs of *C. roseus* RNA binding protein. The amino acid sequences of all the identified homologs species were downloded in FASTA format and used for comparative analysis with the *C. roseus* amino acid sequence.

Multiple Sequence Alignment and Phylogenetic analysis

The amino acid sequence of *C. roseus* RNA binding protein with their homologs protein sequences were subjected to multiple sequence alignment (MSA) for recognizing the conservation through CLUSTRAL-X program (Bateman, 2007).

3D Structure Prediction, Validation and Annotation

The 3D structure of *C. roseus* RNA binding protein was constructed through python based program MODELLER 9v5 (John and Sali, 2003) and a total of 50 models were generated. Modeller generated several models for the same target and the best model was selected for further analysis. The model was evaluated with the lowest value of Modeller objective function, after that used PROCHECK (Laskowski, 1993) statistics. The structure annotation was described through SAS-Sequence structure server. ProFunc server was used to identify the biochemical function of a protein from its three-dimensional structure and PDBsum was used for secondary structure analysis. ProFunc and PDBsum servers are available at European Bioinformatics Institute (Laskowski, 2009).

Physiochemical characterization

For physiochemical characterization, theoretical pI (ioelectric point), molecular weight, -R and +R (total number of positive and negative residues), EI (extinction coefficient), II (instability index), AI (aliphatic index) and GRAVY (grand average hydropathy) were computed using the Expasy's ProtParam server for set of proteins (http://us.expasy.org/tools/protparam.html).

Submission of the modeled protein in protein model database (PMDB)

The model of *C. roseus* RNA binding protein was successfully submitted in protein model database with no stereochemical errors. The submitted model can be accessed via their PMID:PM0080432.

Sequence-Structure-Function Relationship

The sequence-structure-function relationship assessment is used for understanding the molecular mechanism of protein. In this study, all the identified conserved patterns were recommended for the structure prediction through PyMol program (DeLano, 2002) to find out their structural role and functional analysis. These predicted pattern was used for identifying their domain families by Pfam analysis (Finn *et al*., 2010).

RESULT AND DISCUSSION

Sequence analysis and Homology prediction

RNA binding protein (163.08 Kda) of *C. roseus* was extracted from Genbank with 160 aa in length. The homologs protein sequences were found in other plant species and extracted through the protein BLAST program (Johnson *et al.*, 2008). The name and gene-id of all identified glycine-rich RNA-binding protein sequences have been listed in Table-1, having high sequence identity and least e-value**.** After comparative analysis among listed sequences 86% maximum identify, 153 score and 4e-46 E-value was found.

Table 1. RNA Binding protein in different plant species

S.No.	Plant Name	Sequence Id
1	*Solanum tuberosum*	gi|799015|
2	*Catharanthus roseus*	gi|6911142|
3	*Oryza sativa*	gi|169244425|
4	*Sesamum indicum*	gi|747090235|
5	*Zea mays*	sp|P10979.1|
6	*Sinapis alba*	sp|P49310.1|
7	*Arabidopsis thaliana*	sp|Q03250.1|
8	*Daucus carota*	sp|Q03878.1|
9	*Brassica napus*	sp|Q05966.1|
10	*Hordeum vulgare*	sp|Q43472.1|
11	*Sorghum bicolor*	sp|Q99070.1|
12	*Nicotiana sylvestris*	sp|P19683.1|

The primary sequence analysis of protein was calculated through Expasy's ProtParam. The programe computes the extinction coefficient of 276, 278, 279, 280 and 282 nm wavelengths and, in addition, 280 nm has been elected since proteins absorb light strongly. Extinction coefficient of protein at 280 nm was 17,085 M^{-1} cm^{-1}. The computed extinction coefficient can help in the quantitative study of protein-protein and protein-ligand interaction in solution. The instability index

provides to determine the stability of protein in a test tube. There are definite dipeptides, which is particularly divergent in the unstable protein compared with those in the stable once. This method assigned a weight value of instability, which is feasible to compute an instability index (II). A protein whose instability index is slighter than 40 is estimated as stable. The value above 40 estimates that protein may be unstable. The instability index value of the protein was found 55.80, which indicates the protein is unstable. The aliphatic index elucidated as the relative volume of a protein occupied by aliphatic side chains (A, V, I and L). It is estimated as a positive factor for the increment of the thermal stability of globular protein. Aliphatic Index (AI) of the protein sequence was 34.74, the very low aliphatic index of the protein sequence indicates that these proteins may be unstable at low temperature. The Gravy average hydropathy (GRAVY) value for a peptide or protein is calculated as the sum of hydropathy values of all the amino acids. The number of residues in the sequence were divided. A GRAVY index of protein was -0,796. This low value shows the probability of the better interaction with water.

Conservation analysis and Phylogenetic analysis

Multiple sequence alignment of *C. roseus* RNA binding protein with its homologs 11 plant species showed highly conserved residues and patterns at different positions. Beside, the conserve patterns with their respective position in *C. roseus* showed in **Fig-1**. These results concluded that *C. roseus* RNA binding protein showed high similarity with their respective homologs. Hence, it was also suggested that *C. roseus* RNA binding protein must undergo evolution in between plant species and their respective function in them.

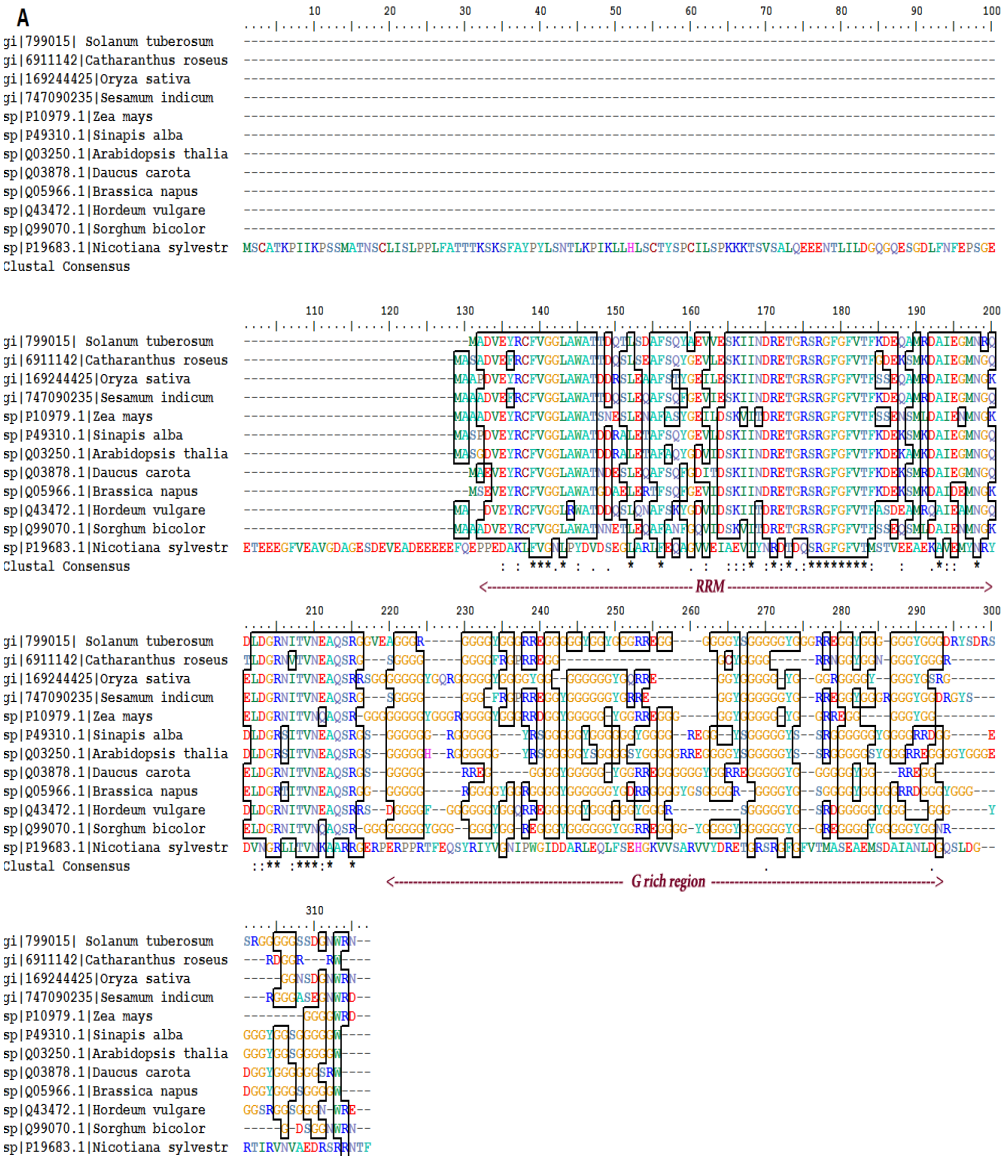


Fig 1. Identification of conserved residues in RRM and glycine-rich regions in the selected orthologus sets of RNA binding protein

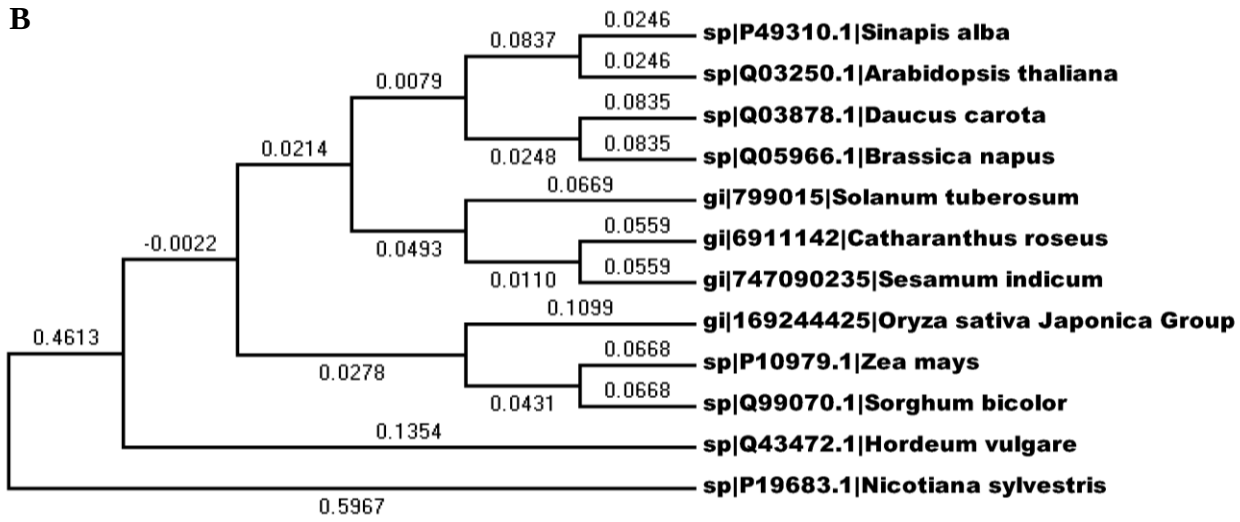


Fig 2. Phylogenetic analysis of RNA binding protein in different plant species

For phylogenetic analysis, special sequences have surpassed through morphological and other plant characters as the most popular form of data. In this section, a single profile of different plants was created and developed a Neighbor-joining tree through MEGA 5.0 software and showed evolutionary relationship among the plant species (Fig-2).

3D Structure Prediction, Validation and Annotation

Comparative modeling of the protein provides a significant hypothesis of homology between the target and the template. This approach provides reasonable results based on the hypothesis and the tertiary structure of the two proteins will be similar if their sequences are related. Absence of the experimentally determined three dimensional protein structure of *C. roseus* in PDB (Protein Data Bank), comparative modeling methods were utilized to construct its theoretical three dimensional structure. BLAST scanning results had shown higher similarity with the crystallographic structure of *Nicotiana tabacum* (PDBid: 4C7Q), while the template was selected on the basis of higher sequence identity. It has been 85.7% sequence identity with 81 conserved residues and 96.4% sequence similarity. Three dimensional structure of RNA binding protein (target) was constructed using comparative modeling and mainly based on the alignment of template. The resulting 50 models were sorted according to the Modeller Objective Function. and root mean square deviation (RMSD). The final model that have the lowest root mean square deviation, related to the trace of the crystal structure was selected for the further study. In constructed model phi and psi torsion angles were checked through Ramachandran plot. The corresponding Ramachandran plot is shown in Fig-3 with following parameters, the phi and psi angles of 93.70% residues in most favoured regions, 4.20% residues in core regions and additional allowed regions, 2.10% residues in disallowed regions. These values showed good quality of the model. The model structure was validated through structure verification servers such as Verify_3d and ProSA webserver (Fig-4A, B). Both programs showed the structure quality of the model was good. Visualization and analysis of model has been done through PyMol software (Fig-5).

Also, ProMotif documentation of the protein via Profunc server for the secondary structure analysis and showed that the 160-residues span of the structure was made of 39 residues (24%) that are involved in the formation of the strands. Likewise, 24 residues (15%) participated in the formation of alpha helices. Besides, 4 beets sheeta and 2 alpha helices were also recorded. After analysis of the predicted structure, it was confirmed that *C. roseus* RNA binding protein can be distinguished into the two domains for the structural framework. It was observed that the first domain found between the arg9 to gly71 residues region belong to the RNA recognation motif (RRM) and the second domain noticed from thr73 to gln85 residues region belong to glycine-rich domain family. The topology of the enzyme structure is illustrated in Fig-3.

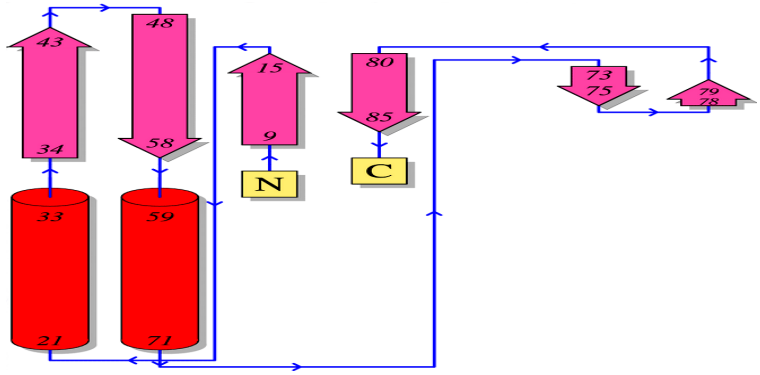
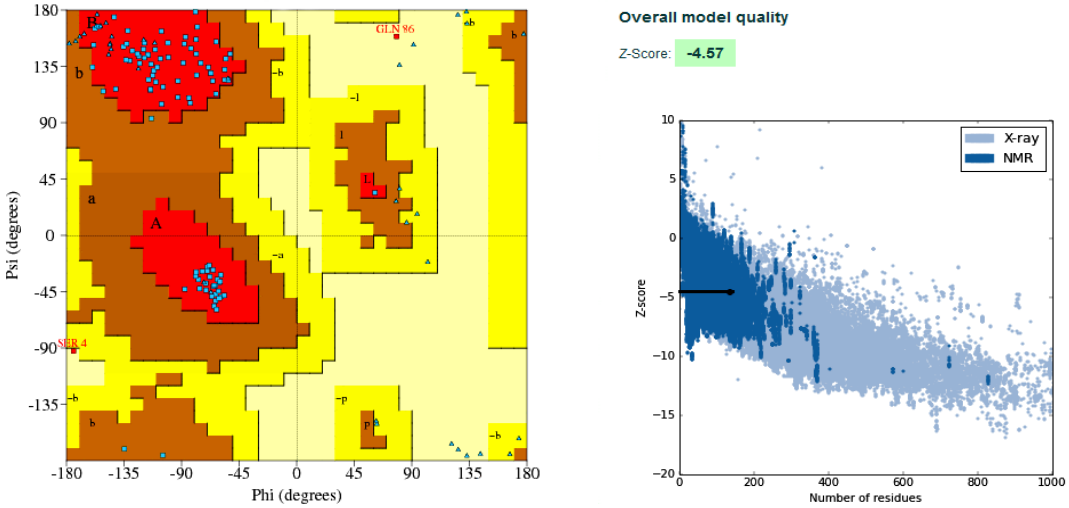


Fig 3. Topology Structure of *C. roseus* RNA binding protein generated through Profunc server



(A) (B)

Fig 4. (A) Showing Ramachandran plot of the predicted model (B) Overall model quality of the structure

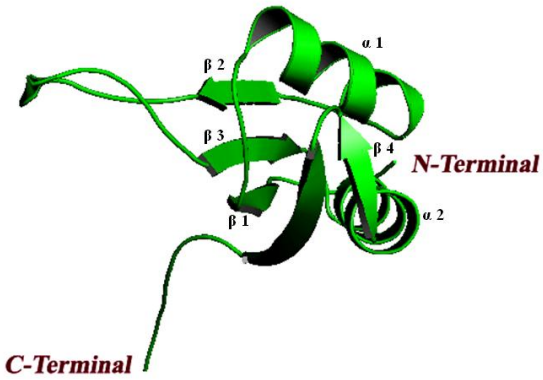


Fig 5. Homology model of *C.roseus* RNA binding protein with two alpha helices and four beta sheets

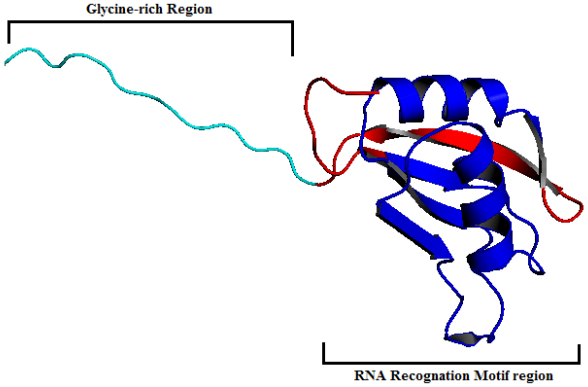


Fig 6. Highlighted structural regions represent the role of patterns in the structural confirmation of *C. roseus* RNA binding protein

Sequence-Structure-Function Relationship

The sequence-structure-function relationship was established by identifying the structural and functional role of conserved patterns, which were found in the multiple sequence alignment profile of all the analyzed sequences. The highlighted structural roles of all the identified conserve patterns have shown in Fig-6. The function of RBPs responces in plant stress and their putative role in enhancing plant tolerance to environmental stress. Additionally, auxiliary domains, such as glycine-rich, arginine-rich or serine-arginine repeats are frequently found in RBPs (Alba and Pages, 1998). Glycine-rich RBPs, harbouring a RRM domain and concomitantly a glycine-rich regions at the C-terminus are widely distributed in cynobacteria, plants and metazoa (Burd and Dreyfuss, 1994; Kim *et al.*, 2010) and have been found to be transcriptionally regulated by environmental stress in plants.

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RESEARCH ARTICLE

STUDY OF PHENOLOGICAL EVENTS OF SOME MEMBERS OF ERICACEAE

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Abstract: Phenological events during the life cycle of plants in eight species of family Ericaceae e.g. *Enkianthus deflexus Schneider, Gaultheria hookeri Clarke, Lyonia villosa Hand- Mazz, Pieris Formosa Don, Agapetes serpens Sleumer, Vaccinium retusum Hook* and *Vaccinium vacciniaceum* Sleumer are recorded on the basis of field studies in their natural habitats. The various phenological events include bud initiation, period of flowering, anthesis time, pollination, fertilization, seed maturation and seed germination. Flower bud initiation takes place in the month of September and October. Buds are covered with scaly bracts and undergo dormancy for four to five months to overcome the severe winter. These buds after overcoming winters bloom in February to June accordingly. The pollen dehiscence takes place before anthesis. Fertilization follows in next 6-10 days and it is completed after pollination within 20 days. Seed and fruit mature from July to September. Seed dispersal takes place in September and October. It was concluded that various phenological events are affected by various climatic conditions.

Keywords: Phenological events, Ericaceae, Flower buds

INTRODUCTION

Ericaceae commonly known as "Heath family" are the largest among the families of Ericales comprising about 80 genera and over 1900 species which are cosmopolitan in nature, occurring in temperate ,sub-temperate or alpine in their distribution .The members have an assemblage of characters which are intermediate between the Polypetalae and Gamopetalae and many of the characters are primitive especially of reproductive organs The plants of Ericaceae can easily be identified on the basis of leaf characters, even in its vegetative phase ,by simple , alternate ,evergreen leaves with reflexed margins. The adaxial surface is shining dark green and smooth while the abaxial side has smooth tamontose dense trichomes . Both vegetative and reproductive buds are dormant and skip over severe winters by protected from thick compact scaly bracts. The shape and size of these vegetative and reproductive buds make a useful taxonomic character. Inflorescence may be terminal or axillary, with individual flowers bisexual, regular each with 4-5 lobed corolla, 5-10 stamens and a superior ovary. Fruit a capsule or berry. Family contains decorative and well known plants. Plants grow in acidic soil..Basal nectar girdling the base of the ovary is uniform in all the members of Ericaceae [Philipson (1985 and Palser 1989)]. Pollination takes place by different types of pollen vectors(Williams etal 1990) eg. honey bee, wasps, ants, flies, butterflies, beetles and birds etc (Govil, etal 1995).These visited the flower at sunny day, but in dark and rainy day no visitor were recorded. Flavon glocoside , tannins etc. are obtained from leaves of *Enkianthus & Agapetes.*

MATERIAL AND METHOD

Analysis of phenological characters of different species of family was done at the place of occurrence. During field study, observations were recorded of different phenological events viz. flower bud initiation, bud dormancy, flowering season, anther maturation and dehiscence, anthesis, pollination, fertilization and seed maturation. Seasonal timings of life cycle phases of the following plants were maintained during field study.(Fig 1-8)
Agapetes serpens sleumer, Cassiope fastigiata, Enkianthus deflexus, Gaultheria hookeri, Lyonia villosa, Pieris Formosa, Vaccinium vacciniaceum and V.retusum

Observation

(i) Flower bud initiation : - In *Agapetes serpens, Cassiope fastigiata, Enkianthus deflexus, Pieris formosa,* and *Vaccinium retusum* early bud initiation takes place during the during the month of September and October and remain dormant for 5-6 months covered by compactly closed scaly bracts which protect the flower buds from severe cold. In case of *Cassiope fastigiata* buds are solitary in the axil of much adpressed overlapping leaves and remain protected as they are covered by thick fleshy leaves, Scaly bracts are absent. In case of *Gaultheria hookeri, Lyonia villosa* and *vaccinium vacciniaceum* flower bud initiation takes place in the month of October.

(ii) Flowering Season : - The flowering season is prolonged from February to June in *Agapetes serpens*. Flower bloom into scarlet red bunches hanging downwards. Maximum flowering is during April-May. But it also depends upon the altitude and weather. At high altitude the flowering is late. In *Cassiope* and *Enkianthus deflexus* dormant flower buds show their

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appearance in May and June. In *C.fastigiata* flower buds bloom as white colour flowers in June to August. In *E.deflexus* dormant buds bloom into orange-red broadly bell shaped umbel flowers. At high altitude flowering is late. In *Gaultheria hookeri* and *Vaccinium retusum* dormant buds show their appearance in April and May. These buds bloom as white colour flower. In *Lyonia villosa* flowering season is from June to July. Flowers bloom into white or orange coloured racemes. In *Pieris formosa* flowering season is from March to May in which they bloom into bright white flowers arranged in panicled raceme in pendent. In *V.vacciniaceum* flowering occurs in dormant bud from April to June. They bloom into pink flowers arranged in raceme clusters.

(iii) Anthesis : - In case of all eight species anthesis period is morning between 8 am to 12 noon. In cloudy rainy day anthesis does not take place and flower buds remain unopen.

(iv) Anther maturation and dehiscence : - In *Agapetes serpens*, anther reach to maturity before anthesis. Sometimes anther dehiscence takes place 2-3 days before anthesis as it was observed that in many cases when the buds are still closed pollen are attached to the style. Dehiscence of anther takes place through pores which are morphologically basal in position but acquired apical position due to inversion of anthers (plate). Anther dehiscence takes place early in the morning before 2-3 days of anthesis. Dehiscence of anther continue upto afternoon. However, the peak hours of anthesis are during noon hours.(fig. 9-12).

(v) Pollination : - In *A. serpens* pollination occurs after 6-7 days of anthesis as observed during the field studies. Both cross and self pollination occur in this species. In *c. fastigiata* pollination takes place only after 4-5 days of anthesis. In rest of the species it is observed that pollination occurs after 1-7 days of anthesis. Cross pollination takes place with the help of different types of vectors or insect pollinators, like honey bee, termites, flies, which are attracted by basal nectary and bright coloured flowers. These vectors visit flower for their forage and carry pollen from one place to another.

(vi) Fertilization: - In all the species of the family studied interval between pollination and fertilization is 6-10 days. The marker for fertilization is the change in colour and fall of petals. The receptivity of stigma remains for 2-3 days and it depends upon the climate.

(vii) Seed maturation: - Between fertilization and seed maturation a long time takes place in all the species observed. It may be from 3-4 months. It is observed that seed mature in July to September in case of *A.serpens*. In *Cassiope fastigiata* seeds mature in August-September. During field visits June-July months is observed for seed maturation in *Enkianthus*. In case of *G.hookeri, V.villosa* and *P.fomosa* seeds maturation takes place in July to august. In both the species of *Vacciunum*May-June and June-July months are observed for seed maturation. After maturation fruit dehisce and liberate the seeds.

(viii) Seed dispersal: - Seed dispersal takes place between September to October in *A.serpens, C.fastigiata, G.hookeri, L.villosa, P.formosa And V.retusum. In E. Deflexus* seed dispersal is found in August to October and in *V.vacciniaceum* it is found only in the month of October.

(ix) Seed germination: - The seeds remain buried in humus soil in dormant stage after dispersal. The germination takes place in next spring when the weather is warm. In *A.serpens, P.formosa and V.retusum* seed germination period is March-April. In *C.fastigiata, E.deflexus & L.villosa* germination takes place in the month of April. In April and May germination is seen in *G.hookeri* and *V.vaccinaceum.*

Table 1. Showing distribution, place of collection, time and altitude of eight members of Indian Ericaceae

S.No.	Name of the speciec	Place of collection	Altitude(Mts)	Period of Collection
1.	*Agapetes serpens*	Sikkim (Lachung)	1500-2700	March-May
2.	*Cassiope fastigiata*	Sikkim (Lachung)	2800-4500	March-May
3.	*Enkianthus deflexus*	Sikkim (Lachung)	2500-3300	March-May
4.	*Gautheria hookeri*	Sikkim (Lachung)	2700-3000	March-May
5.	*Lyonia villosa*	Sikkim (Lachung)	2100-3800	March-May
6.	*Pieris Formosa*	Sikkim (Lachung)	2100-3300	March-May
7.	*Vaccinium retusum*	Sikkim (Lachung)	1400-3600	March-May
8.	*V.vacciniaceum*	Sikkim (Lachung)	1500-2800	March-May

Table 2. Phenological events of members of family Ericaceae.

Name of the species	Period of bud initiation	Period of flowering	Anther maturation (days before anthesis)	Anthe-sis a.m.-noon	Pollination (days after anthesis)	Fertiliza-tion days after pollination	Seed maturation	Seed dispersal	Seed germination
Agapetes serpens	Sept-Oct	Feb-June	2-3	8-12	6-7	6-10	July-Sept	Sept-Oct	Mar-April

Cassiope fastigiata	Sept-Oct	May-June	2-3	8-12	4-5	6-10	Aug-Sept	Sept-Oct	April
Enkianthus deflexus	Sept-Oct	May-June	2-3	8-12	1-7	6-10	Jun-July	Aug-Oct	April
Gaultheria hookeri	October	April-May	2-3	8-12	1-7	6-10	July-Aug	Sept-Oct	April-May
Lyonia villosa	October	June-July	2-3	8-12	1-7	6-10	July-Aug	Sept-Oct	April
Pieris formosa	Sept-Oct	Mar-May	2-3	8-12	1-7	6-10	July-Aug	Sept-Oct	Mar-April
Vaccinium retudum	Sept-Oct	April-May	2-3	8-12	1-7	6-10	May-Jun	Sept-Oct	Mar-April
V.vacciniaceum	October	April-June	2-3	8-12	1-7	6-10	Jun-July	October	April-May

Fig 1. *Agapetes serpens* **Fig 2.** *Cassiope fastigiata*

Fig 3. *Enkianthus deflexus* **Fig 4.** *Gaultheria hookeri*

Fig 5. *Lyonia villosa* **Fig 6.** *Pieris Formosa*

Fig 7. *Vaccinium retusum* **Fig 8.** *V.vaccineacum*

Fig 9. **Fig 10.**

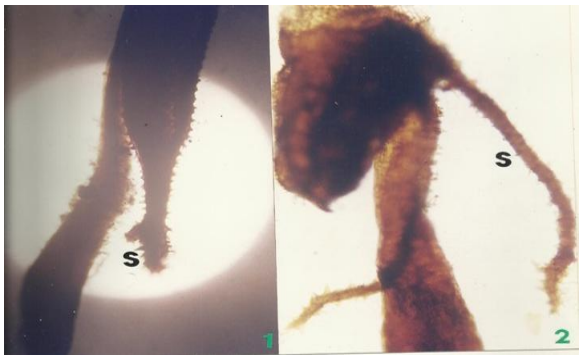

Fig 11. **Fig 12.**

(Fig 9-12): Shows spurs on anthers

RESULT AND DISCUSSION

Phenological events in the biology of reproduction of plants are the regulating factors for the production of progeny. Different aspects of floral biology, mainly flower initiation, blooming period, anthesis, dehiscence of anthesis, pollination after anthesis, fertilization, seed maturation, seed dispersal and seed germination are important events in the life-cycle of a plant. Among the herbaceous plants the life-cycle is complete within a short span of time and not much effect of climatic factors and nutritive factors are visible but in tree species and perennial plants physical factors, hormonal factors and nutritional factors influence various events of phases in growth that are taking place in life-cycle. Ericaceaen plants which are temperate or subalpine have shown adaptability so as to complete efficiently their life cycle. Among all the members studied it is observed that the initiation of flower bud takes place much earlier before the onset of winters. Flower buds which initiate in the month of September-October remain dormant for almost five to six months during the severe winter climate. The dormant buds are protected by hard scales which keep the buds in a compact structure. Flower bud dormancy appears to be an adaptive feature of Ericaceae as a whole. Schneider (1964) concluded that the resting period of flower buds in Ericaceae (Rhododendron) is related with bud scale. He observed that when the scales are removed after onset of rest it causes the termination of rest period. Further the rest period of each flower is independent to rest period of adjacent flower. Philipson (1985) and Stevens (1985), concluded that there is relationship of flower buds with weather. During the present studies it is noticed that temperature highly influences the flower bud differentiation. Our observations are in conformity with the observations of these workers. Period of flowering vary in different members of Ericaceae and it is highly controlled by temperature and altitude. Species growing at low altitude flower early while those which are growing at higher altitude flower late in month of July- August. The same species growing at different altitudes show difference in period of blooming. At a higher altitude where the temperature is low the flowering is delayed. In the members studied longest time for flowering is reported in *Agapetes serpens* from February to June which is not reported in any other member of Ericaceae. *A. serpens* is found at low altitude. A good account of flower and flowering time is given by a number of workers namely Stevenson (1947), Bowers (1960), Leach (1962), Kruaaman (1970), Cox (1973), and Feng (1988) etc. The anthesis of flowers usually takes place early in the morning between 8 a.m.-12 noon. After the anthesis, pollination takes place between 1-7 days and stigma remains receptive during this period. Anther dehiscence takes place two to three days before anthesis. This may lead to high chance of self compatibility. Ericaceae members are self as well as cross pollinated. Various pollinators or pollen vectors visit flowers and they off load pollen on the stigma. It is observed that the pollinators visiting the flowers come either for forage or nectar.

Fertilization occurs after 6-10 days of pollination. The completion of process of fertilization can be marked with specific markers i.e. either there is a change in colour of petals or fall off petals after fertilization. Fruits and seed setting takes a longer period. Seed mature from May to September. Seed dispersal takes place in the month of September-October. A reproductive time table for different species of *Rhododendron* (Ericaceae) has been prepared by a number of workers as falser etal., (1989) for *R. nuttalti,* Rouse etal., (1991) for *R. maogregoriae* etc. Which are similar in most of the members of Ericaceae studied.

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RESEARCH ARTICLE

ECONOMICS OF PRODUCTION AND MARKETING OF BRINJAL IN BILASPUR DISTRICT OF CHHATTISGARH STATE

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Abstract: The study was conducted to work out the cost and return of brinjal production in Bilaspur District of Chhattisgarh. One hundred fifty four vegetable growers were selected randomly from four blocks namely Bilha, Masturi, Kota and Takhatpur. The primary data were collected for the year 2013-14. The study observed average size of farm 1.76 hectare. The dugwell was observed as major source of irrigation as irrigated area from it found to be 41.45 per cent. On an average, the cost of cultivation of brinjal, was amounted as Rs 51781.71/ha. The major share of cost of cultivation gone to labour cost. The cost of production of brinjal was calculated as Rs 284.88/q. The net return against the cost of cultivation was observed Rs 109382.94/ha and cost of production found to be Rs 601.79/q. The input – output ratio of brinjal came to 1:3.11. There were two marketing channels identified in the study area. Channel- I: Producer - consumer. Channel-II: Producer – commission agent/retailer. The channel-I found more efficient as 51.54 than channel –II for the selected vegetable. The study suggested that the labour cost must be reduced to enhance the economic viability of the production and shortest marketing channel must be encouraged by the government as short marketing channel possess more marketing efficiency.

Keywords: Cost of cultivation, Cost of production, Output Input Ratio, Marketing channel

INTRODUCTION

It has been observed that economic returns to vegetables are better than other several crops. The yield per unit area is high and suitable for intensive farming lead generation of supplement incomes and expands employment through it. Vegetables are always been a better choice of crop diversification because of good productivity and much higher returns from a unit area. The diversification in favour of these crops improves exports, reduce trade deficit, besides creating more direct and indirect employment. Chhattisgarh State has to go long way in vegetable production. In the State, there is remarkable gap between actual harvested yield and potential yield of vegetable crops. Hence, scope for harnessing/exploiting potential fully still exists. In the State, during 2010-11 vegetables occupied an area of 0.346 million hectares with the production 4.25 million metric tonnes which accounted 4.1 and 2.9 per cent over the national figures, respectively. The productivity of State 12.3 metric tonnes was quite less than the national average i.e. 17.3 metric tonnes. According to the data from Directorate Horticulture, Chhattisgarh the coverage of vegetables in the year 2010-11 was maximum in Bilaspur as 68348.76 hectares which was 20.41 percent of total area in the State followed by Durg, Surguja and Raipur with 14.82, 14.21 and 11.09 percent, respectively. Though, vegetables are grown more or less in all the Districts of the State, brinjal is one of the vegetables which have large area coverage as 7.97 per cent in the State with the production 439518.90 MT. In Bilaspur District brinjal occupied an area of 1732.15 ha which was 2.53 per cent to total area of vegetables in the District with the production 25809.04 MT (*data 2010-11*). Data reveals that brinjal is popular vegetable which have great economic important to the farmers. Therefore, the economic study of brinjal production and marketing is pertinent. Hence, the study has been under taken in Bilaspur with the following objectives.

Objectives

1. To examine the cost and return of brinjal production on selected households.
2. To find out the marketing pattern of brinjal in the study area.

MATERIAL AND METHOD

The study was conducted in Bilaspur District of Chhattisgarh State. A 10 per cent respondent was selected at random with the sample size of 154 farmers from four Blocks namely Bilha, Masturi, Kota and Takhatpur of the District. The farmers were categorized into four groups on the basis of their land holdings viz marginal, small, medium and large. A 10 per cent intermediary was selected at random with the sample size 30 from the market. The study was based on primary data for the agricultural year 2013-14. The following analytical procedure was adopted to analyse the data:

Cost of cultivation

To work out the cost of cultivation simple arithmetic and statistical techniques of analysis viz. average,

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percentage and standard method of cost of cultivation were adopted.

The study worked out the cost of production of brinjal as per the definition given by Commission on Agricultural Costs and Prices (CACP) that are as follows;

Cost A1 = Value of purchased material inputs (seed, insecticides and pesticides, manure, fertilizer), hired human labour, animal labour (hired and owned), hired farm machinery, depreciation on farm implements and farm buildings, irrigation charges, land revenue cesses and other taxes, and interest on working capital.

Cost A2 = Cost A1 + rent paid for leased-in land.

Cost B1 = Cost A1+ interest on value of owned capital assets (excluding land).

Cost B2 = Cost B1+ rental value of owned land (net of land revenue) and rent paid for leased-in land.

Cost C1 = Cost B1 + Imputed value of family labour.

Cost C2 = Cost B2 + Imputed value of family labour.

Cost C3 = Cost C2+ 10% of Cost C2 on account of managerial functions performed by farmer.

Marketing Cost, Margins and Price Spread

$C = C_f + C_{m1} + C_{m2} + C_{m3} + \ldots C_{mn}$

Where, C = Total cost of marketing of the commodity

C_f = Cost paid by the producers from the time producer leaves the farm till he sells it, and

C_{mi} = Cost incurred by the i^{th} middleman in the process of buying and selling the product.

Gross Margin

$$M = S_i - P_i$$

Where, M = Gross margin

S_i = Sale value of produce for i^{th} middleman

P_i = Purchase value for i^{th} middleman

i = Type of i^{th} middleman

Net Margin of market intermediaries

$$N_{mi} = P_{ri} - (P_{pi} + C_{mi})$$

Where, N_{mi} = Net margin of i^{th} type of market middleman

P_{ri} = Total value of receipts per unit (Sale)

P_{pi} = Per unit purchase price of goods by the i^{th} middleman

C_{mi} = Per unit marketing cost incurred by the i^{th} middleman

Producer's Price

$$P_F = P_A - C_F$$

Where, P_F = Net price received by farmer

P_A = Wholesale price

C_F = The marketing cost incurred by the farmer

Producer's share in consumer rupee

$$P_S = (P_F / P_R)\ 100$$

Where, P_S = Producers share in consumer rupee

P_F = Net price received by farmer

P_R = Price paid by the consumer

Marketing Efficiency

$$ME = (V/I) - 1$$

Where, ME= Index of marketing efficiency

V= Value of the goods sold or price paid by the consumer

I = Total marketing cost or input of marketing

RESULT AND DISCUSSION

The results obtained from the study as well as discussions have been summarized under following heads:

Economics of brinjal

Table 1 showed an overall average total cost of brinjal cultivation as Rs 51781.71/ ha. The expenditure on hired labour accounted for a major proportion 21.28 per cent of the total cost followed by family labour 19.22 per cent, machine power 9.70 per cent and manure and fertiliser 9.56 per cent.

The cost of cultivation per hectare showed a rising trend with the rise in the size of farm as it turned out to be Rs 49504.15/ha, Rs 51340.78/ha, Rs 51914.65/ha and Rs 54367.24/ha on marginal, small, medium and large size farms respectively. Expenditure on family labour amounted higher as 34.45 per cent and 33.87 per cent on small and marginal farms respectively. The paramount expenditures occurred on hired labour with 37.25 per cent and 35.23 per cent on large and medium farms respectively. Machine power was utilised maximum on large and medium farms as amounted Rs 6751.33/ha and Rs 6586.67/ha that were 12.42 and 12.69 per cent to respective total costs. Manure and fertiliser expenses were maximum on large farm as Rs 5092.24/ha followed by medium with Rs 5021.60/ha while least expenses found on marginal farm as Rs 4671.11/ha.

Table 1. Cost of cultivation of brinjal on different size group of farms. (Rs/ha)

Sl. No.	Particulars		Category of vegetable growers				Overall average
			Marginal	Small	Medium	Large	
A.	Labour Cost						
	(i)	Family labour	16765.37	17686.93	3183.56	2177.72	9953.39
			(33.87)	(34.45)	(6.13)	(4.01)	(19.22)
	(ii)	Hired labour	2374.63	3159.45	18287.98	20249.88	11017.99

			(4.80	(6.15)	(35.23)	(37.25)	(21.28)
	(iii)	Bullock labour	4544.01	1479.44	0.00	0.00	1505.86
			(9.18)	(2.88)	(0.00)	(0.00)	(2.91)
	(iv)	Machine power	1570.85	5181.59	6586.67	6751.33	5022.61
			(3.17)	(10.09)	(12.69)	(12.42)	(9.70)
		Total Labour Cost	25254.86	27507.41	28058.20	29178.93	27499.85
			(51.02)	(53.58)	(54.05)	(53.67)	(53.11)
B.	Material Cost						
	(i)	Seed	3089.27	3056.51	3183.56	3276.87	3151.55
			(6.24)	(5.95)	(6.13)	(6.03)	(6.09)
	(ii)	Manure and fertilizer	4671.11	5008.39	5021.60	5092.24	4948.34
			(9.44)	(9.76)	(9.67)	(9.37)	(9.56)
	(iii)	Plant protection	1141.06	1186.27	1288.79	1314.20	1232.58
			(2.30)	(2.31)	(2.48)	(2.42)	(2.38)
	(iv)	Irrigation	940.34	938.60	1142.69	1037.40	1014.76
			(1.90)	(1.83)	(2.20)	(1.91)	(1.96)
		Total Material Cost	9841.79	10189.76	10636.64	10720.71	10347.22
			(19.88)	(19.85)	(20.49)	(19.72)	(19.98)
C.	Total Working Cost (A+B)		35096.65	37697.17	38694.84	39899.64	37847.08
			(70.90)	(73.43)	(74.54)	(73.39)	(73.09)
D.	Other Costs						
	(i)	Depreciation	206.66	202.76	294.45	314.99	254.72
			(0.42)	(0.39)	(0.57)	(0.58)	(0.49)
	(ii)	Interest on working capital	2035.61	2186.44	2244.30	2314.18	2195.13
			(4.11)	(4.26)	(4.32)	(4.26)	(4.24)
	(iii)	Land revenue	12.00	12.00	12.00	12.00	12.00
			(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
	(iv)	Rent paid for leased in land	73.54	120.81	130.11	90.23	103.67
			(0.15)	(0.24)	(0.25)	(0.17)	(0.20)
	(v)	Rental value of land	7384.53	6199.01	5564.19	6538.49	6421.56
			(14.92)	(12.07)	(10.72)	(12.03)	(12.40)
	(vi)	Interest on value of own capital	194.79	255.24	255.24	255.24	240.13
			(0.39)	(0.50)	(0.49)	(0.47)	(0.46)
		Total Cost	9907.12	8976.26	8500.30	9525.12	9227.20
			(20.01)	(17.48)	(16.37)	(17.52)	(17.82)
E.		Total Cost (C+D)	45003.77	46673.43	47195.14	49424.77	47074.28
			(90.91)	(90.91)	(90.91)	(90.91)	(90.91)
F.		Managerial Cost	4500.38	4667.34	4719.51	4942.48	4707.43
			(9.09)	(9.09)	(9.09)	(9.09)	(9.09)
G.		Grand Total (E+F)	49504.15	51340.78	51914.65	54367.24	51781.71
			(100.00)	(100.00)	(100.00)	(100.00)	(100.00)

Note- Figures in parentheses show per cent to the total.

Table 2 depicted cost of cultivation of brinjal as per cost concept. An overall farms average of Cost A1, Cost A2, Cost B1, Cost B2, Cost C1, Cost C2 and Cost C3 turned out to be Rs 22061.38/ha, Rs 22165.05/ha, Rs 22301.51/ha, Rs 28826.74/ha, Rs 40549.05/ha Rs 47074.28/ha and Rs 51781.70/ha respectively. Cost A1 was higher on medium farm as Rs 22957.61/ha while least on marginal farm with Rs 20585.54/ha whereas, Cost A2 was higher on medium farm with Rs 23087.72/ha and minimum on marginal farm as 20659.08/ha.

Table 2. Break-up of cost of cultivation of brinjal on different size group of farms. (Rs/ha)

Sl. No.	Particulars	Category of vegetable growers				Overall average
		Marginal	Small	Medium	Large	
1.	Cost A1	20585.54	22411.44	22957.61	22290.93	22061.38
2.	Cost A2	20659.08	22532.25	23087.72	22381.16	22165.05
3.	Cost B1	20780.33	22666.68	23212.85	22546.17	22301.51
4.	Cost B2	28238.39	28986.50	28907.16	29174.88	28826.74
5.	Cost C1	37545.70	40353.61	41500.83	42796.05	40549.05
6.	Cost C2	45003.77	46673.44	47195.14	49424.77	47074.28
7.	Cost C3	49504.14	51340.78	51914.65	54367.24	51781.70

Table 3 revealed that an overall average cost of production of brinjal per quintal accounted for Cost A1, Cost A2, Cost B1, Cost B2, Cost C1, Cost C2 and Cost C3 as Rs 121.37/q, Rs 121.94/q, Rs 122.69/q, Rs 158.59/q, Rs 223.09/q, Rs 258.99/q and Rs 284.88/q respectively. While, the respective net returns over the cost of production from Cost A1 to Cost C3 were Rs 765.30/q, Rs 764.73/q, Rs 763.98/q, Rs 728.08/q, Rs 663.58/q, Rs 627.68/q and Rs 601.79/q. The large farm received higher net return over Cost A1 and Cost A2 with Rs 767.95/q and Rs 767.47/q and minimum net return gained by medium farm for respective cost as Rs 761.89/q and Rs 761.18/q. On other side, net return over Cost C3 was maximum on small farm and minimum on large farm with Rs 607.94/q and Rs 597.11/q respectively.

Table 3. Economics of production of brinjal on different size groups of farms.

Sl. No.	Particulars		Farm size				Overall average
			Marginal	Small	Medium	Large	
1.	Cost of production Rs/q						
	Cost A1		120.30	121.67	124.78	118.72	121.37
	Cost A2		120.73	122.33	125.49	119.20	121.94
	Cost B1		121.43	123.06	126.17	120.08	122.69
	Cost B2		165.02	157.37	157.12	155.38	158.59
	Cost C1		219.41	219.08	225.58	227.93	223.09
	Cost C2		262.99	253.39	256.53	263.23	258.99
	Cost C3		289.29	278.73	282.18	289.56	284.88
2.	Net return Rs/q						
	Cost A1		766.37	765.00	761.89	767.95	765.30
	Cost A2		765.94	764.34	761.18	767.47	764.73
	Cost B1		765.24	763.61	760.50	766.59	763.98

		Cost B2		721.65	729.30	729.55	731.29	728.08
		Cost C1		667.26	667.59	661.09	658.74	663.58
		Cost C2		623.68	633.28	630.14	623.44	627.68
		Cost C3		597.38	607.94	604.49	597.11	601.79
3.	Net return Rs/ha							
		Cost A1		131145.33	140906.68	140169.78	144191.27	139103.27
		Cost A2		131071.79	140785.87	140039.67	144101.04	138999.59
		Cost B1		130950.54	140651.44	139914.54	143936.03	138863.14
		Cost B2		123492.48	134331.62	134220.24	137307.31	132337.91
		Cost C1		114185.17	122964.51	121626.56	123686.14	120615.60
		Cost C2		106727.11	116644.69	115932.26	117057.43	114090.37
		Cost C3		102226.73	111977.34	111212.75	112114.95	109382.94

Table 4 revealed that an overall average value of net return, family labour income and farm business income of brinjal farm to be Rs 109382.94/ha, Rs 138999.59/ha and Rs 132337.91/ha respectively. The overall average input-output ratio in brinjal worked out to be 1:3.11 on the sample farms. The cost and return of brinjal production on different categories of farm sizes were at par though small farm had maximum input-output ratio as 1:3.18 while large farm had minimum input-output ratio as 1:3.06.

Table 4. Cost and return of brinjal on the sampled farms. (Rs/ha)

Sl. No.	Particulars	Farm size				Overall average
		Marginal	Small	Medium	Large	
1.	Cost C3 (Rs)	49504.14	51340.78	51914.65	54367.24	51781.70
2.	Yield (q)	171.12	184.19	183.98	187.76	181.76
3.	Average price received	886.67	886.67	886.67	886.67	886.67
4.	Output value	151730.87	163318.12	163127.40	166482.19	161164.65
5.	Net Income	102226.73	111977.34	111212.75	112114.95	109382.94
6.	Input-Output ratio	1: 3.07	1: 3.18	1: 3.14	1: 3.06	1: 3.11

Marketing channel of brinjal

There two marketing channels were identified in the marketing of brinjal in the study area as.

Channel I: Producer - Consumer

Channel II: Producer – Commission agent/ Retailer-Consumer

The Table 5 revealed that marketing channel- I was more efficient as efficiency estimated to be 51.54 against channel – II as 11.77.

Table 5. Marketing cost, margin and price spread of brinjal on different size group of farms. (Rs/q)

S. No.	Particulars		Marketing channel - I		Marketing channel - II
			Farm size		Farm size
			Average		Average
1	Farmer				
		Farmer's price	2094.24		819.19
			(98.37)		(36.76)
		Marketing cost	40.52		167.48
			(1.90)		(7.52)
2	Commission agent /Retailer				
		Marketing cost	0.00		7.08
			(0.00)		(0.32)
		Marketing margin	0.00		1234.54
			(0.00)		(55.40)
3.	Consumer				
		Consumer price	2129.00		2228.29
			(100.00)		(100.00)
	Marketing efficiency		51.54		11.77

Note: Figures in parentheses indicate percentage to total.

CONCLUSION

The found major findings as on an average, the cost of cultivation of brinjal, was amounted as Rs 51781.71/ha. The major share of cost of cultivation gone to labour cost. The cost of production of brinjal, was calculated as Rs 284.88/q. The net return against the cost of cultivation and production observed Rs 109382.94 and Rs 601.79/q. The input – output ratio of brinjal came to 1:3.11. There were two marketing channels identified in the study area. Channel- I: Producer - consumer. Channel-II: Producer – commission agent/retailer. The channel-I found more efficient than channel –II for the selected vegetables. The study suggested that the labour cost must be reduced to enhance the economic viability of the production and shortest marketing channel should be encouraged in policy framework by the government as short marketing channel possess greater marketing efficiency.

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RESEARCH ARTICLE

EFFICACY OF AQUEOUS AND ETHANOLIC EXTRACTION ON PHENOLICS AND ANTIOXIDANT ACTIVITY OF *PAEDERIA FOETIDA* L. AND *SPERMACOCE STRICTA* L.F.

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Abstract: Plant phenolics, particularly flavonoids are rich source of antioxidants. Efficient extraction of phenolics with solvents safe for human health is sought for dietary formulations. The study deals with the efficacy of aqueous (temperature 30, 50, 80, and 100°C; duration 10, 20 and 30 min) and ethanolic (concentration 50, 70, and 90%; duration 30, 60 and 90 min) extractions of total phenolic content (TPC) and flavonoid content (TFC), and total antioxidant activity (TAA) in *Paederia foetida* L. and *Spermacoce stricta* L.f. (Family; Rubiaceae). The observations are statistically analyzed and results reveal that the phenolic and flavonoid contents and antioxidant activity is higher in *P. foetida* than *S. stricta*. Furthermore, ethanolic extraction is better than aqueous extraction in terms of antioxidant activity. The result highlights the potential use of the two plant species in dietary formulations to defend oxidative stress.

Keywords: Phenolics, Flavonoid, Antioxidant activity, *Paederia foetida*, *Spermacoce stricta*.

INTRODUCTION

Plants produce a plethora of phytochemicals which is a boon for both the plants and humans (Ruskin *et al.*, 2002). These phytochemicals are useful to defend the plant from different biotic and abiotic stresses due to their biochemical activities (Dicko *et al.*, 2005; Ramakrisna and Ravishankar, 2011). Plants as a whole or their parts have been utilized by humans for their wellbeing including the remedy of different ailments and diseases (Calabrese *et al.*, 2012). The medicinal property of plants has thoroughly been investigated in relation to their phytochemical constituents and their antioxidant activity (Cao *et al.*, 1996; Prior and Cao, 2000). The growing knowledge in this field indicates that an increased intake of antioxidant rich food can lower the risk of many degenerative diseases like cardiovascular diseases and cancer (Liu, 2003; Su *et al.*, 2013). Plants produce three major classes of secondary metabolites or natural products i.e. terpenes, phenolics and alkaloids (Taiz and Zeiger, 2010). Among these natural products phenolics are the most important for dietary formulations and are most widely studied (Crozier *et al.*, 1997). Plant phenolics or polyphenols constitute a chemically diverse group among which flavonoids are of importance by their ability to defend oxidative damage to the plant (Svobodova *et al.*, 2003). The search for new and safe phytoconstituents with higher antioxidant potential from different plants have gained attention to develop natural antioxidant formulations for food, cosmetic, and other applications (Trautinger, 2001; Eshun and He, 2004). *Paedaria foetida* L. and *Spermacoce stricta* L.f. both belong to the family Rubiaceae are medicinally important and widely used in traditional folk medicine for curing various ailments and diseases. The reported photochemical constituents from these plants are chemically diverse and mainly found from the leaves of the plant (Conserva and Ferreira, 2012; Chanda *et al.*, 2013).

A number of extraction methods are usually employed for phenolic extraction out of which solvent extractions are commonly used due to its ease, efficiency and wider applicability. The efficacy of phenolic extraction depends upon the varying polarities of the solvent, extraction time, temperature, sample to solvent ratio, chemical composition and physical properties of the sample (Turkmen *et al.*, 2006). Solvents like methanol, ethanol, acetone, ethyl acetate and their combinations along with varying proportions of water have been used for extraction of phenolics (Robbins, 2003). Aqueous methanol is a preferred solvent for extraction of low molecular weight polyphenols while the higher molecular weight flavanols are better extracted with aqueous acetone (Dai and Mumper, 2010). However, a dietary formulation requires use of non-toxic solvents safe for human consumption (Shi *et al.*, 2005). To address the problem, the extraction efficacy of phenolics from *P. foetida*, and *S. stricta* has been studied utilizing aqueous extraction at different temperatures and also with different concentrations of ethanol. Furthermore, the interrelationship between phenolics and antioxidant capacity has also been assessed to predict the efficacy of extraction in the plant species.

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MATERIAL AND METHOD

Chemicals

Gallic acid, quercetin and 2, 2- diphenyl-1-picrylhydrazyl (DPPH) were purchased from Sigma–Aldrich, (St. Louis, MO, USA). Folin–Ciocalteau's (FC) reagent, aluminum chloride, ammonium molybdate, ascorbic acid, sodium phosphate, sodium carbonate, and potassium acetate were obtained from Merck, India. All other chemicals were of analytical grade.

Materials

Paederia foetida L., and *Spermacoce stricta* L.f., belonging to the family Rubiaceae were collected from Kalyani University campus, Kalyani (22.9750° N and 88.4344° E, 9.75 m above mean sea level), Nadia, West Bengal. The identification of plants was done following the use of appropriate manual (Prain, 1903). The plant specimens were preserved at the herbarium repository of Department of Botany, University of Kalyani as voucher specimen.

Sample Preparation

The leaves were collected from the plant and washed under running water to remove the adherent dirt from the leaves. These leaves were then shade dried for 15 days at room temperature (30 ±1°C). The shade dried leaves were pulverized by a mechanical grinder and extracts were made with water at different temperatures (30, 50, 80, and 100°C) and ethanol at different concentrations (50, 70, and 90%). The sample to solvent ratio was kept constant at a ratio 1:20 (w/v) and extractions were done at different time (aqueous- 10, 20, and 30 min and ethanolic-30, 60, and 90 min) intervals. During the process, samples were occasionally shaken and subsequently the extracts were filtered through Whatman filter paper to remove the debris. The extracts were kept at 4ºC until further use.

Determination of total phenolic content

The total phenolic content (TPC) was determined using modified Folin–Ciocalteu (FC) method (Ainsworth and Gillespie, 2007). The assay mixture was prepared using 0.5 ml of sample solution, 0.5 ml of ethanol, 1ml of FC reagent (1:10), followed by addition of 2 ml 700 mM sodium carbonate (Na_2CO_3). The reaction mixtures were incubated in dark for 45 min at room temperature (30 ±1ºC) and the absorbance was measured in a UV–Vis spectrophotometer (CECIL, CE 7200; Cambridge, England) at 765 nm. The amount of total phenolics was quantified by comparing the standard curve of gallic acid and was expressed as milligram (mg) of gallic acid equivalent (GAE) in per gram (g) of dry sample.

Determination of total flavonoid content

The total flavonoid (TFC) contents were quantified using the method of Chang *et al*., (2002) with modifications. The reaction mixtures were prepared by sequential addition of 0.5 ml of sample, 1.5 ml of 90% ethanol, 0.2 ml 10% aluminum chloride ($AlCl_3$) in ethanol and 0.2 ml 1M potassium acetate. Finally the volume of each reaction mixture was made up to 3 ml by adding distilled water. The reaction mixtures were incubated in dark at room temperature (30 ±1ºC) for 20 min and the absorbance was measured at 415 nm in a spectrophotometer. The amount of total flavonoid was quantified by comparing the standard curve of quercetin and was expressed as mg quercetin equivalent flavonoid (QE) per gram (g) of dry sample.

Estimation of total antioxidant activity

The total antioxidant activity (TAA) of the extracts was determined by the phospho-molybdenum method adopting the procedure of Prieto *et al*., (1999). The assay mixtures were prepared by addition of 3ml reagent solution (0.6M sulfuric acid, 28mM sodium phosphate and 4mM ammonium molybdate) and 1 ml sample extract. The assay mixtures were incubated in a water bath at 90 ±1ºC for 90 min, cooled down to room temperature and the absorbance was recorded at 695 nm in a spectrophotometer. The TAA was estimated by comparing ascorbic acid as standard and expressed as mg ascorbic acid equivalent (AAE) per gram (g) of dry sample.

Statistical analysis

All analyses are done in triplicate, and the average value is presented in table 1 and 2. In order to determine the association between TPC-TAA and TFC-TAA (recorded at maximum level mostly), correlation analysis has been performed. Test of significance (t-test analysis) is also made to assess significant variation, if any, between mean values in a species as well as between species for maximum level of TAA.

RESULT AND DISCUSSION

Total phenolic (TPC) and flavonoid (TFC) contents, and total antioxidant activity (TAA) are represented in table 1 (aqueous extracts) and table 2 (ethanolic extracts) of *P. foetida*, and *S. stricta*.

Aqueous extraction of *P. foetida*

TPC ranges from 3.60 ± 0.36 mg GAE/g (temperature 30ºC, time 10 min) to 4.71 ± 0.25 mg GAE/g (temperature 50ºC, time 30 min); while TFC varies from 0.36 ± 0.74 mg QE/g (30ºC, 10 min) to 4.95 ± 0.29 mg QE/g (50ºC, 30 min). TAA also represents the similar trend with an activity ranging from 5.01 ± 0.85 mg AAE/g (30ºC, 10 min) to 10.8 ± 0.53 mg AAE/g (50ºC, 30 min). The result indicates

that all three parameters in the study increase with an increase of extraction time. However, the trend is not similar with increasing temperature. Maximum amount (TPC and TFC) and activity (TAA) have been recorded at 50ºC; 30 min. The decreasing antioxidant activity at 80ºC and 100ºC in *P. foetida* may be due to degradation or inactivation of phenolics at higher temperature. Temperature treatment above 70ºC during extraction has shown substantial degradation of phenolics like anthocyanin (Havlikova and Mikova, 1985).

In *P. foetida*, significant correlation is found between TPC and TAA ($r = 0.979$, 2df, $P<0.05$) as well as between TFC and TAA ($r = 0.987$, 2df, $P<0.05$) at 50ºC for 30 min. Correlation analyses signify that both phenolics and flavonoids are interrelated with high antioxidant activity.

Aqueous extraction of *S. stricta*

TPC ranges from 1.41 ± 0.19 mg GAE/g (30ºC, 10 min) to 4.70 ± 0.24 mg GAE/g (100ºC, 30 min); while, TFC varies from 0.23±0.81 mg QE/g (30ºC, 10 min) to 1.58 ± 0.31 mg QE/g (100ºC, 30 min). TAA is estimated to be minimum at 30ºC, 10 min (2.17 ± 0.36 mg AAE/g) and maximum at 50ºC, 30 min (6.45 ± 0.29 mg AAE/g). Result also shows that the amount and activity of the observed parameters increase with an increase in temperature. Unlike *P. foetida*, *S. stricta* shows a higher TPC and TFC at 100ºC with 30 min extraction time. The maximum TAA observed in *S. stricta* is at 50ºC, 30 min, corresponding to *P. foetida*.

Correlation analyses (100ºC, 30 min) show a positive and significant relationship between TPC and TAA ($r = 0.999$, 2df, $P<0.05$) but such association is not found between TFC and TAA ($r = 0.863$, 2df, $P>0.05$). It reflects that flavonoid content is not showing maximum antioxidant capacity. It may be due to the inactivation or modification of flavonoids at very high temperature.

Ethanolic extraction of *P. foetida*

The components under study show a gradual increase with an increase in extraction time. TPC ranges from 2.24 ± 0.27 mg GAE/g (concentration 90%, time 30 min) to 4.71 ± 0.31 mg GAE/g (70%, 90min); while, TFC varies between 1.43 ±0.61 mg QE/g (90%, 30 min) and 4.50 ± 0.40 mg QE/g (70%, 90 min). Minimum TAA value is recorded at 90% concentration, 30 min (6.51 ± 0.38 mg AAE/g) and maximum at 50%, 30 min (11.2 ± 0.38 mg AAE/g). The interrelationship between TPC and TAA ($r = 0.899$, 2df, $P>0.05$) and TFC and TAA ($r = 0.918$, 2df, $P>0.05$) is non-significant (recorded at -70%, 90 min).

Ethanolic extraction of *S. stricta*

TPC ranges from 2.20 ± 0.17 mg GAE/g (90%, 30 min) to 4.63 ± 0.18 mg GAE/g (50%, 90 min); while TFC varies from 0.76 ± 0.28 mg QE/g (70%, 30 min) to 1.94 ± 0.19 mg QE/g (50%, 90 min). TAA value has been recorded minimum in 90%, 30 min (5.74 ± 0.47 mg AAE/g) and maximum at 50%, 90 min (9.92 ± 0.41 mg AAE/g) corroborating with that of TPC and TFC. Correlation analyses (50%, 90 min) reveal a positive and significant interrelationship between TPC and TAA ($r = 0.997$, 2df, $P<0.05$) and TFC and TAA ($r = 0.981$, 2df, $P<0.05$).

Test of significance (t-test) analysis:

The t-test analyses reveal significant variation in TAA ($t=12.424$, 4df, $P<0.001$- *P. foetida*; $t= 3.99$ 4df, $P<0.001$- *S. stricta*) between species irrespective of aqueous (50ºC, 30 min) and ethanolic (50%, 90 min) extraction method. In *P. foetida*, TAA activity is random ($t= 1.34$, 4df, $P>0.05$) between extractions; while, non-randomness has been studied ($t= 11.980$, 4df, $P<0.001$) for *S. stricta*. The test also suggests that TAA varied at maximum level between solvents (aqueous – $t = 6.790$, df 4, $P<0.001$; ethanolic – $t= 7.789$, df 4, $P<0.001$). The results also reflect that TAA is higher in *P. foetida* than *S. stricta*, and the efficiency of extraction is better in ethanol than water.

Table 1. Effect of temperature and time on total phenolic content, total flavonoid content and total antioxidant activity of aqueous extracts from *P. foetida*, and *S. stricta*.

Temperature (°C)	Attributes	***Paederia foetida***			***Spermacoce stricta***		
		Extraction Time (min)			Extraction Time(min)		
		10	20	30	10	20	30
30	TPC	3.60± 0.36	3.74± 0.43	3.94± 0.21	1.41± 0.19	2.48± 0.36	2.53± 0.09
	TFC	0.36± 0.74	0.45± 0.89	0.76± 0.73	0.23± 0.81	0.25± 0.54	0.50± 0.49
	TAA	5.01± 0.80	5.29± 0.73	5.41± 0.66	2.17± 0.36	3.65± 0.49	3.82±0.64
50	TPC	4.31± 0.31	4.43± 0.04	4.71± 0.25	4.09± 0.28	4.17± 0.51	4.35± 0.43
	TFC	3.10± 0.81	4.04± 0.35	4.95± 0.29	0.94± 0.47	1.26± 0.93	1.53± 0.73
	TAA	9.93± 0.54	10.3± 0.68	10.8± 0.53	5.63± 0.52	5.91± 0.34	6.45± 0.29
80	TPC	4.37± 0.42	4.48± 0.11	4.61± 0.37	3.94± 0.11	4.16± 0.26	4.24± 0.34
	TFC	1.73± 0.34	1.99± 0.67	2.41± 0.84	0.54± 0.18	0.58± 0.73	0.77± 0.84
	TAA	9.54± 0.61	9.81± 0.34	9.84± 0.22	4.13± 0.69	4.33± 0.43	4.35± 0.52
100	TPC	4.46± 0.21	4.52± 0.18	4.59± 0.37	4.60± 0.05	4.65± 0.15	4.70± 0.24

TFC	1.51± 0.67	2.17± 0.06	3.29± 0.93	0.89± 1.05	1.16± 0.83	1.58± 0.31
TAA	9.82± 0.49	9.15± 0.47	8.94± 0.64	5.27± 0.27	5.25± 0.54	5.06± 0.21

TPC: Total phenolic content TFC: Total flavonoid content, TAA: Total antioxidant activity
Data are presented as mean± SD (n=3), in mg/g dry sample.

Table 2. Effect of concentration and time on total phenolic content, total flavonoid content and total antioxidant activity of ethanol extracts from *P. foetida*, and *S. stricta*.

Ethanol Concentration (%)	Attributes	***Paederia foetida*** Extraction Time (min)			***Spermacoce stricta*** Extraction Time (min)		
		30	60	90	30	60	90
50	TPC	4.59± 0.07	4.63± 0.14	4.70± 0.13	4.56± 0.54	4.61± 0.26	4.63± 0.18
	TFC	3.30± 0.54	4.28± 0.56	4.45± 0.34	0.92± 0.77	1.74± 0.52	1.94± 0.19
	TAA	9.73± 0.4	10.5± 0.23	11.2± 0.38	7.58± 0.76	8.84± 0.35	9.92± 0.41
70	TPC	4.53± 0.21	4.68±0.08	4.71± 0.31	4.27± 0.48	4.55± 0.33	4.56± 0.1
	TFC	1.67± 0.63	4.11± 0.49	4.50± 0.40	0.76± 0.28	0.90± 0.33	1.86± 0.26
	TAA	6.78± 0.45	7.96± 0.74	8.83± 0.37	6.01± 0.56	8.11± 0.24	9.16± 0.39
90	TPC	2.24± 0.27	3.04± 0.21	3.40± 0.16	2.20± 0.17	2.77± 0.28	3.11± 0.49
	TFC	1.43± 0.61	1.85± 0.42	3.12± 0.08	1.24± 0.82	1.26± 0.43	1.28± 0.21
	TAA	6.51± 0.38	7.19± 0.57	7.93± 0.63	5.74± 0.47	6.20± 0.58	6.69± 0.46

TPC: Total phenolic content TFC: Total flavonoid content, TAA: Total antioxidant activity
Data are presented as mean± SD (n=3), in mg/g dry sample.

CONCLUSION

The total phenolic (TPC) and flavonoid (TFC) content, and antioxidant activity (TAA) of *P. foetida* and *S. stricta* are estimated following aqueous and ethanolic extracts. Aqueous and ethanolic extractions for the study are simple, efficient, cost-effective and safe. Results indicate that the presence of substantial antioxidant activity in both species which show high correlation with phenolic and flavonoid contents. These observations highlight the potential of *P. foetida* and *S. stricta* as source for antioxidant and also signify their role in dietary formulations to defend oxidative stress.

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RESEARCH ARTICLE

EFFECT OF ORGANIC MATTER AND SOIL-MICROBIAL COMMUNITY ON PHYSICAL, CHEMICAL AND BIOLOGICAL PROPERTIES OF SOIL

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Abstract: A field experiment was conducted at Varanasi, Uttar Pradesh during rainy (*kharif*), winter (*rabi*) and summer (*zaid*) season of 2004 and 2005 to find out the effect of various sources (farmyard manure, vermicompost and poultry manure) and rates of organic manures (100%, 125%, 150% RND) on yield, quality and economics of scented rice on a sandy clay-loam soil low in available N and medium in available phosphorus and potassium. Pooled data analysis revealed that the application of organic manure significantly influenced the yield attributes and grain yield of rice over 100% RND as urea (control). Progressive increase in dose of all the organic manures significantly increased the organic matter, soil microbial population, physical, chemical and biological properties of soil.

Keywords: Origin matter, Physical, Chemical, Biological, Soil

INTRODUCTION

The soil was sandy clay loam in texture with pH 7.12, 0.45% organic carbon and 180.5, 18.2 and 202.4 kg/ha available N, P and K, respectively. The experiment was carried out in randomized block design in fixed plots lay out replicated with 10 treatment combinations involving 3 sources of organic manures, viz. farmyard manure, vermicompost and poultry manure adopting 3 different rates i.e. 100, 125 and 150% of recommended nitrogen dose and 100% recommended nitrogen dose through urea (control).

The organic manures were applied as per their nutrient content on oven dry weight basis. The farmyard manure, vermicompost and poultry manure contained 0.50, 2.30 and 2.80% N, 0.20, 0.75 and 2.20% P_2O_5 and 0.50, 1.23 and 1.30% K_2O, respectively.

Organic manures were applied as per treatment at sowing and mixed thoroughly in 15cm top soil layer. In control treatment, recommended nitrogen dose through urea was drilled 10 cm deep and 5 cm away from the seed or seedling.

The Pusa Sugandha-3 scented rice was transplanted at 20×10cm. Early Apoorva of tablepea and Pusa red varieties of onion were sown/transplanted at the spacing of 30x10 cm and 30x10 cm, respectively.

Soil organic matter

The second major component of soil is organic matter produced by different soil organisms. The total organic matter in the soil, except identifiable undecomposed or partially-decomposed biomass, is called humus. This solid, dark-coloured component of the soil plays a significant role in the control of soil fertility, in the cycling of nutrients and in the detoxification of hazardous compounds. Humus consists of biological molecules such as proteins and carbohydrates as well as the humic substances (polymeric compounds produced through microbial action that differ from metabolically active compounds).

The processes by which humus is formed are not understood fully, but there is an agreement that four stages of development occur in the transformation of soil biomass into humus : (i) decomposition of biomass into simple organic compounds (ii) metabolization of the simple compounds by microbes; (iii) cycling of carbon, hydrogen, nitrogen and oxygen between organic matter of the soil and the microbial biomass and (iv) microbe-mediate polymerization of the cycled organic compounds. The investigation of molecular structure in humic substances is of special interest in current research. Although it is not possible to describe the exact molecular configuration of humic substances, these molecules essentially contain hydrogen ions dissociate in fresh water to form molecules bearing a net negative charge.

Much of the molecular framework of soil-organic matter, however is not electrically charged. The uncharged portions of humic substances can react with synthetic organic compounds such as pesticides, fertilizers, soild and liquid waste materials and their degradation products. Humus, either as separate solid phase or as a coating on mineral surfaces, can immobilize these compounds or in some instances detoxify them significantly.

Soil organic matter virtually runs the life processes in the soil and is taken as the indicator of soil health and fertility. Organic C content of the soil varies widely,

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depending on the nature of soil, prevailing weather (temperature and water) and plant geography. In general, temperate soils have higher organic C (1.2-2.5%) than the tropical or subtropical soil (0.5-0.6%). However, it is not easy to increase the organic C content in the subtropical environment of Indo-Gangetic plains. Long-term fertility experiments in this region of India have indicated that green manuring improves the organic C status and thereby increases the use and efficiency of applied N, P and K, but the prevailing weather parameters (moisture and temperature) hinder the accumulation of high soil organic C for long period (Yadav and Prasad, 1992; Nambiar, 1994; Singh *et al*., 1994; Abrol *et al*., 1997).

The availability and quality of organic C play the key role in the soil health, which in turn plays the crucial role in crop productivity. The organic C component may be divided into three broad categories: (i) that contributed by plants during root growth; (ii) humus-reserved organic C in soil in terms of left-over plant residues over time and microbial biomass and (iii) the added organic materials in the soils in terms of plant residues and organic manures.

Soil-microbial Community

Biological environment of fertile soils is teeming with life on all size scales, from microfauna (with body widths less than 0.1 mm) to mesofauna (upto 2mm) and macrofauna (upto 20 mm). The most numerous soil organisms are the unicellular microfauna. It has been estimated that 1 kg soil may contain 500 billion bacteria, 10 billion actinomycetes (filamentous bacteria) and nearly 1 billion fungi besides the members from animal kingdom. The microbial community (Table-1) plays a decisive role in the sustenance of crop productivity, as many of them have evolved along with and have established a mutalistic/symbiotic relationship over the years, helping plants to increase their fitness and adaptability in diverse ecosystems (Subba Rao, 1986). Mining and gainful employment of these micro-organisms in crop production systems will shape the agriculture of this century, and this may be termed as 'The century of microbes'. The well-being of humans will surely rest on them. In general, these microbes are heterotrophs and fulfil their energy requirements from plant source. The bulk of these microbes are saprophytes and their proliferation needs adequate supply of organic matter in the soil.

The soil flora and fauna play an important role in soil development. Micro-biological activity in the root zone is important to soil acidity and for nutrient cycling. Soil particles and pore spaces provide micro-niches for the action of micro-ogranisims responsible for carbon and nitrogen cycling. Soil humus provides the nutrient reservoirs, and soil biomass provides the chemical pathways for cycling (Subba Rao, 1986; Lynch, 1990). With the active involvement of micro-organisms, the carbon in dead biomass is converted to CO_2 under aerobic condition and to organic acids or alcohols in anaerobic conditions. Under highly anaerobic conditions, methane (CH_4) is formed. The production of methane in rice ecosystem is a recognised contributor to global warming. The CO_2 produced can be used by photosynthetic micro-organisms or by higher plants to create new biomass and thus initiate the carbon cycle again.

The most common soil bacteria come under the genera Pseudomonas, Bacillus, *Clostridium, Arthobacter, Flavocabterium, Chromobacterium, Sarcina, Mycobacterium, Achromobater* etc. However in the ecological niche of rhizosphere the dominant bacterial genera are : *Pseudomonas, Bacillus, Clostridium, Arthobacter, Flavobacterium, Chromobacterium, Sarcina, Mycobacterium, Achromobater* etc. Amino acid-requiring bacteria dominate in this niche. Thus the composition of bacteria around rhizosphere is infuluenced by the crop plant in question, soil amendments, rhizo-ceposition (influenced by foliar application of agrochemicals) and artificial introduction of other microorganisms. For soil health and fertility, abundance of N_{2-} fixing bacteria has greater significances.

N_2 – fixers

Beijerinck was the first to isolate N_2- fixing bacteria from root nodules in 1888, and by 1895 Nobbe and Hiltner produced the first laboratory culture of *Rhizobia* under the trade name Nitragin. The systematic study of biofertilizers in India was started in 1920 by N.V. Joshi. The work of De (1939) introduced the blue-green algae for N_2 fixation in the rice ecosystem. Since then a lot of progress has been made in this direction and presently biofertilizer-producing industries have come up to meet the growing need.

The N_2- fixing bacteria may be broadly classified into two groups-free living and symbiotic. In the symbiotic nature N_2 fixation is assured, and much work in this direction has been carried out on *Rhizobium*. These bacteria live freely in the soil and in the rhizosphere of both leguminous and non-leguminous plants, but can have symbiotic association only with leguminous plants by forming nodules in the root. However, the origin of leguminous plants and the evolution of bacterial symbiosis have still remained speculative. Of late association of *Rhizobium* with plants other than those from Leguminoceae, as an endophyte has opened-up new arena of research to harness benefit from such associations.

It has been shown by various workers that in the soil with low N status, plant encourages nodulation, whereas in soil having adequate N availability or foliar feeding of urea, nodulation gets affected. One has to strike a balance between fertilizer application

and use of N_2- fixing bacteria without compromising the productivity and profitability of the system.

The free-living forms like *Azotobacter*, *Clostridium* etc. provide enough opportunity for their gainful employment in this regard. Moreover, these bacteria produce growth hormones and other plant growth-promoting substances and also guard against several pathogens through antibiosis. However, due to their free-living nature, they require adequate supply of organic matter in the soil for their proliferation and realisation of benefit. The population of *Azotobacter* in rhizosphere of crop plants and in uncultivated soil is generally low. Many a times inoculation of soil does not yield the desired result, and therefore repeated applications have to be made to improve their population.

Recently the role of endophytic acetic acid bacteria in plant health has come in prominence. These bacteria like *Gluconacetobacter* reside in plant (sugarcane) as an endophyte and help not only N_2 fixation but also in growth promotion and plant defence (Suman *et al*., 2005).

The blue-green algae (*Cyanobacteria*) are another group of atmospheric N_2- fixers that help in the N economy in the various crop-production systems. Rice ecosystem provides a congenial environment for the growth of N_2-fixing blue-green algae. Moreover, they also produce several growth promoting substances that also help to boost up the growth of rice plant. Some blue-green algae also exist in association with other organisms. The association of *Anabaena* with the aquatic tern *Azolla* is of special significance in rice system. The blue-green algae, *Anabaena azollae* fixes atmospheric N_2. The advantage of *Azolla* lies in its fast multiplication and its higher green-compost yield than the green-mauring crops like *dhaincha* and sunnhemp.

Phosphnate and sulphate solubilizers

Solubilization of phosphates by micro-organisms depends on the soil pH. In neutral and alkaline soils having high content of Ca, precipitation of calcium phosphates take place. Micro-organisms readily dissolve such phosphates and make these available to the root. On the contrary, acid soils are generally poor in Ca and the phosphates get precipitated as the compound of Fe or Al, which are not easily mineralized by the soil microflora. Many bacteria (*Bacillus, Pseudomonas*) and fungi (*Aspergillus, Penicillium*) actively take part in the process of solubilization of soil P (Gaur, 1985).

These micro-organisms, which actively help in P solubilization and increase the availability of P to roots, modify their activities when P is easily available through the application of fertilizer P. Therefore to utilize full potential of P solubilizers, P application through fertilizers should be avoided. Increasing response to P application over the years indicates a decreasing availability of P through the microbial route. This microbial mining needs to be strengthened to reduce the burden of fertilizer P application.

Mycorrhiza is a symbiotic fungus-root association, which increases the P-gathering capacity of plant roots from the soil. Frank (1885) was the first to notice such an association in forest trees. Today it has been realised that mycorrhiza is of very common occurrence in plants, and it is estimated that 90% of terrestrial plants have such associations. There are two kinds of mycorriza, viz. ecto and endo-mycorrhiza. In the ecto-type the fungus forms a mantle of hyphae around the root; only a few haustoria go inside the root cortex for food. This type of mycorrhiza is prevalent with trees and, in general, trees growing in mountainous region have such an association (Brundrett, 2002). In the other type, i.e. endo-mycorrhiza, the fungus enters the cells and forms vesicle-arbuscule; and hence it is termed as vesicular arbuscular mycorrhiza (VAM). The nutrition benefit to the host plants arising from mycorrhiza has received considerable attention due to their positive influence in the uptake of P. The fungal hyphae increase the absoring surface for P and ensure prolonged supply, because the root epidermis behind the root hairs has limited capability of P uptake due to the absence of the critical enzyme. Limitation of mature root portion in P uptake has led to increase in P availability through symbiotic association with fungi (mycorrhiza) and in P-deficient soil this has become the norm. The other advantage of the mycorrhiza is the barking effect; they deter several pathogenic fungi and bacteria by blocking their access to root directly and indirectly through antibiosis (Brundrett, 2002; Jones *et al.* 2004).

The inorganic component of the soil S is in the form of SO_4^{-2}, which constitutes only a minor-portion of the total S content in the soil. The bulk of soil S comes from organic matters in the form of S-containing amino acids and vitamins. Micro-organism play a major role in the process of mineralization of sulphates and their availability to roots.

Soil physical parameters viz. bulk density and water stable aggregates did not showed any profound effect due to addition of organic materials (Table-1). The values of chemical properties of soil like organic carbon, available N, P and K increased significantly from initial stage and over control treatment on the completion of 2- year's cycle of rice-table pea-onion sequence. The maximum organic carbon build up was accrued (0.54%) when 150% recommended nitrogen dose was supplied through poultry manure (T_9) while the least value (0.40%) was noticed with the 100% recommended nitrogen dose through urea (T_{10}). The organic carbon of the soil increased over its initial status (0.38%) under nitrogen supply through organic sources. The nutrient status of the experimental site was also affected significantly by the application of different organic manures along

with their varying rates. Results clearly indicated improved fertility status of soil due to increased values of available N, P and K in all organic treatments over its initial value as well as control. Application of organic manures with increased rate enhanced soil fertility over their lower doses. At the end of 2-year cycle, 150% recommended nitrogen dose applied as poultry manure maintained higher values of organic carbon and available N, P and K. Next best treatments in this respect were also found when poultry manure applied with reduced rates of 125% and 100% recommended nitrogen dose, respectively. Continuous application of organic manures in sufficient quantities have been reported to improve the soil organic carbon and available N, P and K in soil thereby sustaining the soil health (Tiwari *et al*. 2002).

Soil biological properties showed improvement in the soil microbial counts over its initial values at the end of 2-years cropping sequence due to supplementation of organic sources. Poultry manure applied @ 150% recommended nitrogen dose was best which lead into higher counts of bacteria (82.45×10^3), fungi (37.82×10^3) and actinomycetes (58.23×10^3) closely followed by the treatments where poultry manure was applied with reduced rates (T_8 & T_7), respectively. The control treatment (T_{10}) had relatively lower values of soil microbial count than the organic treatments. The favourable effect of organics on soil biological properties is a proven fact which helped in providing ideal conditions and presumably increased the microbial activity because of the available high organic matter. Hati *et al.* (2001) and Shanmei *et al.* (2002) also reported favourable effect of organic manures on soil biological properties. These results are in conformity with the findings of Bohra (2005).

Table 1. Effect of organic matter and soil-microbial community on physical, chemical and biological properties of soil at the end of two years cycle of rice-tablepea-onion cropping sequence.

Treatments	Bulk density	Porosity	Water stable aggregates	Organic carbon	N	P	K	Viable count (cfu/g)		
								Bacteria ($x10^3$)	Fungi ($x10^3$)	Actinomycetes ($x10^3$)
T_1 - 100% RND as FYM	1.36	40.32	18.01	0.44	184.34	24.43	154.41	62.82	22.50	33.73
T_2 - 125% RND as FYM	1.37	40.38	18.18	0.45	185.46	24.61	154.87	63.63	23.03	34.74
T_3 -150% RND as FYM	1.39	41.34	18.20	0.46	186.72	25.44	155.44	66.92	24.00	35.43
T_4 -100% RND as VM	1.38	40.30	18.01	0.47	187.73	26.52	157.42	72.34	25.31	36.25
T_5 -125% RND as VM	1.40	40.36	18.20	0.48	189.44	27.82	158.84	77.94	27.94	37.44
T_6 -150% RND as VM	1.41	41.18	18.50	0.49	189.95	28.00	160.42	78.65	28.63	43.18
T_7 - 100% RND as PM	1.39	40.20	18.04	0.50	190.44	28.42	161.72	79.54	29.45	46.94
T_8-125% RND as PM	1.41	40.22	18.32	0.52	191.43	28.84	162.43	80.44	32.11	54.46
T_9 -150% RND as PM	1.42	40.95	18.65	0.54	192.98	29.43	164.12	82.45	37.82	58.23
T_{10} - 100% RND as urea	1.35	40.02	18.00	0.40	178.95	22.44	152.44	41.85	11.49	33.44
Initial	1.35	40.00	18.00	0.38	178,43	22.41	151.24	41.45	11.25	32.41
SEm ±	0.11	0.29	0.23	0.04	3.29	0.19	3.01	-	-	-
C.D. (0.05)	0.33	0.86	0.68	0.12	9.78	0.56	8.94	-	-	-

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RESEARCH ARTICLE

STUDIES ON AERIAL BLIGHT OF SOYBEAN CAUSED BY *RHIZOCTONIA SOLANI*

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Abstrct: Soybean aerial blight caused by *Rhizoctonia solani* is a most important oilseed disease. This disease is destructive and causes heavy losses in the yield particularly in warn and humid parts of the countries. The use of resistant varieties is the cheapest, easiest, safest and most effective method to manage the aerial blight disease. Forty-two entries screened for resistant to aerial blight of soybean, 2 entries (SL 752 and RKS 48) were found absolutely resistant and 6 entries were highly resistant. Soybean crop sown at 29th July showed least disease severity (11.04%) in comparison to 21st June, 9th July and 19th July sowing. Losses assessment study revealed that maximum percent reduction in seed weight, plant height, pods and branches were recorded in 9 score plants (more than 50% leaf area infected) i.e., 55.55%, 40.90%, 71.42%, and 72% respectively. Maximum aerial blight intensity was recorded in the crop sown in flooded field.

Keywords: Aerial blight of soybean, *Rhizoctonia solani*, Screening of soybean varieties, Web blight

INTRODUCTION

Soybean (*Glycine max* (L.) Merrill) is one of the most important oil seed crop of India .It was wonder of the twentinth century. Soybean rank first among world oilseed with an annual production of about 105 mt. Among the different growing countries of the world, USA, China, Brazil, Argentina and India are main which accounts more than 90% of the world's acreage (Taware *et al.*, 2007). Soybean (*Glycine max* (L.) Merill.) a grain legume is widely crop due to its high quality protein (40%) and edible oil (20%). Aerial blight caused by *Rhizoctonia solani* is one of the most soil borne diseases of soybean particularly in the northern zone comprising the states of Haryana, Punjab, Uttar Pradesh and Uttarkhand. Soybean is mainly grown during Kharif season in sandy loam to clay loam soil in Chhattisgarh. In Chhattisgarh, area, production and productivity of soybean are 0.82 m ha, 0.73 mt and 891 kg/ha, respectively which are much lower than national average (Anonymous, 2006b). The disease appears July-August and is characterized by sudden and complete death of the plants. This disease is considered to be one of the most destructive and causes heavy losses in the yield particularly in warn and humid parts of the countries (Anwar *et al*., 1995). Yield losses can exceed 35-60 per cent and the disease is considered as economically important (Patel *et al.*, 1998). The use of resistant varieties is the cheapest, easiest, safest and most effective method to manage the aerial blight disease. Few tolerant cultivars were reported against aerial blight disease (Thind,1998 and Palat *et al.*, 2004). In same context, an attempt was made through this investigation, to "Studies on aerial blight of soybean caused by *Rhizoctonia solani* Kühn*"*.

MATERIAL AND MATHOD

Symptomatology

Disease samples were collected from naturally infected soybean plants, just after initiation of disease and at different development stages. Collected samples were brought to the laboratory for critical examination of symptoms produced using simple microscope.

Evaluation of different entries against *Rhizoctonia solani* under field condition.

The experiment was conducted to evaluate the soybean entries against *Rhizoctonia solani*. Three row of each entries were grown in 5 m length in alternate with susceptible check viz., Bragg and JS 335 on dated 13/7/07 at National Seed Project Research Farm, IGAU, Raipur. Recommended agronomic practices were adopted. For recording observation on aerial blight, 10 plants per cultivar randomly selected and tagged. Visual observations on aerial blight intensity were recorded on the bottom, middle and top trifoliate. Numerical grades were assigned to the amount of disease observed applying 0-9 disease rating scale and per cent disease intensity/index (PDI) was computed applying the formula (Anonymous, 2006-07) as given below.

$$PDI = \frac{\text{Summation of individual rating}}{\text{No. of leaves examined} \times \text{Maximum ratings}} \times 100$$

*Corresponding Author

Uniform method of disease rating

Rating (0-9)	Description	Reaction
0	No lesion/spots	Absolutely resistant
1	1% leaf area covered with lesion/spots	Highly resistant
3	1.1-10% leaf area covered with lesion/spots, no. spots on stem	Moderately resistant
5	10.1-25% of the leaf area covered, no defoliation, little damage	Moderately susceptible
7	25.1-50% leaf area covered, some leaves drop, death of a few plants, damage conspicuous	Susceptible
9	More than 50% area covered, lesion/spots very common on all plants, defoliation common, death of plants common, damage more than 50%	Highly susceptible

Effect of date of sowing on disease severity of aerial blight of soybean under field condition

The experiment was conducted to find out the effect of date of sowing on severity of *Rhizoctonia* aerial blight. Five soybean cultivars i.e. JS-9305, JS-335, JS-9, Bragg and NRC-37 were sown at four dates i.e. 21st Jun, 9th July, 19th July and 29th July in the year 2007 at National Seed Project Research Farm, IGAU, Raipur. Plot size was 1.5×5m. Recommended agronomic practices were adopted for cultivation of soybean crop. For recording observation on aerial blight, 10 plants per cultivar randomly selected and tagged. Visual observations on aerial blight severity were recorded at grain formation stage of the crops. Numerical grades were assigned to the amount of disease observed applying 0-9 disease rating scale and per cent disease intensity/index (PDI) was computed applying the formula (Anonymous, 2006-07).

$$PDI = \frac{\text{Summation of individual rating}}{\text{No. of leaves examined} \times \text{Maximum ratings}} \times 100$$

Assessment of the losses due to aerial blight disease on soybean

Naturally aerial blight infected one acre field, variety JS 335 was selected to asses the losses at National Seed Project Research farm, IGAU, Raipur. The crop was at flowering stage. Field were equally divided in three parts and treated as replication. In each part of the field diseased plants were randomly selected, tagged and grouped in the categories described by Directorate of oilseed Research, Hyderabad as absolutely resistant (healthy), highly resistant, moderately resistant, moderately susceptible, susceptible and highly susceptible. In each category five plants were tagged for assessment of losses and observed for seed weight, plant height, number of pods and number of branches. Percent reduction was calculated by adopting the following formula.

$$\% \text{ reduction} = \frac{\text{Healthy} - \text{Infected}}{\text{Healthy}} \times 100$$

Uniform method of disease rating

Rating (0-9)	Description	Reaction
0	No lesion/spots (healthy)	Absolutely resistant
1	1% leaf area covered with lesion/spots	Highly resistant
3	1.1-10% leaf area covered with lesion/spots, no spots on stem	Moderately resistant
5	10.1-25% of the leaf area covered, no defoliation, little damage	Moderately susceptible
7	25.1-50% leaf area covered, some leaves drop, death of a few plants, damage conspicuous	Susceptible
9	More than 50% area covered, lesion/spots very common on all plants, defoliation common, death of plants common, damage more than 50%	Highly susceptible

RESULT AND DISCUSSION

Symptomatology

Leaves, stem, pods and petiole were infected with the disease. Initial symptoms were observed on the lower leaves touching to the ground. Infected leaves were water soaked brown to reddish brown and later on leaves become tan to black. Slowly and slowly complete leaves become blighted. Tissue in the centre of spot fallout giving the plant a ragged appearance. Dropping of leaves were also observed and some of the leaves were adhere with stem, petiole and pods. Brownish lesion was also observed on stem and pods. Some of the pods were completely blighted.Web like mycelial growth of the fungus was observed on leaves and petioles along with dark brown sclerotia in flood affected field of soybean variety JS 335 at flowering and poding stage.Two type of sclerotia i.e., micro sclerotia and macro sclerotia were observed on infected leaves and petioles.

Similar symptoms of aerial blight were also observed by Happerly *et al*. (1982), Sinclair (1982), Mukhopadhyay and Sing (1984) and Thapliyal and Dubey (1987). They reported that leaves, stem, pods and petiole were infected with the disease. Infected leaves were water soaked brown to reddish brown and later on leaves become tan to black and slowly and slowly leaves become blighted completely. Brownish lesion was also observed on stem, petiole and pods. Some of the pods were completely blighted. Web like mycelial growth of the fungus was formed on leaves and petioles along with dark brown sclerotia at flowering and poding stage.

Evaluation of different entries against *Rhizoctonia solani* under field condition

Forty-two soybean entries were evaluated under natural field condition for resistant to aerial blight of soybean. Observations were recorded at grain formation stage and data are presented in Table 1, indicated that 2 entries (SL 752 and RKS 48) to be free from disease or absolutely resistant, 6 entries were highly resistant, 21 entries were moderately resistant, 13 entries were moderately susceptible and none of the entries exhibited susceptible and highly susceptible reaction. Palat *et al*. (2004) also screened soybean germplasm for their resistance to web blight. They observed 8 cultivars free from the disease, 11 cultivars as resistant and 9 cultivars as moderately resistant. The remaining cultivars categorized in moderately susceptible (6 cultivars), susceptible (9 cultivars) or highly susceptible (6 cultivars), groups. At Pantnagar out of 35, 15 soybean entries were also observed as highly resistant to Rhizoctonia aerial blight during study of performance of previous year resistant entries (Anonymous, 2007).

Effect of date of sowing on disease severity of *Rhizoctonia solani* on soybean under field condition

The results indicated that (Table 2) aerial blight intensity was found to differ with respect to sowing dates. Average aerial blight severity observed at grain formation stage ranged from 0.72 to 56.67% in the crops sown at different dates. However minimum aerial blight severity was recorded in the crop sown at 29th July (11.04%) and maximum aerial blight severity was recorded in the crop sown at 21st June (45.45%). As regards varietals response to aerial blight severity, JS-9 exhibited minimum disease severity in the range of 0.72 to 49.40% at grain formation stage. Thus, from the result, it is revealed that soybean crop sown at 29th July showed least disease severity in comparison to the crop sown at 21st June, 9th July and 19th July. Further, among the varieties JS-9 showed least disease severity in comparison to Bragg, JS-335, NRC-37 and JS-9305. Similar results were also reported by Teo *et al*. (1988). They reported that early sowing or seeding resulted significantly increased seedling infection and disease severity in comparison to late sowing.

Assessment of the losses due to aerial blight of soybean

The data presented in Table 3. It is clear from the data that the per cent reduction in seed weight, plant height, pods and branches differs with respect to different categories of infected plants. The percent reduction in seed weight was ranged from 5.55 to 55.55%. The per cent reduction in plant height was ranged from 4.54 to 40.90%. The per cent reduction in pods was ranged from 7.14 to 71.42%. The per cent reduction in branches was ranged from 8 to 72%. The maximum per cent reduction in seed weight, plant height, pods and branches were recorded in 9 score plants (more than 50% leaf area infected) i.e., 55.55%, 40.90%, 71.42%, and 72% respectively followed by 7 score plants i.e., 44.44%, 36.36%, 64.28% and 64%. The minimum per cent reduction in seed weight, plant height, pods and branches were recorded in 01 score plants (1% leaf area infected) i.e., 5.55%, 4.54%, and 7.14% and 8% in comparison to healthy plants. Stetina *et al.* (2006) also assessed disease severity and yield losses in moderately resistant cultivars of soybean in field plots using foliar and pod ratings (0-10 scale corresponding to 0-100% of tissue affected)

Table 1. Evaluation of different entries against *Rhizoctonia solani* under field condition

Reaction	Number of entries	Entries
Absolutely resistant	2	SL 752 and RKS 48
Highly resistant	6	Nso 11, Dsb 12, Himso 1608, JS 20-06, SL-744 and RKS 45
Moderately resistant	21	LSB 23, JS 20-01, MACS 1126, PS 4221, MAUS 285, DS 2410, NSO 78, AMS 4-4, PS 1433, NRC 78, Himso 1609, TS 94, NRC 77, SL 79, VLS 69, TS 56, VLS 68, MACS 1149, Bragg, RAUS 5 and JS 335
Moderately susceptible	13	JS (SH) 2001-04, VLS 70, DSb 10, PS 1437, NSO 111, KDS 167-9, MACS 1148, AMS 4-63, RCS-9, NRC-76, RKS 45, JS 20-09 and RCS 1
Susceptible	0	-
Highly susceptible	0	-

Table 2. Effect of date of sowing on disease severity of aerial blight of soybean under field condition

Date of sowing	PDI at grain formation stage					
	JS 9305	JS-335	JS-9	Bragg	NRC-37	Average
D 1 21.06.07	51.30	45.92	49.40	34.12	46.53	45.45
D 2 09.07.07	43.89	46.37	24.37	50.65	56.67	44.39
D 3 19.07.07	18.07	7.26	0.72	16.08	29.96	14.40
D 4 29.07.07	32.29	2.20	18.94	0.77	1.04	11.04
Mean PDI	36.38	25.43	23.35	25.40	33.55	

Table 3. Assessment of the losses due to aerial blight of soybean

Rating	Description	Seed weight (gm)*	Reduction (%)	Plant height (cm)*	Reduction (%)	Pods (no.)*	Reduction (%)	Branch (no.)*	Reduction (%)
0	No lesion/spots	90	0.00	110	0.00	140	0.00	25	0
1	1% leaf area covered with lesion/spots	85	5.55	105	4.54	130	7.14	23	8
3	1.1-10% leaf area covered with lesion/spots, no spotson stem	75	16.66	95	13.63	100	28.57	20	20
5	10.1-25% of the leaf area covered, no defoliation, little damage	60	33.33	80	27.27	60	57.14	10	60
7	25.1-50% leaf area covered, some leaves drop, death of a few plants, damage conspicuous	50	44.44	70	36.36	50	64.28	9	64
9	More than 50% area	40	55.55	65	40.90	40	71.42	7	72

	covered, lesion/spots very common on all plants, defoliation common, death of plants common, damage more than 50%								
	Sem±	2.88		3.53		2.88		1	
	CD (5%)	8.9		11		8.9		3.1	

* Means of three replication

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RESEARCH ARTICLE

STUDY ON COSTS AND RETURNS OF PADDY PRODUCTION IN MEERUT DISTRICT OF WESTERN UTTAR PRADESH

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Abstract: The present study was conducted during 2011-12 on costs and returns of paddy production. It was found that cost of cultivation has increased due to increase the cost of productive resources. The share of variable and fixed cost to total cost was 55.54 and 8.11 percent, rental value of land was to be 27.00 per cent and 9.09 per cent was the managerial cost to the total cost. The overall profit margin was only Rs. 255.50 per quintal. The benefit cost ration was found to be highest for the large farmer followed by small.

Keywords: Paddy production, Coats, Meerut district

INTRODUCTION

Paddy is a choice crop of the millions of poor and small farmers not only for income but also for household food security. Global food demand is rising because of population growth, increasing affluence and changing dietary habits. The FAO forecasted the global food production will need to increase over 40% by 2030 and 70% by 2050 (FAO, 2009). Green revolution was initiated during the mid-sixties, the adoption of new dwarf high yielding variety of wheat and Rice resulted the food production increased manifold, which transformed the status from food deficit to a net food surplus country. Paddy is one of the most important cereal crops and India is second largest producer of paddy next to china. The area under paddy cultivation has increased from 30.81 (1950- 1951) to 42.56 million hectare (2010-2011) and production from 20.58 to 95.33 million tonnes and the productivity increased by 668 to 2240 kilogram per hectare in the reported period. Rice along with wheat forms the bedrock of Indian food security and to meet the country's stated goal of ensuring food for all.

Paddy is an intensive input utilization crop varies from the region to region and farmer to farmers Under changing climatic conditions, water is anticipated to become scarce and increasing competition for land, putting added pressure on agricultural production. Rapidly increase input price, poor infrastructure facilities, declining the size of holding, with low marketable surplus, cost of production is increasing and adversely affecting the margin of the cultivars. Therefore, it is required to produce more output from scarce resources in cost effective manner. Keeping in view the above discussion and importance present study is an attempt on economic analysis of paddy production with the objective of its costs and returns as per cost concept of commission for agricultural costs and prices.

METHODOLOGY

Meerut district of Western Uttar Pradesh occupy an important place in area and production and productivity of paddy. Therefore, Meerut district was selected purposively for the present investigation. Out of 12 community blocks, two blocks were selected purposively on the basis of highest area and production under paddy cultivation. A complete list of all the villages of the each selected block was prepared with the help of block officials and arranged in alphabetical order. From each selected block, two villages and a total of four villages were selected randomly for the selection of the respondents.

A list of all the farmers of each of selected villages was obtained from gram pradhan of the respective villages, and the information on their land holding possess by each category of farmers were procure from the record of village revenue officer and tehsil head quarter. All the farmers were then categorised into four size groups i.e. marginal (less than one hectare), small (1 to 2 hectare), medium (2 to 4 hectares) and large category (more than 4 hectares). From the list of the farmers 25 respondents from each village and a total of 100 were selected in probability proportion to their population for the collection of data.

The primary information's were collected by personal interview method with the help of pre-tested and well-structured survey schedules, The information related to expenditure on human labour, machine labour, bullock labour, seed, manure & fertilizers, irrigation and plant protection chemicals and output (main product and by-product) was also collected in quantity terms and their prices were also collected. The required secondary information was

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collected from published sources. Tabular analysis was employed to work out the costs and returns as per adopted CACP cost concepts.

Cost Concepts used

Cost A_1 = All the variable costs excluding family labour cost and including depreciation. The items covered in cost A1 was

1. Cost of hired human labour. **2.** Cost of hired bullock labour. **3.** Cost of owned bullock labour. **4.** Cost of owned machinery **5.** Cost of hired machinery. **6.** Cost of fertilizer. **7.** Cost of manure. **8.** Cost of seed (owned /purchased) **9.** Cost of plant protection chemicals. **10.** Irrigation charges (both owned and hired tube well, pumping sets etc.) **11.** Canal water charges. **12.** Land revenue, land development and other taxes. **13.** Depreciation of farm machinery, equipment's and farm buildings. **14.** Interest on owned working capital. **15.** Interest payment on crop loan. **16.** Miscellaneous expenses.

Cost A_2 = Cost A1 + rent paid for Leased in land

Cost B_1 =Cost A1 + Interest on owned fixed capital assets excluding land

Cost B_2 = CostB1 + Rental value of own land (net of land revenue) + Rent paid for leased in land

Cost C_1 = Cost B1 + Imputed value of family labour

Cost C_2= Cost B2 + Imputed value of family labour

Cost C_2* = Cost C2 was estimated by taking into account statutory minimum Or actual wage rate, whichever is higher.

Cost C_3=Cost C_2* +10 per cent of cost C_2* on account of managerial function performed by the farmer.

RESULT AND DISCUSSION

Component wise cost of cultivation of paddy

The component wise various costs incurred in the cultivation of paddy crop are given in the table 1. A perusal of table reveals that, the overall cost of production of paddy was Rs. 69954.30. Off the total cost of cultivation, 32 per cent (Rs.22344.83/ha) expenditure was incurred as operational cost, human labour constituted the most important component of operational cost with its share of more than 23.50 per cent followed by machinery expenses being 5.25 per cent of the total cost. The material cost accounted for 23.62 per cent (Rs.16532.00/ha) of the total cost, among the material cost items 11.73 per cent expenses incurred on manure & fertilizer followed by seed, irrigation and plant protection chemicals accounted 1.68, 6.91 and 3.30 per cent respectively. The share of rental value of land alone accounted 27 per cent (Rs.18950.00/ha) and the remaining was incurred on land revenue, depreciation on implements (2.13%), interest on working capital (4.57%) and interest on fixed capital (1.47%) of the total cost of cultivation.

Table also present category wise comparison and shows that expenditure share on family labour was negatively related with size of farm while hired labour was positively related to it. Among the categories expenditure on machine labour varies from 4.66 per cent on large farms to 6.02 per cent on marginal farms.

Expenditure on bullock labour and transportation expenditure was found less than 2 per cent to the total cost. Among the categories share of material costs was by and large same. No significant variation was observed on expenditure on seed, manure and fertilizer, irrigation and plant protection chemicals. Rental value of land accounted to almost same for all categories of farms.

Cost concept wise cost of paddy crop on various sized farms groups

The results related to various categories of cost as per CACP cost concepts for the paddy of different sized farms are presented in table2. Table indicates that per hectare cost A_1 was Rs. 33684.46, 35468.09, 39210.61 and Rs.41686.07on marginal, small, medium and large farm respectively. The share of cost A_1 was 50.01, 51.70, 54.33 and 56.37 per cent of "Cost C_3 "on the respective categories. It has also been observed that as the land holding size increases, the cost A_1 also increases. And it was also found that cost A_2 cost B_1, cost B_2, cost C_1, cost C_2 & cost C_3 on per hectare basis showed the increasing trends with the farm size groups. It was found the actual wage rate (Rs. 200/ man day) was higher than minimum statuary waging rate (Rs. 150/ Man day) thus, the cost C_2 & cost C_2^* were same for all the farm size groups and per hectare cost C_3 is the total cost of cultivation of paddy crop, includes the managerial cost of farmers also. Average (overall) cost A_1 was to be Rs. 36936.29, found to be 52.80 per cent of the total cost. The overall average per hectare cost of paddy production was Rs. 69954.30/ hectare.

Table 1. Component wise cost of cultivation of paddy. (Rs/ha)

Particulars	**Farm size group**				
1.Operational cost	**Marginal**	**Small**	**Medium**	**Large**	**Overall**
Family labour	7714.33 (11.45)	6985.32 (10.18)	6353.08 (8.80)	5342.27 (7.22)	6678.76 (9.54)
Hired labour	7692.78	8804.59	11245.71	13410.82	9763.37
	(11.42)	(12.83)	(15.58)	(18.13)	(13.95)
Bullock labour	1227.39	1259.10	1207.68	1200	1226.76
	(1.82)	(1.83)	(1.67)	(1.62)	(1.75)

Machine labour	4059.32 (6.02)	3643.46 (5.31)	3512.64 (4.86)	3452.12 (4.66)	3666.21 (5.24)
Total transportation cost	927.55 (1.37)	969.22 (1.41)	1091.37 (1.51)	1052.13 (1.42)	1009.73 (1.44)
Subtotal (A)	**21621.37 (32.10)**	**21661.69 (31.57)**	**23410. (32.43)**	**22717.34 (33.07)**	**22344.83 (31.93)**
2.Material cost					
Seed	1241.97 (1.84)	1200.41 (1.74)	1164.32 (1.61)	1065.50 (1.44)	1175.71 (1.68)
Manure and fertilizer	7144.71 (10.60)	8144.52 (11.80)	8648.88 (11.98)	8952.85 (12.10)	8207.08 (11.73)
Irrigation	5583.80 (8.29)	4888.70 (7.12)	4555.83 (6.31)	4250.25 (5.74)	4837.60 (6.91)
Plant protection& Intercultural	1953.65 (2.90)	2181.77 (3.18)	2523.97 (3.49)	2650.25 (3.58)	2311.63 (3.30)
Subtotal (B)	**15924.13 (23.64)**	**16415.40 (23.92)**	**16893.00 (23.40)**	**16918.85 (22.87)**	**16532.02 (23.62)**
3.Other cost					
7 % interest on working capital	2748.13 (4.08)	2977.31 (4.34)	3515.37 (4.87)	3654.25 (4.94)	3200.24 (4.57)
Depreciation	1067.64 (1.58)	1358.53s (1.96)	1701.16 (2.35)	1952.45 (2.64)	1496.35 (2.13)
Land revenue	37.52 (0.05)	40.48 (0.05)	43.68 (0.06)	45.45 (0.06)	41.61 (0.05)
Interest on own Fixed capital	873.55 (1.29)	959.01 (1.39)	1096.03 (1.51)	1245.65 (1.68)	1029.77 (1.47)
Rental value of own land	18950 (28.13)	18950 (27.47)	18950 (26.25)	18950 (25.62)	18950 (27.08)
Subtotal (C)	23676.84 (35.15)	24285.33 (35.66)	25306.24 (35.06)	25847.80 (34.95)	24717.97 (35.32)
TOTAL (A+B+C)	**61222.30 (90.91)**	**62362.40 (90.91)**	**65609.70 (90.91)**	**67223.90 (90.91)**	**63594.80 (90.91)**
10 % of C_2* for managerial work	6122.23 (9.09)	6236.24 (9.09)	6560.97 (9.09)	6722.39 (9.09)	6359.48 (9.09)
Total cost C_3	**67344.17 (100.00)**	**68598.66 (100.00)**	**72170.69 (100.00)**	**73946.38 (100.00)**	**69954.30 (100.00)**

Figures in the parenthesis indicate the percentage to the total costs

Table 2. Cost concept wise cost of cultivation (Rs/ha)

Particulars	**Farm size group**				
	Marginal	**Small**	**Medium**	**Large**	**Overall**
Cost A_1	33684.46	35468.09	39210.61	41686.07	36936.29
	(50.01)	(51.70)	(54.33)	(56.37)	(52.80)
Cost A_2	33684.46	35468.09	39210.61	41686.07	36936.29
	(50.01)	(51.70)	(54.33)	(56.37)	(52.80)
Cost B_1	34558.01	36427.10	40306.64	42931.72	37966.06
	(51.31)	(53.10)	(55.84)	(58.05)	(54.27)
Cost B_2	53508.01	55377.10	59256.64	61881.72	56916.06
	(79.45)	(80.72)	(82.10)	(83.68)	(81.36)
Cost C_1	42272.34	43412.42	46659.72	48273.99	44644.82
	(62.77)	(63.28)	(64.65)	(65.28)	(63.81)
Cost C_2	61222.34	62362.42	65609.72	67223.90	63594.82
	(90.90)	(90.90)	(90.90)	(90.90)	(90.90)
Cost C_2*	61222.34	62362.42	65609.72	67223.90	63594.82
	(90.90)	(90.90)	(90.90)	(90.90)	(90.90)
Cost C_3	**67344.17**	**68598.66**	**72170.69**	**73946.38**	**69954.30**

Figures in the parenthesis indicate the percentage of the total costs

Table 3. Per hectare and per quintal returns from paddy on various farm size groups.

Particulars	**Farm size groups**				
	Marginal	**Small**	**Medium**	**Large**	**Overall**
Yield of main product (qt/ha)	40.86	42.50	44.10	44.96	42.86
Yield of By- product (qt/ha)	60.81	62.83	63.10	65.52	62.44
Price of main product (Rs/qt)	1710.25	1725.25	1745.52	1788.33	1741.56
Price of By-product (Rs/qt)	100.00	100.00	100.00	100.00	100.00
Return from main product (Rs/ha)	69880.82	73323.13	76977.43	80403.31	74643.26
Return from By-product (Rs/ha)	6081.00	6283.00	6310.00	6552.00	6244.00
Gross returns (Rs/ha)	75961.82	79606.13	83287.43	86955.31	80887.26
Return over various Costs (Rs/ha)					
Cost A_1	42277.36	44138.04	44076.82	45269.24	43950.97
Cost A_2	42277.36	44138.04	44076.82	45269.24	43950.67
Cost B_1	41403.81	43179.03	42980.79	44023.59	42921.20
Cost B_2	22453.81	24229.03	24030.79	25073.59	23971.20
Cost C_1	33689.48	36193.71	36627.71	38681.32	36242.44
Cost C_2	14739.48	17243.71	17677.71	19731.41	17292.44
Cost C_2^*	14739.48	17273.71	17677.71	19731.41	17292.44
Cost C_3	8617.65	11007.47	11116.74	13008.93	10932.96
Cost of production (Rs/qtl)	1499.36	1466.25	1493.36	1498.98	1486.12
Profit Margin (Rs/qtl)	210.89	259.00	252.16	289.35	255.44
B : C Ratio	**1.12**	**1.16**	**1.15**	**1.17**	**1.15**

Cost of production and returns from paddy cultivation

Table 3. shows the yield of main product, by-product and their prices, the yield of paddy was observed to be 40.86, 42.50, 44.10 and 44.96 quintal and by-products 60.81, 62.83, 63.10, and 65.52 quintals per hectare under marginal, small, medium and large category of farms. The prices received by the farmers in the respective category was Rs. 1710.25, 1725.25, 1745.52, and 1788.33 per qtl. The price of by-product was taken as Rs100.00 per quintal for all the categories. The gross return and net return per hectare was estimated to be Rs. 75961.82, 79606.13, 83287.43 and Rs. 86955.31 and Rs. 8617.65, Rs.11007.47, Rs.11116.74 and Rs. 13008.93 on marginal, small, medium, large size of farms respectively. The net return per hectare was observed positively related with the size of farms. The per quintal profit margin on the respective category of farms was found to be Rs.210.89, Rs.259.00, Rs.252.16 and Rs.289.35 respectively. Benefit: Cost ratio was found highest for large farms (1.17) and lowest for marginal farms (1.12). It is clear from the study that as the size of farm increases the returns per hectare also increases.

On the basis it is concluded that in case of marginal and small farmers mostly inputs used by the farmers were hired, directly affect the cost of production. The profit margin may be increased if the resources to be utilised rationally and if available at subsidised rate.

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REVIEW ARTICLE

TILLAGE INFLUENCE ON CROP PRODUCTIVITY AND SOIL HEALTH

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Abstract: There is an urgent need to match food production with increasing world population through identification of sustainable land management strategies. However, the struggle to achieve food security should be carried out keeping in mind the soil where the crops are grown and the environment in which the living things survive. Soil are create physical environment suitable for seed germination, seedling emergence and root development. This process requires optimum soil water and soil temperature regimes and freedom from oxygen and mechanical stress. Tillage affect the soil physical environment though its affect on physical properties of soil. The change in bulk density which always accompanies alters the pore size distribution and porosity, volume water content and particle to particle contact. Conservation agriculture (CA), practicing agriculture in such a way so as to cause minimum damage to the environment is being advocated at a large scale world-wide. Conservation tillage, the most important aspect of conservation agriculture, is thought to take care of the soil health, plant growth and the environment.

Keywords: Tillage, Crop productivity, Soil

INTRODUCTION

The growing concern for food security through improved soil management techniques demands identification of an environmental friendly and crop yield sustainable system of tillage. Tillage is defined as the mechanical manipulation of the soil for the purpose of crop production affecting significantly the soil characteristics such as soil water conservation, soil temperature, infiltration and evapotranspiration processes. This suggests that tillage exerts impact on the soil purposely to produce crop and consequently affects the environment. As world population is increasing so the demand for food is increasing and as such the need to open more lands for crop production arises. The yearning for yield increases to meet growing demand must be done in a way that soil degradation is minimal and the soil is prepared to serve as a sink rather than a source of atmospheric pollutants. The greatest challenge to the world in the years to come is to provide food to burgeoning population, which would likely to rise 8,909 million in 2050. The scenario would be more terrible, when we visualize per capita availability of arable land (Fig 1). The growth rate in agriculture has been the major detriment in world food production. It has been declining since past three decades.

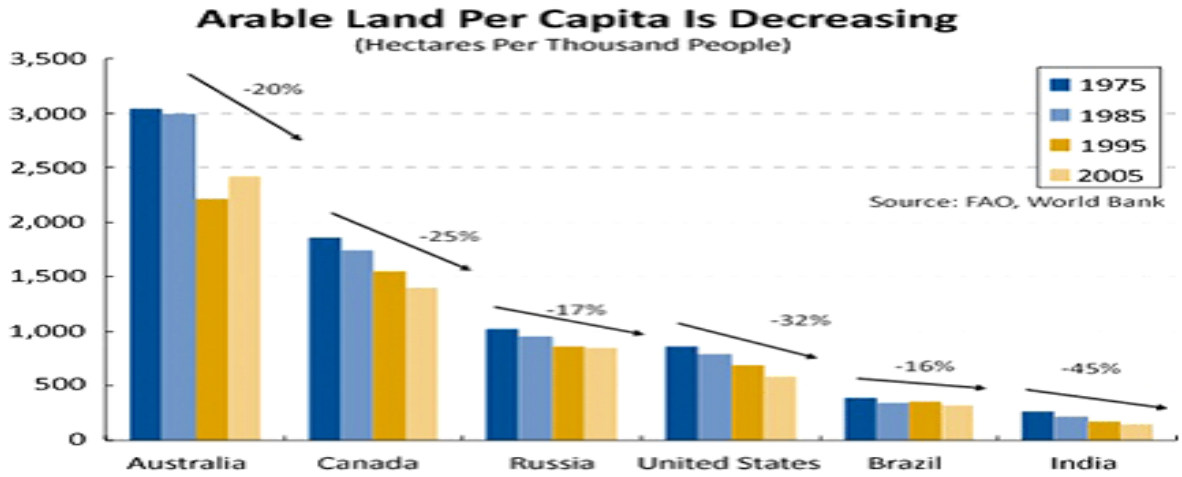

Fig. 1. Decline in arable land per capita in several countries over thirty-year period between 1975 and 2005.

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Soil tillage is among the important factors affecting soil physical properties and crop yield. Among the crop production factors, tillage contributes up to 20% (Khurshid, *et. al*., 2006). Tillage method affects the sustainable use of soil resources through its influence on soil properties (Hammel, 1989). The proper use of tillage can improve soil related constrains, while improper tillage may cause a range of undesirable processes, e.g. destruction of soil structure, accelerated erosion, depletion of organic matter and fertility, and disruption in cycles of water, organic carbon and plant nutrient (Lal, 1993). Use of excessive and unnecessary tillage operations is often harmful to soil. Therefore, currently there is a significance interest and emphasis on the shift to the conservation and no-tillage methods for the purpose of controlling erosion process (Iqbal *et al*., 2005).

Conventional tillage practices modify soil structure by changing its physical properties such as soil bulk density, soil penetration resistance and soil moisture content. Annual disturbance and pulverizing caused by conventional tillage produce a finer and loose soil structure as compared to conservation and no-tillage method which leaves the soil intact (Rashidi and Keshavarzpour, 2007). This difference results in a change of number, shape, continuity and size distribution of the pores network, which controls the ability of soil to store and transmit air, water and agricultural chemicals. This in turn controls erosion, runoff and crop performance (Khan, *et. al.,* 2001).

Soil is a key natural resource and soil quality is the integrated effect of management on most soil properties that determine crop productivity and sustainability (Anikwe and Ubochi, 2007). Tillage practices profoundly affect soil physical properties. It is essential to select a tillage practice that sustains the soil physical properties required for successful growth of agricultural crops (Jabro, *et. al*., 2009). Seedbed preparation is crucial for crop establishment, growth and ultimately yield (Atkinson, *et al*., 2007). Tillage systems create an ideal seedbed condition for plant emergence, development, and unimpeded root growth (Licht and Al-Kaisi, 2005). Appropriate tillage practices are those that avoid the degradation of soil properties but maintain crop yields as well as ecosystem stability (Greenland, 1981). The best management practices usually involve the least amount of tillage necessary to grow the desired crop. This not only involves a substantial saving in energy costs, but also ensures that a resource base, namely the soil, is maintained to produce on a sustainable basis.

Tillage effects on crop performance

Tillage impact on crop yield is related to its effects on root growth, water and nutrient use efficiencies and ultimately the agronomic yield (Lal, 1993). An increase in root length density has been found only in the upper soil layers of non tillage (Martınez, *et. al*., 2008) and reduced tillage systems compared to the conservation system because soil compaction of deeper soil layers under non tillage may impede proper development of roots. However, Malhi and Lemke (2007) reported a 22% increase in root mass under non tillage compared with conservation tillage. This could be attributed to the cracks, worm channels and higher number of biopores which may facilitate root growth under non tillage. According to Busari and Salako (2013), maize yield under a minimum tillage system is likely to be more sustainable compared with conventional tillage. They added that best crop yield under non tillage than other tillage methods could be linked with poor root development that is usually associated with low yield under zero tillage and rapid structural deterioration caused by slaking and dispersion under conservation tillage (Guzha, 2004) which were possibly not the case under minimum tillage.

The effect of tillage systems on crop yield is not uniform with all crop species, in the same manner as various soils may react differently to the same tillage practice. Francis & Knight, 1993, compared the traditional tillage, traditional tillage (the soil was ploughed by mouldboard, to a 30 cm depth, after burning the straw of the preceding crop) and conservation tillage, conservation tillage, (the residues of the previous crop were left on the soil surface, as mulch, and a minimum vertical tillage (chiseling, 25 cm depth) and disc harrowing (5 cm depth) were carried out. Results revealed that crops yield was higher in conservation tillage, (Table 1).

Table 1. Effect of tillage on crop yield

Crop	Treatment	Thousand kernel weight (g)	Yield (kg ha^{-1})
Sunflower	CT	54.5	>2,000
	TT	56.0	>2,000
Wheat	CT	47.3	3,094
	TT	46.6	2,517

Results presented by Nicou and Charreau (1985) showed the effect of tillage on yields of various crops in the West African semi-arid tropics (Table 2). Cotton showed the smallest yield increase with tillage within the range of crops tested. Tillage effects in semi-arid zones are closely linked to moisture conservation and hence the management of crop residues. Several authors (Unger, *et. al.*1991; Thomas, *et. al*. 1990, Sharma, *et. al*. 2009) emphasize the link between crop residue management and tillage and recognize them as the two practices with major impact on soil conservation in the semi-arid zones.

Table 2. Effect of tillage on crop yields in the West African semi-arid tropics

Crop	Number of annual results	Yield (kg ha^{-1})		Yield increase (%)
		control	with tillage	
Millet	38	1558	1894	22
Sorghum	86	1691	2118	25
Maize	31	1893	2791	50
Rice	20	1164	2367	103
Cotton	28	1322	1550	17
Groundnut	46	1259	1556	24

Soil physical properties

Effects of conservation tillage on soil properties vary, and these variations depend on the particular system chosen. No-till (NT) systems, which maintain high surface soil coverage, have resulted in significant change in soil properties, especially in the upper few centimeters (Anikwe & Ubochi, 2007). Soil physical properties are generally more favorable with no-till than tillage-based systems. Many researchers have found that NT significantly improved saturated and unsaturated hydraulic conductivity owing to either continuity of pores or flow of water through very few large pores (Benjamin, 1993).

Most studies on cereal production comparing conventional and conservation tillage have given inconsistent results, apparently depending on soil type, crop rotation, and local climatic conditions (Martin- Rueda *et al*. 2007). Studies carried out by Malhi (2007) indicate that the yield of spring barley decreased by 8% when plowing tillage was replaced by reduced tillage, and it decreased by 12% when no tillage was applied. Higher water holding capacity or moisture content has been found in the topsoil (0–10 cm) under NT than after ploughing. Therefore, to improve soil water storage and increase water use efficiency (WUE) most researchers have proposed replacement of traditional tillage with conservation tillage (Fabrizzi, *et.al*.,2005).

Soil penetration resistance is a measure of the soil strength and an indicator of how easily roots can penetrate into the soil and thus a measure of plant growth and crop yield. Soil penetration resistance before tillage operation under all tillage implements. Penetrometer resistance measurements of soil can be used to assess the need for tillage operations, which help maintain effective plant rooting and facilitate good water and nutrient uptake.Irena, *et. al.*, 2012 observed the soil tillage systems significantly modified soil bulk density in the spring vegetation period of spring barley only in the upper soil layer ($P < 0.01$) (Table 3). At the 0-5 cm depth, RT caused an increase in the soil bulk density value in the surface soil layer of 0.15 Mg m–3, and NT caused an increase of 0.30 Mg m–3 as compared with CT. Differences in bulk density between tillage systems were not significant at the 10-20 cm depth; however, bulk density in CT was slightly lower than in RT and NT.

Table 3. Volumetric water content and soil bulk density as affected by tillage system (mean of 2004-2006). (Irena *et. al.*, 2012)

Tillage systems[a]	Volumetric water content (%)		Bulk density (Mg m^{-3})	
	Soil layer (cm)			
	0-5	10-20	0-5	10-20
CT	12.2 c	16.4 b	1.39 c	1.59
RT	15.3 b	18.0 a	1.54 b	1.62
NT	17.6 a	18.9 a	1.69 a	1.64
	LSD values			
Tillage systems	1.61**	1.32**	0.075**NS	

The means in a column with the same letter are not significantly different. NS: not significant; **P < 0.01.
[a]Tillage systems: CT, conventional tillage; RT, reduced tillage; NT, no-tillage.

Conservation in soil tilled with chisel plow and mouldboard plow whereas the rotary harrow further increased the soil moisture contents with all tillage implements. Similarly, Makki and Mohamed (2008) also observed the highest moisture conservation in soil tilled with chisel plow compared to other tillage implements. Cogle, *et. al.* (1997) also reported that deep tillage increases the soil porosity and manipulate surface roughness to improve water intake. The deep tillage decreased soil bulk density and penetration resistance up to the tilled depth 40 cm and encouraged more root growth in the deeper soil layers, which in turn, increased water holding capacity (Meherban and Chaudhury, 1998).

Soil chemical properties

Soil chemical properties that are usually affected by tillage systems are pH, CEC, exchangeable cations and soil total nitrogen. According to Lal, (1997b) soil chemical properties of the surface layer are generally more favorable under the no till method than under the tilled soil. Annual no-tillage, implying yearly practice of no-till system over a long period of time, is beneficial to maintenance and enhancement of the structure and chemical properties of the soil, most especially the SOC content. In study observed that with annual no-tillage, plant residues left on the soil surface increase the organic matter in the topsoil. Similarly, Lal, (1997b) reported a significantly higher SOC in soil with no-tillage compared to un-tilled soil.

A reduced total N loss was also observed under no-tillage compared to conservation tillage by Dalal, (1992). Higher mineralization and/or leaching rate could be implicated for reduction in organic C and total N under tilled plot due to soil structure deterioration following tillage. Tillage technique is often shown to have no effect on soil pH (Rasmussen, 1999), though soil pH has been reported to be lower in no-till systems compared to conservation tillage. The lower pH in zero tillage was attributed to accumulation of organic matter in the upper few centimeters under zero tillage soil causing increases in the concentration of electrolytes and reduction in pH (Rahman, *et. al.,* 2008). Conversely, Cookson, *et.al*.,(2008) found that surface soil pH decreased with increasing tillage disturbance and reported a significantly higher soil pH in no-tillage plots compared to those in tilled plots. Therefore, tillage may not directly affect soil pH but its effects on pH will depend on the prevailing climatic condition, soil type and management factors. Rahman, *et. al.* (2008) reported that exchangeable Ca, Mg, and K, were significantly higher in the surface soil under no-tillage compared to the ploughed soil. Lowest values of soil OM, N, P, K, Ca and Mg were recorded in conventional till plots and it could be due to the inversion of top soil during ploughing which shifts less fertile subsoil to the surface in addition to possible leaching.

Busari and Salako (2013) observed that zero tillage soil had a significantly higher pH at the end of the first year after tillage but the pH became significantly lower compared with the conservation tillage soil at the end of the second year after tillage. However, the soil organic C (SOC) and the effective cation exchange capacity (ECEC) were significantly higher at the end of the two years of study under zero tillage than under conservation tillage (Table 4). The study however, revealed that minimum tillage (MT) resulted in significantly higher pH and SOC than conservation tillage at the end of each of the two years of the study suggesting that less soil disturbance is beneficial to soil chemical quality improvement.

Table 4. Effect of tillage on soil chemical properties.
Source: Busari and Salako (2013)

	2008					2009				
Tillage	pH (H_2O)	OC (g kg^{-1})	TN (g kg^{-1})	Avail. P (mg kg^{-1})	ECEC (cmol kg^{-1})	pH (H_2O)	OC (g kg^{-1})	TN (g kg^{-1})	Avail. P (mg kg^{-1})	ECEC (cmol kg^{-1})
CT	6.0	16.50	1.38	26.64	6.31	6.69	2.79	0.32	65.59	8.05
MT	6.2	19.80	1.52	24.33	6.24	6.79	4.59	0.55	40.47	8.51
ZT	6.1	21.20	1.58	33.28	7.36	6.64	5.00	0.53	61.13	9.39
LSD (Pr0.05)	0.05	2.20	ns	7.13	0.49	0.04	0.44	0.08	13.25	0.79

OC¼organic carbon; TN¼total nitrogen; Avail. P ¼available phosphorus, ECEC¼effective cation exchange capacity; ZT¼zero tillage; MT¼minimum tillage; CT¼conventional tillage; LSD=least significant difference; ns¼not significant.

Soil biological properties

The soil biological property most affected by tillage is SOC content (Doran, 1980). The soil organic matter content influences to a large extent the activities of soil organism which in turn influence the SOC dynamics. Earthworms which are a major component of the soil macrofauna are important in soil fertility dynamics as their burrowing activities aid in improvement of soil aeration and water infiltration. The fact that the population of earthworms are affected by tillage practices has been documented in a ploughless tillage review by Rasmussen (1999). A six year study by Andersen (1987) revealed a significantly higher earthworm population under no-till soil than under ploughed soil. Kemper, *et. al.* (1987) reported that less intense tillage increased the activities of surface-feeding earthworms. Due to disruption of fungi mycelia by tillage technique, Cookson, *et. al.* (2008) observed a decreased fungal biomass and increased bacterial biomass with increasing tillage disturbance. They also reported alteration in the composition and substrate utilization of the microbial community with distinct substrate utilization in no-till soil.

Strategies for mitigating challenges

Conservation agriculture (CA) is a concept for resource-saving agricultural crop production that

strives to achieve acceptable profits together with high and sustained production levels while concurrently conserving the environment. Interventions such as mechanical soil tillage are reduced to an absolute minimum and the use of external inputs such as agrochemicals and nutrients of mineral or organic origin are applied at an optimum level and in a way and quantity that does not interfere with or disrupt the biological processes. One of the soil conservation techniques developed in USA is known as 'conservation tillage'(CT), this involves soil management practices that minimize the disruption of the soil's structure, composition and natural biodiversity, thereby minimizing erosion and degradation, but also water contamination (Anonymous, 2001).

Principles of conservation agriculture

Conservation agriculture systems utilize soils for the production of crops with the aim of reducing excessive mixing of the soil and maintaining crop residues on the soil surface in order to minimize damage to the environment. This is done with objective to:

• Provide and maintain an optimum environment of the root-zone to maximum possible depth.

• Avoid physical or chemical damage to roots that disrupts their effective functioning.

• Ensure that water enters the soil so that a plants never or for the shortest time possible, suffer water stress that will limit the expression of their potential growth; and so that residual water passes down to groundwater and stream flow, not over the surface as runoff.

• Favour beneficial biological activity in the soil

Conservation tillage is now commonplace in areas where rainfall causes soil erosion or where preservation of soil moisture because of low rainfall is the objective. World-wide, Conservation tillage is practiced on 45 million ha, most of which is in North and South America (FAO, 2001) but is increasingly being used in other semi-arid and tropical regions of the world (Lal, 2000b). In USA, during the 1980s, it was recognized that substantial environmental benefits could be generated through soil conservation and to take advantage of this policy goals were changed. These were successful in reducing soil erosion; however, the social costs of erosion are still substantial, estimated at $37.6 billion annually (Lal, 2001). World-wide erosion caused soil degradation was estimated to reduce food productivity by 18 million Mg at the 1996 level of production (Lal, 2000b). Because of the increasing population and rising standards of living, it is essential to develop those agricultural practices that maximize agricultural production while also enhancing ecosystem services. Eco-efficiency is related to both "ecology" and "economy," and denotes both efficient and sustainable use of resources in farm production and land management (Willcocks, 1988). Experience has shown that conservation agriculture systems achieve yield levels as high as comparable conventional agricultural systems but with less fluctuations due, for example, to natural disasters such as drought, storms, floods and landslides. Conservation agriculture therefore contributes to food security and reduces risks for the communities (health, conditions of living, water supply), and also reduces costs for the State (less road and waterway maintenance).

CONCLUSION

Soils are one of the world's most precious commodities. Continuing soil degradation is threatening food security and the livelihood of millions of farm households throughout the world. Soil types and their various reactions to tillage are of paramount importance in determining the superiority of one practice over the other. Conservation agriculture permits management of soils for agricultural production without excessively disturbing the soil, while protecting it from the processes that contribute to degradation e.g. erosion, compaction, aggregate breakdown, loss in organic matter, leaching of nutrients etc. Conservation agriculture is a way to achieve goals of enhanced productivity and profitability while protecting natural resources and environment. Therefore, to achieve sustainable food production with minimal impact on the soil and the atmosphere, conservation tillage practices become more important now than ever. Research reports indicate that conservation tillage, particularly minimum tillage, is better than continuous tillage in terms of soil chemical improvement. All available reports are in agreement that soils under conservation tillage are more favored than continued tillage in terms of physical and chemical properties, crop performance, soil fauna activities and biological properties improvement.

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RESEARCH COMMUNICATION

PERFORMANCE OF INDIAN MUSTARD (*BRASSICA JUNCEA* L.) GENOTYPES ON PLANT GEOMETRY

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Abstract: A field experiment was conducted during winter (*rabi*) season of 2015-16 at Banaras Hindu University, Varanasi to assess the effect of planting geometry on growth and yield of Indian mustard (*Brassica juncea* L.) genotypes. The treatments were comprised of three genotypes (NRCHB-101, Kranti and RGN-73) and four levels of planting geometry (30 cm x 10 cm, 30 x 20 cm, 45 cm x 15 cm and 45 cm x 30 cm). Mustard genotype 'RGN-73' showed its distinct superiority over 'Kranti' and 'NRCHB-101' and proved to be the most suitable genotype, and planting geometry of 45 cm x 15 cm was observed to be the optimum plant geometry as this treatment was superior over other corresponding treatments of plant geometries, *viz.,* 30 cm x 10 cm, 30 cm x 20 cm and 45 cm x 30 cm. This was corroborated from the similar significantly higher values of plant height, dry matter accumulation/plant, primary and secondary branches/plant, yields and other quality components recorded under the best treatments (genotype 'RGN-73' and geometry of 45 cm x 15 cm). The highest net profit could be realized with the plant geometry of 45 cm x 15 cm of Indian mustard genotype 'RGN-73'.

Keywords: Genotype, Plant Geometry, Indian mustard, Yield

INTRODUCTION

Oilseed *Brassicas* occupies prominent position in the country during winter season contributing nearly 23.5% and 24.2% to the total oilseed cropped area and production, respectively **(**GOI, 2014**)**. Indian mustard (*Brassica juncea* (L.) Czernj and Cosson) is an important winter (*rabi*) oilseeds crop of Rajasthan, Gujarat, Madhya Pradesh, Haryana, Uttar Pradesh, Bihar, West Bengal and Assam. India occupies third position in rapeseed-mustard production in the world after China and Canada. For increasing the productivity of mustard crop, the improved varieties which are capable of giving high yields should be cultivated. Production of any genotypes is greatly influenced by surrounding biosphere as well as non-monitory inputs like sowing distance, selection of seeds, sowing time etc. Planting geometry decided on the basis of plant ideotype which provide the condition for greater light interception during early crop growth stages. It is, therefore, imperative to define plant geometry to accommodate more number of plants per unit area. Planting geometry *i.e*. row to row and plant to plant distance plays a vital role in harnessing potential yield. Sub-optimal planting geometry, wider row and plant spacings leads to low population which in turn fails to compensate the yield obtained with optimum plant population, while narrower row and plant spacings increase the inter and intra-plant competition leading to poor growth, development and dry matter accumulation resulting in poor yield (Sharma, 1992). Thus, the optimal plant geometry for Indian mustard is required for obtaining maximum yield. Selection of appropriate genotype for the region is also one of the major concerns. Even before releasing the variety, a typical variety trial is conducted under different location to check the suitability, but only environment is not yield governing factor, it also affected by ecosystem as well as physico-chemical properties of soil. Therefore, considering the above factors, the present study was carried out to study the performance of Indian mustard genotypes on plant geometries.

MATERIAL AND METHOD

A field experiment was carried out during winter (*rabi*) season of 2014-15 at Institute of Agricultural Sciences, Banaras Hindu University, Varanasi ($25^0 18'$ North latitude, $83^0 03'$ East longitude and at an altitude of 128.93 meters above the mean sea level). Mean minimum and maximum temperature during the crop season ranged from 5.8 to 22.1^{o}C and 17.1 to 39.2^{o}C, respectively. Rainfall of 188 mm was received during the crop growth period. The maximum rainfall of 61.2 mm was recorded in the month of April, 2015. Soil of the experimental field was sandy loam in texture free from salts, neutral in reaction (pH 7.4), low in organic carbon (0.39%), available nitrogen (147 kg/ha), medium in available phosphorus (21.5 kg/ha) and rich in available potassium (246.1 kg/ha). Twelve treatment combinations comprising three genotypes, *viz.*, NRCHB-101 (V_1), Kranti (V_2), RGN-73 (V_3) and four plant geometries *i.e.* G_1 (30 cm x 10 cm), G_2 (30 cm x 20 cm), G_3 (45 cm x 15 cm), and G_4 (45 cm x 30 cm) were tried in split-plot designed with three replications. Net plot size was 12.96 m^2 (3.6 m x 3.6 m). Genotypes were sown during the last week of

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October 2015. All other recommended package of practices was adopted for raising a good crop. Harvesting was done during last week of February 2016. Seed oil content was estimated by the conventional Soxhlet's method taking petroleum ether as a solvent (AOAC, 1995) where seed samples were kept in an oven at 70°C for removal of moisture after which the seeds were crushed in a pestle-mortar for extraction of oil. The oil content was expressed in per cent. Oil yield was calculated by multiplying seed yield and oil content in the seed. Economics of different treatment combinations were also worked out by taking account the cost of cultivation and sale value of produce.

RESULT AND DISCUSSION

Among genotypes, variation in plant height and dry matter accumulation/plant were significant. Mustard genotype 'RGN-73' was recorded the highest plant height due to rapid initial growth habit, and the lowest plant height was recorded in 'Kranti' due to its slow initial growth habit (Table 1). Dry matter accumulation/plant was higher in 'RGN-73' compared to 'Kranti' and 'NRCHB-101' at all the growth stages except at 30 days after sowing (DAS). The results of present investigation are in agreement with the findings of Singh *et al.* (2008). Similar to plant height and dry matter accumulation/plant, the highest number of primary and secondary were recorded under 'RGN-73' at all the growth stages of the crop. Moreover, 'RGN-73' seems to have higher capacity to utilize photosynthates more efficiently for achieving maximum production of more number of branches and higher dry matter production.

Significantly taller plants and higher dry matter accumulation/plant were recorded with the plant geometry of 45 cm x 15 cm at all the growth stages of the crop except at 30 DAS (Table 1). Number of primary branches and secondary branches/plant were also significantly greater with 45 cm x 15 cm. Higher dry matter accumulation/plant was mainly attributed to higher plant height, number of primary and secondary branches/plant. These findings were in conformity with Kumari *et al.* (2011).

Data with respect to seed yield as affected by different genotypes and plant geometries (Table 2) revealed that seed and stover yield and biological yield of Indian mustard were significantly higher for 'RGN-73' and was superior to 'Kranti' and 'NRCHB-101'. Maximum seed yield was recorded with plant geometry of 45 cm x 15 cm, which was significantly superior to all other treatments of plant geometries. Contrary to seed yield, data pertaining to oil content in seed of mustard as influenced by different genotypes and plant geometry indicated similar values with some differences in total oil yield (Table 2). The interaction effect of genotypes and planting geometry on various parameters of mustard was found non-significant.

Table 1. Effect of plant geometry on growth parameters of Indian mustard genotype at different stages

Treatment	Plant height (cm)				Dry matter accumulation (g) /plant				Primary branches /plant				Secondary branches /plant		
	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest	60 DAS	90 DAS	At harvest
Genotype															
NRCHB-101	13.6	50.5	109.4	115.7	1.79	6.70	16.31	22.37	2.0	6.5	7.6	7.9	12.2	16.9	18.0
Kranti	13.1	50.0	108.1	114.3	1.33	6.19	18.89	22.02	2.0	6.5	7.6	7.9	12.2	16.8	18.0
RGN-73	15.7	56.3	121.8	128.8	1.88	7.59	20.66	24.73	2.1	7.5	8.8	9.2	14.1	19.8	20.7
SEm ±	0.3	1.2	2.9	3.0	0.04	0.18	0.56	0.65	0.1	0.2	0.2	0.2	0.4	0.5	0.5
CD (P=0.05)	1.1	3.8	8.4	8.9	NS	0.54	1.65	1.96	NS	0.6	0.6	0.7	1.0	1.4	1.5
Plant Geometry															
30 x 10	14.1	42.0	90.9	96.1	1.70	6.35	8.58	10.87	1.9	6.0	7.0	7.3	11.2	15.5	16.5
30 x 20	13.8	50.3	109.1	115.4	176	6.25	16.15	19.10	2.0	6.6	7.8	8.1	12.5	17.2	18.4
45 x 15	14.3	61.7	133.6	141.3	1.90	9.20	26.54	31.26	2.1	7.7	9.0	9.4	14.4	19.9	21.2
45 x 30	14.4	55.0	118.8	125.6	1.85	7.51	25.67	31.16	2.1	7.0	8.3	8.6	13.2	18.2	19.5
SEm±	0.4	1.5	3.3	3.5	0.05	0.21	0.65	0.76	0.1	0.2	0.3	0.3	0.4	0.6	0.6
CD(P =0.05)	NS	4.3	9.7	10.2	NS	0.62	1.92	2.25	NS	0.6	0.7	0.8	1.2	1.6	1.8

DAS: Days after sowing; NS: Non-Significant

Table 2. Effect of plant geometry on yields, oil content and oil yield of Indian mustard genotype

Treatment	Grain yield (kg/ha)	Stover yield (kg/ha)	Biological yield (kg/ha)	Harvest index (%)	Oil content (%)	Oil yield (kg/ha)
Genotype						
NRCHB-101	1382	4634	6016	22.97	39.36	544
Kranti	1365	4580	5945	22.96	39.44	538
RGN-73	1530	5161	6691	22.87	40.26	616
SEm±	37	159	166	0.73	1.20	30
CD(P = 0.05)	110	465	487	NS	NS	NS
Plant Geometry						
30 x 10	1143	3851	4994	22.89	38.86	444
30 x 20	1382	4620	6002	23.03	39.48	546

45 x 15	1702	5662	7364	23.11	40.55	690
45 x 30	1510	5032	6542	23.08	39.93	603
SEm±	44	182	192	0.84	1.40	35
CD(P = 0.05)	131	535	562	NS	NS	103

Table 3. Interaction effect of plant geometry on economics of Indian mustard genotype

Treatment	Gross return (`/ha)	Net return (`/ha)	B:C* ratio
V_1G_1	30,547	15,247	1.00
V_1G_2	37,970	22,670	1.48
V_1G_3	44,455	29,155	1.91
V_1G_4	42,775	27,475	1.80
V_2G_1	31,364	16,064	1.05
V_2G_2	36,666	21,366	1.40
V_2G_3	47,461	32,161	2.10
V_2G_4	38,396	23,096	1.51
V_3G_1	34,860	19,560	1.28
V_3G_2	39,157	23,857	1.56
V_3G_3	51,075	35,775	2.34
V_3G_4	45,844	30,544	2.00

*Cost of cultivation: `15,300/ha

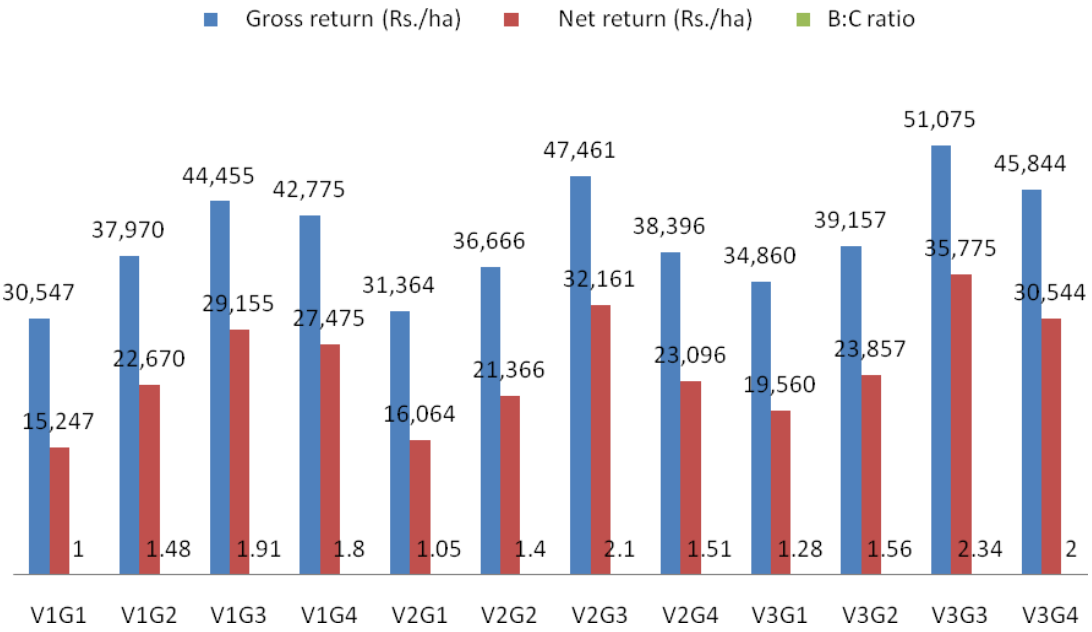

Fig. 1: Interaction effect of plant geometry on economics of Indian mustard genotype

On the basis of economics, it is evident from the data that maximum gross income (`51, 075/ha) as well as net return (`35, 775/ha) was obtained under the treatment combination of V_3G_3 ('RGN-73' and plant geometry 45 cm x 15cm). Similarly, the benefit: cost ratio in terms of net return per rupees invested indicated that maximum benefit: cost ratio (2.34) was recorded (Table 3) under the treatment combination of V_3G_3 ('RGN-73' and plant geometry 45 cm x 15 cm).

It can be inferred that mustard genotype 'RGN-73' proved to be most productive and remunerative genotype at plant geometry of 45 cm x 15 cm under the agro-ecological conditions of eastern Uttar Pradesh.

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RESEARCH COMMUNICATION

ROOTING RESPONSE OF GUAVA (*PSIDIUM GUAJAVA* L.) THROUGH CUTTING UNDER GARHWAL HIMALAYAN REGION

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Abstract: Rooting response of Guava (*Psidium guajava* L.) through cutting, experiment was done valley region in Garhwal Himalayan. The experiment was laid out in Randomized Block Design (RBD) with three replications. For preparing the rooting media, soil and farm yard manure (FYM) in ratio of 2:1 by v/v were mixed thoroughly, then the mixture was filled in root trainers. Properly prepared hardwood cuttings of about 15-20 cm in length during the month of August were treated with various concentrations of IBA viz., 2000, 3000 and, 4000ppm for 10 second by concentrated solution quick dip method with control, and planted in three different conditions namely Mist chamber, Shade house and open condition. The result shows mist house growing condition was found effective in increasing the rooting performance of the cuttings. The cuttings treated with 4000ppm IBA performed best in all aspects, Survival percentage of cutting, number of sprouts, number of leaves**,** shoot length, shoot diameter, number of primary root, number of secondary root, root length, root diameter, fresh weight of root, dry weight of root and rooting percentage. Overall treatment G_2C_3 (Mist chamber with 4000 ppm IBA) treatment combination was found best in all parameters taken.

Key words: Guava, IBA, Growing condition, Rooting percentage

INTRODUCTION

Guava (*Psidium guajava* L.) belong to Myrtaceae family. Place of origin of guava is tropical America. Guava is one of the important fruits of India. Among different states, guava is widely cultivated in Uttar Pradesh and Bihar state. It is a rich source of Vitamin-C (260mg/100gm) which is the second after aonla (600mg/100gm). Guava can be used in preparation of Juice, Jam and Marmalade (Hossen *et al.*, 2009). In India, total fruits area and production has been estimated at 7216 thousand ha, 88977 thousand MT annually (NHB, 2013-14).

Guava plants can be propagated by several ways such as seeds, cuttings, air layers, grafting. The seed propagation is now restricted to rising of rootstock materials. Although guava is hard-to-root, investigations have indicated that it can be successfully propagated from cuttings under mist. Abdullah *et al.* (2006) showed that the cuttings of guava gave 60 % rooting and 70.9 % survival percentage in the non-mist propagator when treated with 4000ppm concentration of IBA. Tready (1983) observed that rooting percentage could be enhanced from 0 to 30.5 percent in hardwood cuttings of guava treated with 500ppm IBA. Khattak *et al* (1983) reported that the tried different concentration of IBA in semi hardwood cuttings of guava and achieved 4% rooting in cuttings of guava with the treatment of 6000ppm of IBA. Luqman *et al.* (2004) observed that the semi-hard wood guava (*Psidium guajava* L.) in number of leaves, number of branches, branch length, number of roots per cutting, root length, root weight and rooting percentage maximum at 1000ppm and found significantly different. hardwood stem cuttings of guava were noticed hard to root (Luis *et al.*, 1986).

MATERIAL AND METHOD

The present investigation was conducted in month of August 2014 in the mist house located at the Horticultural Research Centre, HNB Garhwal University, Srinagar Garhwal, Uttarakhand, India. The research centre is situated in the Alaknanda valley at 30^0 13' 25.26'' N and 78^0 48' 04.93'' E and 563 m above mean sea level, and exhibits a subtropical climate with dry summer and rigorous winters with occasional dense fog in the morning hours from mid December to mid February. The average temperature inside the mist house during experiment was 74±5% relative humidity and 35±3 ^{0}C temperature. The temperature of the soil measured was around 25±2 ^{0}C.

15 cm long Hardwood stem cuttings of Guava (*Psidium guajava* L.) were collected from five year old plants and stem cuttings were prepared. For rooting media, soil and farm yard manure (FYM) in ratio of 2:1 by v/v were mixed thoroughly, then the mixture was filled in root trainers. The basal ends of the cuttings were dipped in dilute solutions of Indole-3-Butyric Acid (2000ppm, 3000ppm, 4000ppm with Control) by quick dip method for 10 seconds before planting in the rooting medium (Singh *et al*. 2011). After the treatment, the cuttings were immediately planted in root trainers and inserted 7.5 cm deep in the rooting media. The experiment was replicated thrice with 10 cuttings in each treatment and a total of 120 cuttings were planted in shade house (G_1), 120 cuttings were planted in mist chamber (G_2) and

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120 cuttings were planted in open condition (G_3). The planted cuttings were allowed to root for 30 days. After 30 days cuttings nine number of cutting per treatment were carefully removed from the pots and dipped in water to remove the soil particles adhering to roots to record the observations pertaining to roots viz., number of primary root, number of secondary root, root length, root diameter, fresh weight of root, dry weight of root, rooting percentage, except for the observations on various stem leaf characters and all other were recorded after planting. The data pertaining to root and shoot character were tabulated and statistically analysed as per the methods outlined by Cochran and Cox (1992).

RESULT AND DISCUSSION

The survival and rooting response of *Guava* cuttings treated with different concentration of IBA is shown in table 1. Significantly the maximum survival percentage of cutting (70.00), number of sprouts (4.00), number of leaves (11.00), shoot length (9.667 cm), shoot diameter (3.00 mm), number of primary root (22.00), number of secondary root (60.0), root length (10.00 cm), root diameter (2.333 mm), fresh weight of root (1.047 gm), dry weight of root (0.643 gm), rooting percentage (66.667) was observed under G_1C_3 treatments (Mist chamber growing condition with 4000ppm concentration of IBA), while the minimum survival percentage of cutting (10.00), number of leaves (2.00), shoot length (2.633 cm), shoot diameter (0.667 mm), number of primary root (4.667), number of secondary root (9.00), root length (3.50 cm), fresh weight of root (0.490 gm), dry weight of root (0.217 gm), rooting percentage (10.00) was recorded under G_3C_0 (Open condition with control) treatment and the lowest number of sprouts (1.00) was observed under G_1C_0, G_3C_0 (Mist chamber and open condition with control) treatment and the minimum root diameter (1.667 mm) was show under G_2C_3 and G_3C_0 (Shade house with 4000 ppm concentration of IBA and open condition with control). The enhanced hydrolytic activity in presence of applied IBA coupled with appropriate planting time might be responsible for the increased percentage of rooted cuttings. High carbohydrate and low nitrogen have been reported to favour root formation (Carlson, 1929). These finding are agreed with the finding of El-Shazyl and El-Sabrout (1994) in Leconte pear and Singh *et al.* (2014) in *Morus alba* under mist chamber. The rooting behavior of cuttings may have varied with the seasons and low temperature adversely affecting rooting (Shafrir and Mendel, 1970). It may be due to the action of auxin which might have caused hydrolysis and translocation of carbohydrates and nitrogenous substances at the base of cuttings and resulted in accelerated cell elongation and cell division in suitable environment (Hartmann *et al*., 2007). Junior *et al.* (2004) have found an increment of rooting and number of roots with the increase of concentration of IBA. The cuttings presented high survival (90%), with conditions planted in the field after the sixth month (from the cutting) or grafted in the eighth month. The effects of indole-3-butyric acid (IBA) on the rooting of semi-hardwood cuttings from the kiwifruit (*Actinidia deliciosa*) were investigated by Ucler *et al*. (2004). Singh *et al*. (2014) observed that the stem cuttings of *Morus alba* were treated with 1000, 1500 and 2000 mg l^{-1} indole-3-butyric acid (IBA) and Naphthalene acetic acid (NAA) solutions by quick dip method. Among all the treatments, numbers of sprouted cuttings, length of the roots, percentage of rooted cutting, lengths of longest sprouts of root were higher in IBA 2000 mg l^{-1}.

Intermittent mist is often used on cuttings because it reduces the temperature of the leaves, lowers respiration, and increases relative humidity around the leaf surface (Langhans, 1955). Significant variations in shoot and root parameters have been observed in hardwood cuttings of grape varieties kept under different propagating structures including open condition (Ravindran *et al*., 2006). Kumar *et al.* (2007) in which they have tried different seasons and found best rooting of Phalsa cuttings in the month of July in mist and open conditions followed by the month of August and June in mist and open conditions respectively. Selvarajan and Madhava Rao (1982) reported that mist chamber provides most favorable environment for better rooting of patchouli cuttings. High humidity and suitable temperature maintained inside the plastic tunnel rather than outside provides good vegetative growth (Whitecomb, 1983). This may be due to effect of environmental factors, light, air temperature and soil temperature, seems to be mediated through enzymatic activation, mobilization of reserve food materials. Such changes in activity of enzymes under different environmental conditions have been earlier reported by Nanda and Kochar, (1985).

Table 1. Effect of growing condition and IBA on the rooting and survival performance of Guava (*Psidium guajava*)

Treatments	Survival % of cutting	Number of sprouts	Number of leaves	Shoot length (cm)	Shoot diameter (cm)	Number of primary root	Number of secondary root	Root length (cm)	Root diameter (cm)	Fresh weight of root	Dry weight of root	Rooting %
G_1C_1	43.333	2.333	7.000	6.333	1.333	14.667	45.333	7.000	1.167	0.860	0.477	40.000
G_1C_2	50.000	3.333	8.000	8.867	2.333	16.000	46.333	9.000	1.667	0.920	0.577	46.667
G_1C_3	70.000	4.000	11.000	9.667	3.000	22.000	60.667	10.000	2.333	1.047	0.643	66.667
G_1C_0	23.333	1.000	2.333	3.533	1.000	6.333	25.667	4.333	0.833	0.590	0.320	20.000

G_2C_1	40.000	2.333	4.333	5.167	1.333	9.000	36.667	6.333	1.333	0.757	0.370	36.667
G_2C_2	43.333	2.000	6.333	6.400	2.000	12.000	34.667	6.667	2.000	0.810	0.407	40.000
G_2C_3	46.667	3.333	6.333	7.167	2.333	13.667	44.333	7.000	1.667	0.747	0.383	43.333
G_2C_0	13.333	1.333	3.000	3.933	0.933	5.000	14.667	3.667	0.667	0.553	0.283	13.333
G_3C_1	23.333	2.000	3.333	4.900	1.667	8.667	37.333	6.000	1.167	0.650	0.320	23.333
G_3C_2	36.667	2.667	3.000	4.767	1.667	11.667	30.667	5.667	1.167	0.660	0.303	33.333
G_3C_3	30.000	2.000	5.000	5.667	2.000	11.333	35.333	6.333	1.333	0.600	0.293	26.667
G_3C_0	10.000	1.000	2.000	2.633	0.667	4.667	9.000	3.500	0.667	0.490	0.217	10.000
CD at 5%	6.753	0.716	7.000	6.333	1.333	14.667	45.333	7.000	1.167	0.860	0.477	3.056
S.Em	2.302	0.2444	8.000	8.867	2.333	16.000	46.333	9.000	1.667	0.920	0.577	8.964

C1 = 2000 ppm, C1 = 2000 ppm, C3 = 4000 ppm, C0 = Control, G1 = Mist chamber, G2 = Shade house, G3 = Open condition

CONCLUSION

Among various concentration of IBA, 4000 ppm concentration show the best performance in terms on survival percentage of cutting, number of sprouts, number of leaves**,** shoot length, shoot diameter, number of primary root, number of secondary root, root length, root diameter, fresh weight of root, dry weight of root and rooting percentage. While among the various growing condition of guava, mist chamber was shown best result in present study. It is suggested that mist chamber growing condition and 4000ppm concentration of IBA give the overall best performance of *Guava* within a short time and recommended for commercial vegetative multiplication of *guava*.

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RESEARCH COMMUNICATION

EFFECT OF TILLAGE AND ORGANIC MULCHES ON CONTENT AND UPTAKE OF NUTRIENTS ON INDIAN MUSTARD IN VINDHYAN REGION OF EASTERN UTTAR PRADESH

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Abstract: A field experiment was conducted on conventional and reduced tillage with different organic mulches during 2012-13 to study the effect of tillage and organic mulches on content and uptake of nutrients on mustard crop in vindhyan region of eastern Uttar Pradesh at the Agronomy farm of Rajiv Gandhi South Campus, Barakachha (BHU), Mirzapur which is situated in *Vindhyan* region. Data revealed that the content and uptake in grain and stover of mustard crop increased significantly with implementation of reduced tillage and application of water hyacinth. The maximum content and uptake of N, P, K and S were found with application of water hyacinth @ 2 t per hectare under reduced tillage condition. Paddy straw mulch is the second highest treatment in content and uptake of macro nutrients in mustard crop. The increasing order of organic mulches was- No mulch < legume straw mulch < paddy straw mulch < water hyacinth regarding content and uptake of macro nutrients by mustard crop. The maximum content of nitrogen (3.40%) and (3.46%) among all nutrients was observed in mustard grain with application of water hyacinth under reduced tillage system. The similar trend was found in case of potassium uptake by stover of mustard crop (62.51 and 65.29 kg ha^{-1}) under reduced tillage and water hyacinth, respectively.

Keywords: Soil, Mulching, Mustard, Content, Uptake

INTRODUCTION

Mustard is an important *rabi* oilseed crop in India. It occupies about 24.70 per cent of area and 48.28 per cent of production of the total oilseed production in India. Its area, production and productivity in the country is 5.43 m ha, 6.41 million tonnes and 1159 kg ha^{-1}, respectively. In Rajasthan, the total area under mustard cultivation is 2.84 m ha with the estimated production of 3.5 m tonnes & average productivity of mustard in the state is 1234 kg ha^{-1} (Awasthi *et al*., 2009).

In general, mulches have favorable effect on physical, chemical and biological properties of soil by stabilizing soil, aggregates, enhancing soil organic matter, soil nutrients and reducing run off and soil erosion by intercepting rain drops. Soil moisture is the major limiting factor for crop production under rainfed situation, therefore, moisture conservation is important to achieve higher yield. The effect of mulch on soil temperature, moisture regime and root growth as well as yield depend on the climatic environment, made of mulch application and quality and quantity of mulch materials. Among the various soil moisture conservation practices, mulching is one of the technology is assuming greater importance. Further, mulching reduces evaporation, checking down weeds and there by enhance infiltration of water (Katiyar, 2001). Further it moderates wide fluctuation in soil temperature too. Green manuring also play an important role in soil and moisture conservation and improvement of soil properties. Mulching is the process of covering the surface soil with various mulching materials such as straw, dry leaves, stubbles, cut grasses, polyethylene etc. Tillage plays a vital role in plant growth at different stages under rainfed cultivation. It also improves soil condition by altering the mechanical impedance to root penetration, hydraulic conductivity and holding capacity, which in turn affects plant growth (Bonciarelli, 1986).

MATERIAL AND METHOD

A field study was carried out during rabi season of 2012-13 at Rajiv Gandhi South Campus, Brakachha (BHU), Mirzapur which is situated in *Vindhyan* region of district Mirzapur (25º 10’ latitude, 82º 37’ longitude and altitude of 427 meters above mean sea level) occupying over an area of more than 1000 ha. The climate of Barkachha is sub-humid, characterized by extremes of temperature both in summer and winter with medium rainfall. Maximum temperature in summer (May) is reached up to 39.85˚C and minimum temperature in winter (January) falls below 8.12˚C. The average annual rainfall of locality is 1100 mm, of which nearly 90 per cent is contributed by South West monsoon between July to September and 10 percent rain fall in other months. The total rainfall and evaporation during the crop season 2012-13 was 53.55 mm and 43.9 mm; maximum and minimum temperature was 37.48ºC and 4.75ºC, and relative humidity was 96.28 and 83.96 per cent respectively.

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The experiment was conducted with eight treatment combinations, involves application of Conventional tillage and no mulch (T_1M_0), Conventional tillage and Water hyacinth mulch (T_1M_1), Conventional tillage and paddy straw mulch (T_1M_2), Conventional tillage and legume straw mulch (T_1M_3), Reduce tillage and no mulch (T_2M_0), Reduce tillage and water hyacinth mulch (T_2M_1), Reduce tillage and paddy straw mulch (T_2M_2), Reduce tillage and legume straw mulch (T_2M_3). The experiment was conducted under two tillage systems viz., conventional tillage and reduces tillage. In this system seeds were sown in rows with the help of hand operated narrow blade (*Kudal*) by opening furrow, with spacing of 30 cm between two rows. Higher seed rate (5 kg ha^{-1}) was applied at 4 cm depth in open furrows made with a manual single row drill at a spacing of 30×10 cm and immediately covered with soil. The recommended dose of fertilizers (25:40:25:2 Kg NPK & S/ha). Fifty percent of nitrogen and full dose of phosphorus, potassium and sulphur were applied at sowing and remaining 50% N was applied at the pre - flowering stage. Nitrogen in grain and stover was determined by modified Kjeldahl method. Oven dried grain and stover samples were digested in diacid mixture and P, K and S were determined by adopting standard methods (Jackson, 1973).

RESULT AND DISCUSSION

The highest nitrogen content grain (3.40 per cent) and stover (0.79 per cent) were observed in reduced tillage over conventional tillage grain (3.29 per cent) and stover (0.73per cent). Among the different mulches, the water hyacinth mulch was higher in nitrogen content of grain and stover (3.46 and 0.80 per cent) compared to rest treatments. Similar findings was also reported by Quddus (1989) andVerma *et al.* (2011). Phosphorus content in grain (0.64 per cent) and stover (0.13 per cent) was found highest under reduced tillage over conventional tillage grain (0.60 per cent) and stover (0.11per cent). The similar trend was observed in case of water hyacinth mulch. Potassium content in grain (0.74 per cent) and stover (1.29 per cent) was found in reduced tillage over conventional tillage grain (0.70 per cent) and stover (1.24 per cent). In the reduced tillage system observed superior in case of sulphur content in grain (0.62 per cent) and stover (0.38 per cent) over conventional tillage grain (0.58 per cent) and stover (0.34 per cent) (Table 1). Similar trend was seen in all the treatment combinations of tillage and organic mulches, (Kumar and Lal, 2012). The data revealed that (Table 2) the uptake of N,P,K & S increased with increasing content of these nutrients under different treatments. In the tillage system nitrogen uptake by grain (46.76 kg ha^{-1}) and stover (38.38 kg ha^{-1}) were recorded highest in reduced tillage over conventional tillage grain (40.97 kg ha^{-1}) and stover (34.12 kg ha^{-1}). Maximum values of uptake of these nutrients by mustard grain and stover were recorded under water hyacinth with reduced tillage system, while minimum under no mulch treatment. Similar trend was found in case of phosphorus, potassium and sulphur uptake by mustard grain and stover (Cepeda and Gomez, 2010).

Table 1. Effect of tillage and organic mulches on content of N, P, K & S in grain and stover of mustard

Treatments	Nitrogen (%)		Phosphorus (%)		Potassium (%)		Sulphur (%)	
	Grain	Stover	Grain	Stover	Grain	Stover	Grain	Stover
Tillage								
Conventional tillage	3.29	0.73	0.6	0.11	0.7	1.24	0.58	0.34
Reduce tillage	3.4	0.79	0.64	0.13	0.74	1.29	0.62	0.38
CD (0.05)	0.03	0.01	0.01	0.02	0.02	0.03	0.04	0.03
Mulch								
No mulch	3.15	0.7	0.57	0.08	0.67	1.17	0.55	0.32
Water hyacinth mulch	3.46	0.8	0.65	0.14	0.75	1.31	0.64	0.39
Paddy straw mulch	3.42	0.78	0.63	0.13	0.74	1.3	0.62	0.38
Legume straw mulch	3.35	0.77	0.62	0.12	0.72	1.27	0.61	0.37
CD (0.05)	0.04	0.02	0.01	0.01	0.01	0.01	0.02	0.02

Table 2. Effect of tillage and organic mulches on uptake of N,P,K & S by grain and stover of mustard

Treatments	Nitrogen uptake (kg ha^{-1})		Phosphorus (kg ha^{-1})		Potassium uptake (kg ha^{-1})		Sulphur uptake (mg kg^{-1})	
	Grain	Stover	Grain	Stover	Grain	Stover	Grain	Stover
Tillage								
Conventional tillage	40.97	34.12	7.47	5.1	8.73	57.69	7.27	16.02
Reduce tillage	46.76	38.38	8.77	6.19	10.14	62.51	8.6	18.36
CD (0.05)	2.43	1.29	0.47	1.27	0.84	3.77	0.04	1.47
Mulch								
No mulch	36.31	30.42	6.58	3.64	7.7	51.15	6.33	13.76
Water hyacinth mulch	49.21	40	9.27	6.9	10.64	65.29	9.03	19.18
Paddy straw mulch	46.42	38.11	8.57	6.25	10.04	63.3	8.46	18.41
Legume straw mulch	43.51	36.47	8.06	5.81	9.36	60.67	7.91	17.4
CD (0.05)	2.31	1.11	0.5	0.7	0.49	1.31	0.46	0.75

CONCLUSION

Highest content of N, P, K and S by mustard grain and stover were recorded under water hyacinth with reduced tillage system, while minimum under no mulch treatment. Similar trend was found in case of phosphorus, potassium and sulphur uptake by mustard grain and stover.

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RESEARCH COMMUNICATION

EVALUTION OF DIFFERENT ANTIFUNGAL COMPOUNDS AGAINST *RHIZOCTONIA SOLANI* CAUSING AERIAL BLIGHT OF SOYBEAN

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Abstrct: Soybean (*Glycine max* (L.) Merrill) is one of the most important oil seed crop of India . Soybean aerial blight caused by *Rhizoctonia solani* is a most important oilseed disease. The disease appears July-August and is characterized by sudden and complete death of the plants. Antifungal activity of different medicinal plant leaf extracts, oils and *Trichoderma spp* were studies under *in vitro* condition. The Out of fifteen medicinal plants leaf extracts, studies, the extract of Butch significantly inhibited the mycelial growth of *Rhizoctonia solani* under *in vitro* conditions. Among the medicinal oils, Eucalyptus and Neem oils were found to significantly inhibit the mycelial growth of *Rhizoctonia solani* at 5% concentrations. Among the antagonists, maximum mycelial growth inhibition was observed by *Trichoderma harzianum* (74.81%) followed by *Trichoderma viride* (67.40%) while *Trichoderma spp.* (mushroom isolates) was least effective against *Rhizoctonia solani*.

Keywords: Aerial blight of soybean, *Rhizoctonia solani*, Antifungal compound, *Trichoderma spp.*

INTRODUCTION

Soybean (*Glycine max* (L.) Merrill) is one of the most important oil seed crop of India .It was wonder of the twentinth century. Soybean rank first among world oilseed with an annual production of about 105 mt. Among the different growing countries of the world, USA, China, Brazil, Argentina and India are main which accounts more than 90% of the world's acreage (Taware *et al.*, 2007). Soybean is mainly grown during Kharif season in sandy loam to clay loam soil in Chhattisgarh. In Chhattisgarh, area, production and productivity of soybean are 0.82 m ha, 0.73 mt and 891 kg/ha, respectively which are much lower than national average (Anonymous, 2006b). Soybean aerial blight is a most important oilseed diseases. The disease appears July-August and is characterized by sudden and complete death of the plants. This disease is considered to be one of the most destructive and causes heavy losses in the yield particularly in warn and humid parts of the countries (Anwar *et al*., 1995). Yield losses can exceed 35-60 per cent and the disease is considered as economically important (Patel *et al.*, 1998). Although various fungicides have shown promising results in controlling the aerial blight of soybean but the phytotoxicity and fungicidal residue problems leading to the environmental pollution are the major constraints in disease management. Substancial emphasis is being given these days on using eco-friendly approaches for controlling plant diseases. Plant products are the best alternatives available today. Several; medicinal plant species have not been screened against plant pathogens. In same context, an attempt was made through this investigation, to evalution of different antifungal compounds against *Rhizoctonia solani* causing aerial blight of soybean.

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MATERIAL AND MATHOD

Leaf extracts of medicinal plants

Antifungal activity of fifteen medicinal plant leaf extracts were studies under *in vitro* condition taking plant leaf dextrose agar medium. The following medicinal plant viz., Lemon grass (*Cymbopogan flaxuosus*), Bhringraj (*Wadelia chinensis*), Kalmegh (*Andrographis paniculata*), Ashwagandha (*Withania somnifera*), Satawar (*Asparagus racemosus*), Butch (*Acorus calamus*), Mandukparni (*Centella asiatica*), Bramhi (*Bacopa moniari*), Patchouli (*Pogostemon patchouli*), Vantulsi (*Hyptis suaveolens*), Eucalyptus (*Eucalyptus globulus*), Besrum (*Ipomea spp*), Neem (*Azadirachta indica*), Karanj (*Pongamia pinnata*) and Datura (*Datura stramonium*) were used. PDA without extract was used as control. The preparation of leaf extract medium was same as PDA medium. 20gm leaves of each medicinal plant were taken in 100ml water and boiled till it becomes softened. Softened medicinal plant leaves were cursed in pastel and mortar, and then extract was filtered. Two gm of dextrose and two gm agar- agar were mixed in filtered leaf extracts and volume was made up to 100 ml and then sterilization was done by autoclaving at 15 lbs pressure for 20 minutes. To avoid bacterial contamination a little amount of streptomycin sulphate was added at the time of pouring of media. In each sterilized petriplates 20 ml media was poured and allowed to solidify. A 5 mm disc from 4 days old culture of test fungus was placed in the centre of medium. Three replications were maintained in each treatment along with a control. The inoculated petriplates were than incubated in the BOD incubator at 27±2 ^{o}C and observation were recorded at 3 and 5

days after incubation and calculated % growth inhibition of pathogen.

Medicinal oils

Antifungal activities of different medicinal plant oils were studied under *in vitro* condition taking potato dextrose agar medium. The following medicinal oil *viz.,* Alsi (*Linum usitaticimum*), Til (*Sesamum indicum*), Neem (*Azadirachta indica*), Eucalyptus (*Eucalyptus globulus*), Arandi (*Ricinus communis*), Mahua (*Maduca indica*), Karanj (*Pongamia pinnata*) and Mustard (*Brassica compestris*) were used. PDA without oil was used as control. To evaluate the bio efficacy of medicinal oils with 5 % concentration 5 ml oils were mixed in 95 ml PDA in each conical flask of 250 ml capacity. There after autoclaving was done at 15 lbs for 20 minute. To avoid the bacterial contamination, a little amount of streptomycin sulphate was added at the time of pouring of media. 15-20 ml media was poured in each of the sterilized petriplates of 90 mm diameter and allowed to solidify. On solidification, 5 mm disc of 3 days old culture of test fungus was placed in the centre of the plates. Three replications were kept in each treatment along with control. Inoculated petriplates were incubated in the BOD incubator at 27±2 ^{o}C and observations were recorded at 1, 2 and 3 days after inoculation and calculated % growth inhibition of pathogen.

Bioagents

The pure cultures of *Trichoderma viride* and *Trichoderma harzianum* were obtained from department of plant pathology. The culture of *Trichoderma spp*. (Mushroom isolates) were obtained from paddy straw mushroom beds. The antagonistic activity of these isolates against *R. solani* was evaluated by dual culture technique. An amount of 20 ml sterilized melted PDA was poured in 90 mm diameter petriplates. After solidification of medium, 5 mm disc of the antagonist and the test pathogen were separately cut with the help of a sharp sterilized cork borer from the edge of 3 days old culture and placed in straight line at distance of 5 mm from the edge. In control plates antagonist was replaced with the test fungus. Three replications were maintained. The inoculated petriplates were incubated at 27±2 ^{o}C. Observation was made on the radial growth of the antagonist and test pathogen when the fungus in control plate reached to rim of the plate. The per cent growth inhibition of the test pathogen in presence of antagonist *was* calculated over control as bellow.

$$\text{Per cent growth inhibition of } \textit{Trichoderma spp.} = \frac{\text{Growth of test pathogen in control plate} - \text{Growth of test pathogen in presence of}}{\text{Growth of test pathogen in control plates}} \times 100$$

RESULT AND DISCUSSION

Leaf extracts of medicinal plants

Hot water leaf extracts of different medicinal plant species were evaluated to observe the inhibitory activity against *Rhizoctonia solani* under *in vitro* condition. Fifteen medicinal plant leaf extract were evaluated to study the antifungal activity on the growth of *Rhizoctonia solani* at 3 and 5 days after inoculation. The data presented in Table 1. It is clear from the data that the mycelial growth of *Rhizoctonia solani* differs significantly with respect to different medicinal plant leaf extracts used. The per cent inhibition in mycelial growth of *Rhizoctonia solani* ranged from 12.83 % to 87.71 %. The maximum inhibition in mycelial growth was recorded in the extract of Butch (87.71%) followed by Eucalyptus *(*75.93 %). They were statistically at par with each other at 3 DAI. Minimum inhibition in mycelial growth was recorded in Satawar (12.83 %) as comparison to control. The per cent mycelial growth inhibition at 5 DAI by different plant extracts ranged between 0.00 to 87.04 %. The maximum mycelial growth inhibition was recorded in plant extract of Butch (87.04 %) followed by Eucalyptus (66.66 %). Bhringraj, Kalmegh, Satawar, Mandukparni, Patchouli, Besrum, Neem and Karanj were failed to inhibit the mycelial growth of *R. solani* . The results indicate that all plant extracts inhibited the growth of the fungus from 12.83% in Satawar to 87.71% in Batch after 3 days of inoculation respectively. The other plant extracts showing promising results against *R. solani* were Eucalyptus and Ashwagandha. Tiwari *et al.* (2007) also tested the efficacy of medicinal plant extracts *in vitro* against *Rhizoctonia solani* and reported that out of 950 extracts, *Acorus calamus* (Butch) was highly effective against *R. solani* at all concentration (1%, 5% and 10%). Similarly Reddy *et al.* (2002) reported that extract of, *Eucalyptus globulus, Allium sativam* and *Zingiber offinale* caused 61 to 100 percent inhibition of the mycelial growth of *Rhizoctonia solani* causing root rot of chickpea. Sharma *et al.* (2005) tested the efficacy of eight plant extracts against *Rhizoctonia solani in vitro* and reported that *Eucalyptus globulus* inhibited 85% mycelial growth at 10% concentration.

Medicinal oils

All the medicinal oils were superior in reducing the mycelial growth of *Rhizoctonia solani* over control at 5% (Table 2). Maximum mycelial growth inhibition was recorded in Eucalyptus oil (100 %) followed by Neem (86.78, 71.85 and 49.26 %) at 1, 2 and 3 days after inoculation respectively. Minimum mycelial growth inhibition was recorded in Arandi (38.01%) at 1 DAI, Mahua (37.41%) at 2 DAI and Til (8.15%) at 3 DAI (Plate 8). Madhukar and Reddy (1989) reported that Eucalyptus oil completely checked the fruit rot diseases of guava caused by *Rhizoctonia solani* and anthracnose caused by *Pestalotiopsis*

versicolor. Coconut oil, castor oil and groundnut oil also effective in reducing the fruit rot of guava. Singh and Dwivedi observed the fungitoxic activity of the oils of *Eucalyptus globulus* against the sclerotial production of *S. rolfci.* Similarly Singh *et al.* (1989) evaluated 6 oils of medicinal plants for their antifungal activity against *Sclerotium rolfsii* and 10 soil inhabiting fungi. Out of these, the oil of *Azadirachta indica* was most effective followed by *Eucalyptus globulus.*

Bioagents

The data are presented in Table 3 revealed that all the isolates of *Trichoderma* in dual culture inhibited mycelial growth of *Rhizoctonia solani* and inhibition ranged from 55.77 to 74.81 per cent over control. A clear visible band was formed in the zone of contact between the two fungal growths. Minimum mycelial growth of *Rhizoctonia solani* was recorded in *Trichoderma harzianum* (22.67mm) followed by *Trichoderma viride* (29.34mm). Maximum mycelial growth of *Rhizoctonia solani* was recorded in *Trichoderma spp* (Mushroom isolates) (38mm). It is concluded from the above data that *Trichoderma harzianum* isolates was found most effective species to inhibit the mycelial growth of *Rhizoctonia solani.* Ray *et al.* (2007) also tested the efficacy of bio-agents under *in vitro* condition. Among the bio-agents, *T. harzianum* found most effective as it inhibited the mycelial growth of *R. solani* after 96 hr of incubation followed by *T. viride* and *P. flourescens* where 82.43 and 80.36 mm growth were observed, respectively. Sarojaini and Nagmani, (2007) tested the antagonistic potential of *Trichoderma* isolates against *Rhizoctonia solani* and found that all the isolates inhibited the mycelial growth of *R. solani* in dual cultures. Similarly Cundom *et al.* (2003) evaluated the antagonistic activity of nine isolates of *Trichoderma spp.* in dual culture and found that all the isolates significantly inhibited the mycelial growth of *R. solani* in dual culture.

Table 1. Evaluation of leaf extracts of medicinal plants against *Rhizoctonia solani* under *in-vitro* condition

S.N.	Medicinal plants	3 DAI**		5 DAI**	
		Mycelial growth (mm)*	% inhibition	Mycelial growth (mm)*	% inhibition
1	Lemongrass	35.66	42.78	57.50	36.11
2	Bhringraj	44.50	28.60	90.00	0.00
3	Kalmegh	45.50	27.00	90.00	0.00
4	Ashwagandha	28.83	53.74	53.33	40.74
5	Satawar	54.33	12.83	90.00	0.00
6	Butch	7.66	87.71	11.66	87.04
7	Mandukparni	47.50	23.79	90.00	0.00
8	Brahmi	31.16	50.00	59.16	34.26
9	Patchouli	47.66	23.53	90.00	0.00
10	Vantulsi	38.16	38.77	81.66	9.26
11	Eucalyptus	15.00	75.93	30.00	66.66
12	Besrum	46.66	25.14	90.00	0.00
13	Neem	51.66	17.11	90.00	0.00
14	Karanj	46.66	25.14	90.00	0.00
15	Datura	36.66	41.18	64.16	28.71
16	Control	62.33		90.00	
	S Em±	3.14		1.23	
	CD (5%)	9.1		3.6	

* Means of three replications

** Days after inoculation

Table 2. Evaluation of medicinal oils against *Rhizoctonia solani in-vitro* condition

Medicinal oils	1 DAI**		2 DAI**		3 DAI**	
	Mycelial growth (mm)*	% inhibition	Mycelial growth (mm)*	% inhibition	Mycelial growth (mm)*	% inhibition
Alsi	22.00	45.45	50.00	44.44	78.66	12.60
Til	24.33	39.67	51.66	42.60	82.66	8.15
Neem	5.33	86.78	25.33	71.85	45.66	49.26
Eucalyptus	0.00	100.00	0.00	100.00	0.00	100.00

Arandi	25.00	38.01	53.00	41.11	90.00	0.00
Mahua	7.00	82.64	31.33	65.18	53.33	40.74
Karanj	19.00	52.88	40.33	55.18	63.66	29.26
Mustatd	24.00	40.49	56.33	37.41	76.66	14.82
Control	40.33		90.00		90.00	
S Em±	1.47		0.62		1.74	
CD (5%)	4.4		1.9		5.2	

* Means of three replications
** Days after inoculation

Table 3. Effect of *Trichoderma spp* on mycelial growth of *Rhizoctonia solani*

Trichoderma species	**Dual culture (mycelial growth mm)***		**% Inhibition**
	*Trichoderma**	*Rhizoctonia **	
Trichoderma viride	60.66	29.34	67.40
Trichoderma harzianum	67.33	22.67	74.81
Trichoderma spp (Mushroom isolates)	52.00	38.00	57.77
Control	90.00	90.00	
CD (5%)	2.3	2.3	
S Em±	0.70	0.70	

*Mean of three replication

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RESEARCH COMMUNICATION

EFFECT OF WEED MANAGEMENT ON INDIAN MUSTARD (*BRASSICA JUNCEA* L.) CULTIVARS

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Abstract: A field experiment was conducted at Banaras Hindu University, Varanasi (U.P.) during winter (*rabi*) seasons of 2011-12 and 2012-13 to develop weed management practices for popular Indian mustard (*Brassica juncea* L.) cultivars, *viz.*, 'Kranti', 'Pusa bold' and 'Varuna' with pre-emergence application of alachlor 0.75 kg/ha, pendimethalin 0.75 kg/ha and metolachlor 0.75 kg/ha alone or their integration with hand weeding after one month of sowing. Pre-emergence application of alachlor 0.75 kg/ha, pendimethalin 0.75 kg/ha and metolachlor 0.75 kg/ha with one hand weeding at 30 days after sowing (DAS) were the most effective in minimizing weed population and their dry weight in mustard. These treatments recorded maximum seed yields (19.71, 19.06 and 18.94 q/ha) and increase 47.76%, 42.77% and 41.87% over weedy check, respectively. No significant difference was seen in mustard cultivars with respect to weed management. The maximum seed yield was obtained with 'Kranti'. The net return was maximum in alachlor 0.75 kg/ha applied along with hand weeding over other treatments. Unchecked weeds caused 32.27% seed yield loss with minimum net return.

Keywords: Cultivars, Herbicides, Hand weeding, Indian mustard, Weed, Yield

INTRODUCTION

Indian mustard (*Brassica juncea* (L.) Czernj and Cosson) is one of the most important winter oilseed crops of India. India occupies third position in rapeseed-mustard production in the world after China and Canada. In India, during 2013-14, the rapeseed-mustard crop had production of about 7.96 million tonnes from an area of 6.70 million hectares with an average productivity of 1188 kg ha^{-1}. Weeds were of major importance and accounted for the major losses among the various environmental and other constraints responsible for low productivity of mustard. Yield losses due to weeds varied from 25 to 45% depending on the type of weed flora and their intensity, stage and duration of crop-weed competition (Singh *et al.,* 2013). Therefore, the management of weeds is more important for achieving higher yields of Indian mustard. The use of herbicides is found effective and economic for controlling weeds in Indian mustard, but the use of herbicides alone is not enough to provide weed free environment (Yadav, 2004). Nowadays, there is also renewed interest in the development of research programmes that consider the potential for the development of crop varieties that interfere with the development of weeds. Therefore, the present investigation was undertaken to study the weed management practices on Indian mustard cultivars.

MATERIAL AND METHOD

The field experiment was conducted during *rabi* (winter) seasons of 2011-12 and 2012-13 at Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (25°18′ N latitude, 83°03′E longitude and altitude of 129 m above mean sea level), Uttar Pradesh, India on a sandy loam soil with pH 7.4, organic carbon 0.38%, available N, P and K 195.0, 18.8, 218.0 kg/ha, respectively. Mean minimum and maximum temperature during crop seasons ranged from 5.8 to 22.1°C and 17.1 to 39.2°C, respectively. During the years, weather conditions were extremely favourable for both crop and weed growth. The field experiment was conducted in factorial randomized block design with three replications, having 24 treatment combinations consisting of eight weed control treatments (*i.e.* alachlor 0.75 kg/ha, pendimethalin 0.75 kg/ha, metolachlor 0.75 kg/ha, alachlor 0.75 kg/ha + hand weeding (HW), pendimethalin 0.75 kg/ha + HW, metolachlor 0.75 kg/ha + HW, HW and weedy check) and three Indian mustard cultivars (*i.e.* 'Kranti', 'Pusa bold' and 'Varuna'). Mustard crop was sown in rows at 30 cm apart on 16 and 20 October during 2011 and 2012, respectively. Herbicides alachlor, pendimethalin and metolachlor are applied at 2 DAS using volume spray of 600 litres/ha with a knapsack sprayer fitted with flat-fan nozzle, whereas hand weeding was given at 30 DAS. Recommended package of practices were adopted to raise the experimental crop. A uniform dose of diammonium phosphate (100 kg/ha) was drilled at the time of sowing and 150 kg/ha urea was applied in two equal splits, half at sowing and the remaining after first irrigation at 35 DAS as top dressing. Observation on weed population (No./m^2) and weed

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dry matter production (g/m^2) were recorded at 45 DAS and 90 DAS. Data related to yield attributes and seed yield were recorded at harvest. Net return (` ha^{-1}) of the treatments was computed based on the prevalent market prices.

Table 1. Effect of treatments on weed population and dry matter production of weeds

Treatment	Weed population*(No./m^2)				Weed dry matter production*(g/m^2)			
	2011-12		2012-13		2011-12		2012-13	
	45 DAS	90 DAS	45 DAS	90 DAS	45 DAS	90 DAS	45 DAS	90 DAS
Weed management practice								
Alachlor 0.75 kg ha^{-1}	48	24	48	30	20.70	14.58	24.20	16.50
Pendimethalin 0.75 kg ha^{-1}	54	28	50	36	25.41	16.00	27.11	17.10
Metolachlor 0.75 kg ha^{-1}	56	31	54	39	27.21	18.31	28.32	18.60
Alachlor 0.75 kg ha^{-1} + hand weeding (30 DAS)	30	15	41	19	13.11	8.80	15.71	11.21
Pendimethalin 0.75 kg ha^{-1} + hand weeding (30 DAS)	36	16	42	22	14.10	9.10	17.00	14.91
Metolachlor 0.75 kg ha^{-1} + hand weeding (30 DAS)	38	19	45	23	15.18	10.12	18.88	15.50
Hand weeding (30 DAS)	47	22	51	27	18.16	15.10	25.41	74.11
Weedy check	99	81	88	64	71.50	47.50	65.50	38.50
CD (P=0.05)	8.23	5.32	7.37	6.34	3.82	4.60	5.31	4.71
Cultivar								
Kranti	50	30	48	31	24.40	17.5	27.50	19.12
Pusa bold	51	34	49	33	25.00	18.00	28.20	19.20
Varuna	53	34	53	36	25.38	18.12	28.80	19.24
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS

*Data is transformed to $\sqrt{x+1}$; NS: Non-significant

Table 2. Effect of treatments on siliquae/plant, seeds/siliqua, seed yield and net return (Mean of two years)

Treatment	Siliquae/plant	Seeds/siliqua	Seed yield (kg/ha)	Net return* (`/ha)
Weed management practice				
Alachlor 0.75 kg ha^{-1}	217.68	17.11	1680	35,700
Pendimethalin 0.75 kg ha^{-1}	207.35	16.96	1611	34,030
Metolachlor 0.75 kg ha^{-1}	202.68	11.68	1549	32,070
Alachlor 0.75 kg ha^{-1} + hand weeding (30 DAS)	242.68	17.68	1971	39,530
Pendimethalin 0.75 kg ha^{-1} + hand weeding (30 DAS)	232.18	17.36	1906	37,780
Metolachlor 0.75 kg ha^{-1} + hand weeding (30 DAS)	226.32	17.10	1894	37,620
Hand weeding (30 DAS)	213.52	17.06	1660	31,300
Weedy check	156.35	16.48	1335	26,550
CD (P=0.05)	17.72	0.61	162	-
Cultivar				
Kranti	232.39	17.14	1826	38,780
Pusa bold	217.56	16.69	1734	36,020
Varuna	217.56	16.64	1523	29,690
CD (P=0.05)	17.70	0.48	167	-

*Price of mustard seeds: `30/kg; Common Cost of Cultivation: `12,500/ha.

RESULT AND DISCUSSION

The most dominant weed species at experimental site were *Chenopodium album, Anagallis arvensis, Melilotus indica, Fumaria parviflora, Vicia sativa, Rumex spinosus, Melilotus alba, Cynodon dactylon* and *Cyperus rotundus.*

Weed population and dry matter production of weeds were significantly minimized by application of different weed control treatments as compared to weedy check (Table 1). Pre-emergence application of alachlor, pendimethalin or metolachlor each at 0.75 kg/ha along with one hand weeding at 30 DAS being at par, caused maximum reduction in weed population and dry weight of weeds during both the years. Chauhan *et al.* (2005) reported similar effects of pendimethalin and hand weeding. Application of alachlor, pendimethalin and metolachlor alone was significantly inferior to integrated weed management treatments.

There was a significant difference in the siliquae/plant and seeds/siliqua as these recorded values were more in the treated plots than in weedy check (Table 2). No significant differences in yield attributes was observed among the alachlor 0.75 kg/ha, pendimethalin 0.75 kg/ha, metolachlor 0.75 kg/ha and one hand weeding at 30 DAS. However, integration of these herbicides that is alachlor 0.75 kg/ha, pendimethalin 0.75 kg/ha, metolachlor 0.75 kg/ha along with one hand weeding at 30 DAS resulted in maximum siliquae/plant and maximum seeds/siliqua. The highest seed yields (19.71, 19.06 and 18.94 q/ha) were recorded with application of alachlor, pendimethalin and metolachlor each at 0.75 kg/ha supplemented by one hand weeding at 30 DAS and estimated 47.76%, 42.77% and 41.87% higher yield over weedy check, respectively. All the weed control practices significantly increased the seed yield over weedy check. The increase in seed yield over with weed control practices is believed to be an indirect expression of reduction in crop-weed competition which significantly helped in increasing the yield components and the seed yield of crop.

Mustard cultivars did not have significant influence on population and dry matter production of weeds during both the years. However, a significant increase in siliquae/plant and seeds/siliqua was observed due to different cultivars. The increase in seed yield was recorded 19.89% and 13.85% with 'Kranti' and 'Pusa bold', respectively over 'Varuna'. More seed yield in 'Kranti' and 'Pusa bold' were mainly due to maximum expression of yield attributes like siliquae/plant and seeds/siliqua. Similar finding was reported by Sharma and Mishra (1997). Net return followed the same pattern as seed yield and the highest net return was obtained with mustard cultivar 'Kranti'. Among weed management practices, net return was maximum in alachlor, pendimethalin and metolachlor integration with one hand weeding at 30 DAS and this was to be `39,530, 37,780 and 37,620/ha, respectively. Hand weeding was costly, therefore, all herbicidal treatments were superior to it in influencing net return due to weed control.

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