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Modeling and forecasting of tea production in West Bengal

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ABSTRACT

Tea production in West Bengal is playing great role not only in world tea market but also in contributing substantially to Indian economy and in employment generation. Taking all these into consideration the present study attempts to analyze the growth and trend behavior of tea production scenario in West Bengal. Using time series data on tea production parameters and factors of production, the study attempts to model and forecast the future production behavior of tea in West Bengal. In this endeavour, a new method in formulating weather and other factor indices have been developed using direct effects from path coefficient analysis. Comparison of methods indicates that the newly developed method has outperformed some of the existing methods in literature. The study identified relative humidity and fertilizer consumption as the significant contributors in tea production. Using ARIMA models, in association with factors of production the study forecasts tea production of 318992 thousand kg from 120345 hectare of plantation with average productivity of around 2625 kg^{-1}/ha in West Bengal during 2020.

Keywords: Factors of production, indices, modeling and forecasting

Tea serves as the most important and popular drink for two-thirds of the world population not only because of its attractive aroma and taste but also because of its many pharmacological effects, like suppressing tumor cell growth, reducing cardiovascular diseases, anti obesity and decrease the risk of atherosclerosis (Wang *et al*., 2010). Globally, tea is cultivated in 3.7 million hectares of land with an annual production of 4.07 million tones (Anon., 2010) thereby, resulting in average productivity of around 1100kg^{-1} ha. Amongst tea producing countries, the principal producers are China, India, Sri Lanka, Kenya and Indonesia. These five countries account for 77% of world production and 80% global exports. India is the largest tea producing country in the world and tea contributes 1% of the GDP of the country (Gupta and Dey, 2010). Major tea producing states in the country are Assam, West Bengal, Tamil Nadu and Kerala. West Bengal offers tea from Darjeeling, Dooars and Terai, contributing 24 percent of total production of India (Hazarika and Muraleedharan, 2011). Tea is grown on 115095 ha with production of 226.32 million kg in West Bengal in 2011 (Anon., 2012) Darjeeling is known as "The Champagne of Teas", cultivated on the slope of the Himalayas. None of tea in world has been able to match "the Darjeeling flavor". Darjeeling's Castleton tea held world record of Rs. 5001 per^{-1} kg due to its unique, delicate flavor and character (Arya, 2013). There are 309 tea estates in the State in the organized sector covering 103431 hectares. Besides, 8078 small growers are growing tea in 11094 hectare (Anon., 2011). Indian tea industry is one of the oldest agro-based well organized industries as it provides direct employment to more than a million workers mainly drawn from the backward and economically weaker section of the society of which a sizeable number are women (Jain, 2011). It is also a substantial foreign exchange earner and provides sizeable amount of revenue to the State and Central Exchequer. In 2003 West Bengal contributes 47 % of tea export of India (Anon., 2004).

But the production of tea in West Bengal was 221.57 million kg in 2009 as compared to 233.08 million kg in 2008. The over all production of tea declined by 4.9%, the production also declined by 6.2% during 2008 over the period 2007 (Anon., 2009). From 2001 to 2009 there is no considerable expansion in the land used for tea over a period of ten years in West Bengal (Rasaily, 2013). Tea production is influenced by various factors such as soil, climate, plant growth, pests and diseases. The seasonal effect on tea quality and production has long been known (Tang *et al*., 2011). A report of 2011 indicates that tea industry in West Bengal facing problems of low levels of productivity, high cost of production, decline in quality of production (Anon., 2011). So the study of growth, trends and production scenario of tea has got greater emphasis in research arena, not only in West Bengal but also in other states. Roy (2011) reviewed the growth in tea industry of Assam from 1970 to 2008 and revealed that growth of tea in Assam was stagnated. Ahammed (2012) analyzed the trends in Bangladesh tea using polynomial models. Borodoloi (2013) analyzed global tea production and export

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trend of India using linear regression analysis. Tea production in Sri Lanka was forecasted using ARIMA models (Rohana, 2005). Dutta *et al.* (2012) studied the linear relationship between rainfall and fertilizer with north east tea production. Study on above aspects and also on analysis of growth, trend, associationship of production with inputs, modeling and forecasting of tea production in West Bengal is very rare and almost nil. Hence there is a need to study production scenario of West Bengal tea thoroughly. As weather and technology factors affecting tea production, it is necessary to study what extent the climatic factors and other factors of production are associated. In this study attempt has been made not only to study trend, growth of tea in West Bengal but forecast production scenario considering various factors of production like weather and fertilizer.

MATERIA AND METHODS

To study the production scenario of tea in West Bengal and influence of associated factors like weather and fertilizer on production, long term data on area, production and yield of tea from Tea board of India was collected for last 50 years. Data on ancillary variables like weather (Temperature, Rainfall, Relative humidity) and fertilizer consumption (Nitrogen, Phosphorus and Potassium) for West Bengal was also collected from India meteorological Department and Fertilizer Association of India respectively. Fertilizer consumption of a particular crop is not available, but the total consumption fertilizer is assumed to pursue a good indicator of tea production in state.

Time series data are very much susceptible to presence of outlier; as such present investigation started with test for outlier as per Grubb's statistic (www.graphpad.com). On rejection of outlier or replacement of extreme values (if any) by median, the data are subjected to test of randomness using turning point test. (Descriptive statistics provide simple summaries about the sample data) Descriptive statistics are used to describe the basic features of the data in any study. The most widely used descriptive measure of central tendency and dispersions like arithmetic mean, range, standard deviation along with simple and compound growth rates are used to explain each series. Procedure for simple and compound growth rate is as follows

Simple growth rate: This has been calculated using the formula $\frac{X_t - X_0}{X_0 \text{x } n}$ x100,
where, X_t is the value of the series for the last period and X_0 is the value of the series for first period and n is the number of periods.

Compound growth rate: Procedures given by Prajneshu and Chandran (2005) was followed for computing compound growth rate. If Y denotes the area, production and productivity at a time X and r is the compound growth rate, model employed for estimating r is based on eq., (1) :

$$X_t = Y_t(1+r)^t \quad (1)$$

The usual practice is to assume a multiplicative error-term in equation (1) so that the model may be linearized by means of logarithmic transformation, giving equation (2) :

$$\text{Ln}(Y_t) = \text{A} + \text{B.X} + e \quad (2)$$

where, A = Ln(Y_0), and B = Ln(1 + r). Equation (2) is then fitted to data using the "method of least squares" and goodness of fit is assessed by the co-efficient of determination R^2. Finally, the compound growth rate is estimated by equation (3) :

$$\hat{r} = \exp(\hat{B}) - 1 \quad (3)$$

Trend models

To trace the path of production process different parametric trend models as given in table below are used. Among the competitive trend models, the best models are selected based on their goodness of fit (measured in terms of R^2) value and significance of the coefficients.

Table 1: Linear and non-linear trend models

Model No.	Model	Name of the model
I.	$Y_t = b_0 + b_1 t$	Linear equation
II.	$Y_t = b_0 + b_1 t + b_2 t^2$	Second Degree Polynomial
III.	$Y_t = b_0 + b_1 t + b_2 t^2 + b_2 t^3$	Third Degree Polynomial

where Y is the area/ production/ productivity and t is the time points

Association of the factors of production with yield

The production of tea is assumed to be influenced by climatic factors like rainfall, temperature and also use of several factors like fertilizer consumption and other resources. Hence these factors are needs to consider for forecasting. Monthly weather data on maximum and minimum temperature, rainfall and relative humidity for 8.30 and 5.30 hrs was used for whole crop season data. Two synthetic variables were developed *i.e.,* difference in maximum and minimum temperature and humidity. Also yearly state wise fertilizer consumption data of N, P and K was also incorporated.

For selection of effective variables influencing production methodology of weather indices proposed by Agarwal *et al.* (2001) was followed. In this method two variables are generated from original weather parameter. These indices are known as un-weighted indices and weighted indices. Un-weighted indices are totality of weather variable over crop season and weighted indices are weighted sum of weather variables over crop season. The weights are being the correlation coefficient between yearly (linear detrended) crop yield and weather parameters of respective months. Similarly indices were also generated for interactions of weather variables, using monthly product of weather variable taking two at time. Fertilizer indices (un-weighted and weighted) also developed from fertilizer parameters (N, P and K) using above procedure. Combinations of weather and fertilizer indices generated are presented in Table 1. Using this method total 36 variables are generated from weather and fertilizer data. Then These 36 variables were regressed with yield using stepwise regression (Draper and Smith 1981; Gomez and Gomez 1966) and significant variables were selected.

Table 2: Weather indices developed by method using Agarwal *et al.*

	Un-weighted weather indices							
	Tmax	**Tmin**	**RF**	**RH_1**	**RH_2**	**Diff in temp**	**RH diff**	**Fertilizer**
Tmax	Z10							
Tmin	Z120	Z20						
RF	Z130	Z230	Z30					
RH_1	Z140	Z240	Z340	Z40				
RH_2	Z150	Z250	Z350	Z450	Z50			
Temp Diff temp						Z60		
RH Diff							Z70	
Fertilizer								Z70
	Weighted weather indices							
Tmax	Z11							
Tmin	Z121	Z21						
RF	Z131	Z231	Z31					
RH_1	Z141	Z241	Z341	Z41				
Rh_2	Z151	Z251	Z351	Z451	Z51			
Temp Diff temp						Z61		
RH Diff							Z71	
Fertilizer								Z71

Tmax=Maximum Temperature, Tmin=Minimum Temperature, RF=rainfall, RH_1= Morning relative humidity and RH_2 = Evening relative humidity, Temp Diff= Difference in temperature and RH Diff = Difference in humidity

Proposed method 1

In the above method it is assumed that technology impact is linear and hence yield was detrended using linear model. In this paper, modification to above method is made and one method is proposed. Instead of assuming linear trend, we have taken the best fitted trend model to de-trend the series before calculation of weather indices. Then correlation coefficients between best fitted detrended yield and weather variables are taken as weights during development of weather indices. In the same way correlation coefficients between best fitted detrended yield and fertilizer parameters is taken as weight during development of fertilizer indices. Un-weighted indices for weather and fertilizer are also developed. Both fertilizer and weather indices (36 variables) together regressed with yield using stepwise regression and significant parameters were selected.

Proposed Method 2

Agarwal *et al*. (2001) have used correlation coefficients as weight for developing weather indices. Simple correlation coefficient provides linear association of two variables and it doesn't consider presence of other variables. Direct effects of path coefficient analysis are the standardized partial regression coefficients which measures the effect of independent variable on dependent variable excluding the indirect effects of other variables via the independent variable concerned. Here we proposed second method for selection of associated variables using direct effect between the best fitted detrended yield and weather as weight during the development of weather indices. Fertilizer indices are also generated using weight from direct effects of path analysis and the best fitted detrended yield. Then un-weighted and weighed indices of fertilizer and weather together regressed with yield using stepwise regression and significant parameters were selected.

So, factors associated with production are selected using three methods *i.e.* weather indices method by Agarwal *et al.*, proposed method 1 and proposed method 2.

Modeling and forecasting of tea

ARIMA technique given by Box and Jenkins (1976) was used. Use of such models in forecasting purpose is also found in Mishra *et al.* (2013). Factors of production selected from above procedures also used in modeling. Modeling of tea production is done using ARIMA modeling without and with considering factors of production. Detailed procedure of ARIMA modeling is given below.

ARIMA model: ARIMA models, stands for Autoregressive Integrated Moving Average models. Integrated means the trends has been removed; if the series has no significant trend, the models are known as ARMA models.

Autoregressive Models (AR): The notation AR (p) refers to the autoregressive model of order p; the AR(p) model is written

$$X_t = c + \sum_{i=1}^{P} \alpha_i X_{t-i} + \mu_t$$

where, $\alpha_1, \alpha_2 ... \alpha_p$ are the parameters of the model, c is a constant and μ_t is white noise i.e. $\mu_t \sim WN(0,\sigma^2)$.

Moving Average model (MA): The notation MA (q) refers to the moving average model of order q:

$$X_t = \mu + \sum_{i=1}^{q} \theta_i \varepsilon_{t-i} + \varepsilon_t$$

where the $\theta_1, ..., \theta_q$ are the parameters of the model, μ is the expectation of X_t (often assumed to equal 0), and ε_t the is the error term.

Given a set of time series data, one can calculate the mean, variance, autocorrelation function (ACF), and partial autocorrelation function (PACF) of the time series. Based on the nature of ACF and PACF appropriate ARIMA models are worked out, but the final decision is made once the model is estimated and diagnosed. In this step one can see whether the chosen model fits the data reasonably well.

Developed models are compared according to the minimum values of Root Mean Square Error (RMSE), Mean Absolute Error (MAE), Mean Square Error (MSE) and Mean Absolute Percentage Error (MAPE) and maximum value of Coefficient of determination (R^2) and of course the significance of the coefficients of the models. Best fitted models are put under diagnostic checks through auto correlation function (ACF) and partial autocorrelation function (PACF) of the residuals to verify to the residuals estimated from the models are white noise, if there are, one can accept particular fit otherwise discard it. Once the model satisfies the requirement, are used for forecasting purpose.

$$\text{RMSE} = \sqrt{\frac{\sum_{i=1}^{n}\left(\frac{X_i - \hat{X}_i}{X_i}\right)}{n}} X100$$

$$\text{MAPE} = \frac{\sum_{i=1}^{n}\left|\frac{X_i - \hat{X}_i}{X_i}\right|}{n} \text{x}100$$

$$\text{MAE} = \frac{\sum_{i=1}^{n}\left|X_i - \hat{X}_i\right|}{n}, \quad R^2 = \frac{\sum_{i=1}^{n}\left(\hat{X}_i - \bar{X}\right)^2}{\sum_{i=1}^{n}\left(X_i - \bar{X}\right)^2}$$

where, $X_i, \bar{X}, \hat{X}_i$ are the value of the i^{th} observation, mean and estimated value of the i^{th} observation of the variable X.

Using above procedures, four types of models were developed considering with and without factors of production. First model was obtained without considering any factors of production known as univariate ARIMA. Second and third model was developed using ARIMA with associated factors selected from weather indices and proposed method 1. Fourth model was developed using ARIMA with associated factors from proposed method 2. These models are compared for maximum R square, minimum AIC, SBC, Log likelihood, RMSE, MAE etc. Best fitted ARIMA model is selected and used for forecasting tea production in West Bengal up to 2020.

RESULTS AND DISCUSSION

In consonance with the objectives of the study and as discussed in materials and method section are subjected to test of outlier and randomness. Table 3 presents the results of outlier and randomness test. It is also clear from the table that the series under consideration followed definite trends in all the selected parameters and no outlier is detected.

Area under tea in West Bengal has varied between 82705 hectare to 115100 hectare with an average of 99267.72 hectare (Table 4), registering a simple growth rate of almost 0.75 % per annum as against compound growth rate of 0.70%. The value of skewness (0.17) indicates that there has been shift of area in favour of tea during the early phase of study period. This is well supported by the findings of Rasaily, 2013, that in West Bengal during 2001 to 2009 estate sector area declined by 7.41% and may be used for non plantation purpose. So far about the productions of tea during study period is concerned, an average production of 154422.74 thousand kilogram associate with a simple growth rate of almost 4.69 % per annum. Skewness is positive (0.70) while kurtosis is negative (-0.06) indicates that that there has been increase in production during early half of the study period and it remains steady for a long duration. Average productivity of tea in West Bengal is 1524.33 kg^{-1} ha and ranges between *998* kg^{-1} *ha to 2426* kg^{-1} *ha*. By and large the productivity of tea has recorded a 1.40% compound growth rate during the whole period under study. Both skewness and kurtosis were positive indicating been increase in productivity during early half of the study period could not be sustained for longer period. Lower productivity of West Bengal may be attributed due to lower productivity in Darjeeling district around *545* kg^{-1} *ha* which in turn may be due to fact that tea plucking included collection of finest two leaves and bud to enhance the unique flavour and also due to old age tea bushes as opined by Kadavil, (2007).

Knowing the above overall performance, path of movement of the series was traced through parametric trends models (Table 5). A wide range of models has been explored, among the competitive models the best fitted models are selected based on the maximum Adj. R^2 along with significance of coefficients. Among the competitive parametric models, all cases cubic models are found best fitted; thereby indicating that the movement of all the series was uniform throughout the West Bengal. This may be due to the changes in policies and its execution at different point of times.

The most important factors affecting crop production are identified by using methods described (Table 6).Yield was detrended using cubic polynomial model and this detrended yield was used in analysis. In case of weather indices by Agarwal *et al*. and proposed method 1, it is found that F11 *i.e.* weighted fertilizer and Z41 *i.e.* weighted morning humidity was significant factors affecting crop yield. In case of proposed method 2, weighted fertilizer (F11) and un-weighted relative humidity (Z40) are found significant. Overall, fertilizer and relative humidity are main factors affecting tea production positively in West Bengal. Patra *et al*. (2013) found that variation in green leaf yield (81.9 %) of Darjeeling tea was due to relative humidity. Dutta *et al.* (2012) also opined that fertilizer application had positive impact on North eastern tea.

After selection of significant associated variable with tea production, forecasting models are developed using ARIMA technique. ARIMA model are developed without and with inclusion of factors of production. Data for the period 1963-2010 is used for model building and 2011-12 for model validation. Each and every series is checked for stationarity before developing the model, if not, differencing or transformation technique is used to make these stationary. ARIMA models were developed for West Bengal tea area without considering factors of production and presented in table 7. For area, ARIMA (2,1,1) model was best fitted with R^2 (0.98) and lower values of AIC, SBC, Log likelihood etc criteria's. ACF and PACF of residuals are non significant. Tea area in West Bengal is forecasted using univariate ARIMA (2,1,1). In case of ARIMA with factors of production, the explanatory variables are forecasted using best fitted ARIMA models. Forecasted values of these explanatory variables are used in the ultimate ARIMA model for forecasting tea production. From Table 6, it is clear that R^2 value for production and productivity is higher in case of proposed method 2. In case of production, ARIMA (2,1,1) model with factors of production using proposed method 2 provides R^2 (0.97) and lower AIC, SBC and log likelihood values. For Productivity ARIMA with explanatory variables using proposed method 2 provide R^2 (0.94) and lower AIC, SBC and log likelihood values. Model validation is done for the year 2011 and 2012 and results are represented in table 8. From the table it was clear that minimum error is obtained from ARIMA with explanatory variables generated proposed method 2. Hence ARIMA with explanatory variables using proposed method 2 is used for forecasting of tea production and productivity.

Table 3: Test of outliers and randomness for area, production and yield of tea in West Bengal.

	No. of observation	No. of point (p)	E (P)	V(P)	τ-cal	Inference	Outlier
Area	50	8	32	8.57	8.20	Trend	No
Production	50	24	32	8.57	2.73	Trend	No
Yield	50	26	32	8.57	2.05	Trend	No

Table 4: Per se performance of tea production in West Bengal

	Area (hectare)	Production ('000 kg)	Yield(kg hectare^{-1})
Mean	99267.72	154422.74	1524.33
Maximum	115100.00	279300.00	2426.59
Minimum	82705.00	83456.00	998.10
SD	10577.20	49149.75	330.20
CV (%)	10.66	31.83	21.66
Kurtosis	-1.26	-0.06	0.49
Skewness	0.17	0.70	0.67
SGR (%)	0.75	4.69	2.86
CGR (%)	0.72	2.13	1.40

Table 5: Trends in area, production and yield of tea in West Bengal

	Model summary				Parameter estimates			
	R^2	Adj R^2	F	Sig.	Constant	b_1	b_2	b_3
				Area (hectare)				
Linear	0.97	0.97	1380.06	0.00	81078.78	713.29		
Quadratic	0.97	0.97	771.59	0.00	82662.06	530.61	3.58	
Cubic	0.98	0.97	545.18	0.00	84127.39	201.98	19.53	-0.21
Logarithmic	0.75	0.74	140.61	0.00	68767.22	10271.07		
Compound	0.97	0.97	1526.65	0.00	82185.35	1.007		
Growth	0.97	0.97	1526.65	0.00	11.32	0.01		
Exponential	0.97	0.97	1526.65	0.00	82185.35	0.01		
				Production ('000 kg)				
Linear	0.92	0.92	543.05	0.00	72010.87	3231.84		
Quadratic	0.95	0.95	471.53	0.00	93231.60	783.29	48.01	
Cubic	0.97	0.97	544.86	0.00	72651.85	5398.64	-176.01	2.93
Logarithmic	0.69	0.66	104.49	0.00	18543.61	45757.40		
Compound	0.96	0.96	1171.07	0.00	85980.78	1.021		
Growth	0.96	0.96	1171.07	0.00	11.36	0.02		
Exponential	0.96	0.96	1171.07	0.00	85980.78	0.02		
				Yield (kg hectare^{-1})				
Linear	0.87	0.87	332.98	0.00	984.33	21.18		
Quadratic	0.89	0.89	199.18	0.00	1095.35	8.37	0.25	
Cubic	0.94	0.94	247.11	0.00	883.68	55.84	-2.05	0.03
Logarithmic	0.69	0.67	108.12	0.00	606.57	309.06		
Compound	0.90	0.90	444.23	0.00	1046.24	1.014		
Growth	0.90	0.90	444.23	0.00	6.95	0.01		
Exponential	0.90	0.90	444.23	0.00	1046.24	0.01		

Table 6: Regression analysis of factor influencing the productivity of tea in West Bengal

Model		Regression coefficients	Std. error	Sig.	R^2	Adj R^2	RMSE	MAE
Weather indices model by Agarwal *et al.*	Intercept	-803.88	617.70	0.20	0.88	0.88	113.31	94.63
	F11	0.58	0.04	0.00				
	Z41	9.06	2.85	0.00				
Proposed method 1	Intercept	-890.87	670.92	0.19	0.88	0.88	112.06	96.23
	F11	0.6	0.04	0.00				
	Z41	8.89	2.91	0.02				
Proposed method 2	Intercept	-675.72	672.73	0.32	0.9	0.89	111.5	95.81
	F11	1.41	0.09	0.04				
	Z40	1.89	0.7	0.01				

Note: F11 weighted fertilizer, Z41 weighted relative humidity and Z40 un-weighted relative humidity indices

Table 7: Best fitted ARIMA models for area, production and yield of tea in West Bengal.

Types		Model	R^2	Log Likelihood	AIC	SBC	RMSE	MAPE	MAE	MaxAPE	MaxAE
					Area						
Without Factors	Univariate	ARIMA (2,1,1)	0.89	-423.72	855.44	863.01	1435.95	0.92	902.19	6.76	5592.01
					Production						
Without Factors	Univariate	ARIMA (2,1,2)	0.92	-516.77	1043.53	1052.99	9570.70	4.40	6851.87	15.84	23585.20
With	Weather indices model by Agarwal *et al.*	ARIMA (4,1,0)	0.96	-518.73	1051.47	1064.71	9123.97	4.55	6990.68	14.20	18213.02
Factors	Proposed method 1	ARIMA (2,1,1)	0.97	-515.25	1042.50	1053.85	8769.31	4.26	6586.25	11.17	20363.44
	Proposed method 2	ARIMA (2,1,1)	0.97	-515.73	1043.46	1054.81	8842.98	4.24	6529.62	11.79	20242.37
					Yield						
Without Factors	Univariate	ARIMA (4,1,1)	0.90	-223.82	453.63	459.05	94.53	4.55	69.55	16.04	264.26
With Factors	Weather indices model by Agarwal *et al.*	ARIMA (4,1,1)	0.92	-289.32	594.65	609.783	80.74	4.00	58.63	13.86	188.80
	Proposed method 1	ARIMA (4,1,1)	0.94	-284.58	585.15	600.29	89.71	4.08	62.00	14.31	202.13
	Proposed method 2	ARIMA (2,1,1)	0.94	-285.43	582.85	594.20	84.17	4.18	63.62	12.14	180.10

Table 8: Model validation of area, production and yield of tea in West Bengal

Year	Actual	Predicted univariate	Predicted weather indices model by Agrawal *et al.*	Predicted proposed method 1	Predicted proposed method 2
			Area (hectare)		
2011	115100	115760			
2012	115100	116020			
			Production ('000kg)		
2011	271600	250755	255319	255147	255126
2012	279300	274179	272116	278358	278204
			Yield (kg ha^{-1})		
2011	2360	2096	2111	2158	2202
2012	2427	2311	2313	2388	2398

Table 9: Forecasting of area, production and yield of tea in West Bengal

Year	Area (ha)	Production (‘000kg)	Yield (kg ha^{-1})
2013	115778	269129	2310.95
2014	116534	270596	2299.23
2015	117028	281950	2380.26
2016	117810	292860	2463.85
2017	118319	299251	2507.6
2018	119076	304248	2534.62
2019	119612	310892	2573.41
2020	120345	318923	2625.19

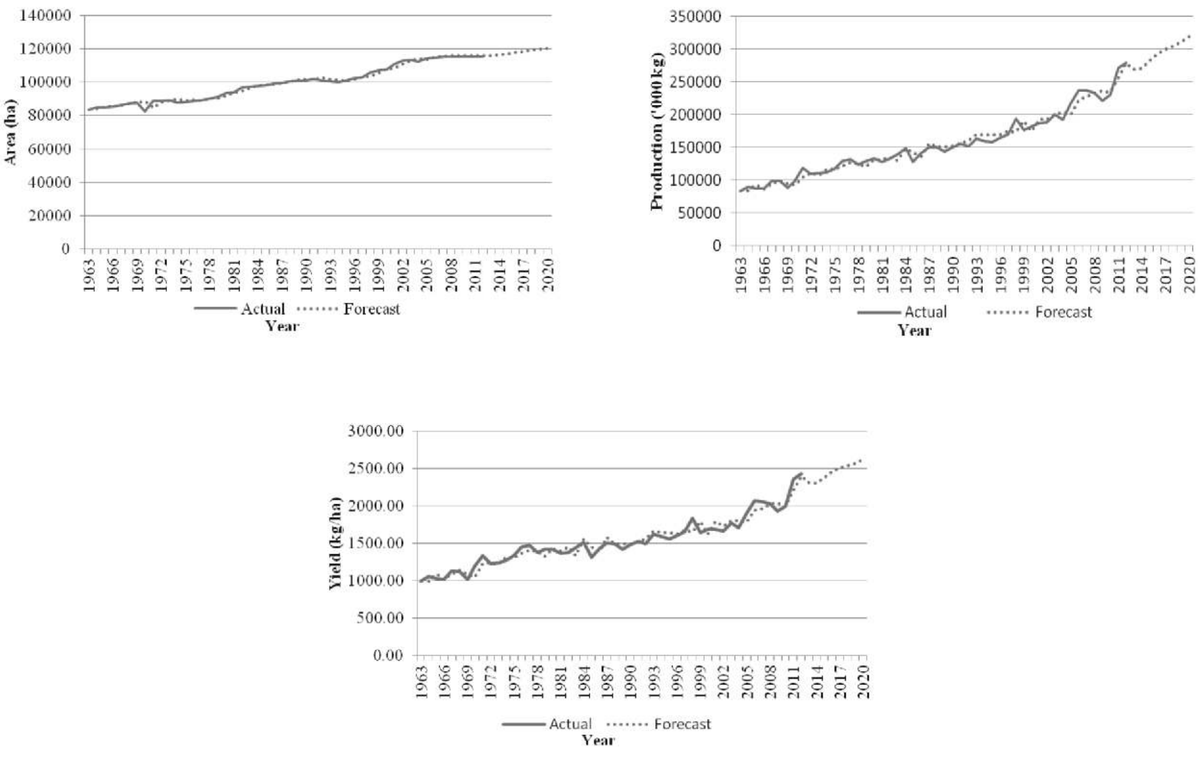

Fig. 1: Observed and forecasted area, production and yield of tea in West Bengal

Forecasting figures in table 9 indicate that there will be increase in area, production and yield of tea in West Bengal. It can be seen that forecasted production for the year 2013 is lower than 2012 but in later years the production increases. West Bengal is supposed to produce 318.92 million kg of tea from 121073 hectare of land with productivity of 2600 kg^{-1} *ha* (Figure 1). Though productivity of tea in West Bengal would increase (2600 kg^{-1} *ha*) in 2020 but still it will remain lower than many countries like Turkey (2900 $kgha^{-1}$) in 2011 (Anon., 2012). In world market, Kenya, Vietnam and Turkey are competitive markets of Indian tea. Though reasons for low productivity are not taken up in this study, Arya in 2013 reported that the reasons for low productivity were high production cost, aged tea gardens, pest and weather. More over against suggested rate of replanting (2% per annum) of tea garden the actual being less than 0.3% which is surely disturbing (Anon., 2011). As Darjeeling tea fetching more price in global market, production of tea in Darjeeling should be taken in to with ultimate sincerity.

Thus the above critical review of tea production scenario in West Bengal indicate that

1) Expansion/growth in tea production parameters has taken place mostly during early phase of tea industry in West Bengal.
2) Growth in production parameters for last fifty years is very low.
3) Inspite of definite trend (cubic) in production parameters, the tea industry in West Bengal is far away from either of the production potential or from the highest productivity.
4) RH and fertilizer are the two major factors of production are identified.
5) Among the indices based model for tea production in West Bengal, model proposed in method 2 based on path indices are found to be superior over other models in literature.
6) Inspite of marginally increased forecasted values of area, production and yield, the tea industry in West Bengal will be far away from highest productive countries in the world with respect to quantum of produce. Thus, the study strongly advocates for immediate break in tea industry of West Bengal.

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Genetic diversity of wheat genotypes based on principal component analysis in Gangetic alluvial soil of West Bengal

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ABSTRSCT

The present investigation was planned to assess genetic diversity for yield, yield contributing traits and quality traits in forty nine germplasm of bread wheat along with 4 checks and two triticale variety collected from DWR, Karnal were evaluated in randomized block design with two replication in Nadia district of West Bengal during rabi season in two consecutive years 2010-2011 and 2011-2012. Principal component analysis (PCA) indicated that five components (PC1 to PC5) accounted for about 75 % of the total variation among traits in bread wheat cultivars. Out of total principal components retained PC1, PC2 and PC3 with values of 25.9%, 17.1% and 13.3% respectively contributed more to the total variation. The first principal component had high positive loading for 9 characters out of 16 viz. weight of grains spike^{-1}, number of grains spike^{-1}, number of spikelets spike^{-1}, spike length, plant height, days to heading, days to flowering, grain protein content and yield plant^{-1} which contributed more to the diversity. The result of present study could be exploited in planning and execution of future breeding programme in wheat.

***Keywords*: Principal component analysis, *Triticale*, wheat**

Wheat (*Triticum aestivum* L.) is the most important cereal crop for the majority of world's populations. It is the most important staple food of about two billion people (36% of the world population). Approximately one-sixth of the total arable land in the world is cultivated with wheat. Whereas paddy is mainly cultivated in Asia, wheat is grown in all the continents of the world. India is one of the principal wheat producing and consuming countries in the world. The annual production of wheat in India during 2011-12 was 94.88 million tonne (MT) (Sharma, 2013) unfortunately fall by 2.47 MT in 2012-13. Wheat provides a large fraction of the dietary protein and total food supply, and is grown all throughout the world, in a wide variety of climates. Wheat is a staple crop, grown as a primary food product and for other uses as well. Wheat is cultivated over a wide range of climatic conditions and therefore understanding of genetics is of great value for genetics and plant breeding purposes.

One of the important approaches to wheat breeding is hybridization and subsequent selection. Parents' choice is the first step in plant breeding program through hybridization. In order to benefit transgressive segregation, genetic distance between parents is necessary (Joshi *et al*., 2004). The higher genetic distance between parents, the higher heterosis in progeny can be observed (Anand and Murrty, 1968). Estimation of genetic distance is one of appropriate tools for parental selection in wheat hybridization programs. Appropriate selection of the parents is essential to be used in crossing nurseries to enhance the genetic recombination for potential yield increase (Islam, 2004). Some appropriate methods, cluster analysis, PCA and factor analysis, for genetic diversity identification, parental selection, tracing the pathway to evolution of crops, centre of origin and diversity, and study interaction between the environment are currently available (Eivazi *et al.,* 2007). Principal component analysis helps researchers to distinguish significant relationship between traits. This is a multivariate analysis method that aims to explain the correlation between a large set of variables in terms of a small number of underlying independent factors. The cluster analysis is also an appropriate method for determining family relationships but the main advantage of using PCA over cluster analysis is that each genotype can be assigned to one group only (Mohammadi, 2002). The main objective of this study is to assess the potential genetic diversity among wheat genotypes by using cluster analysis and cluster analysis-PCA-based methods for selection of parents in hybridization programme to obtain desirable segregants in advanced generation.

MATERIALS AND METHODS

The wheat germplasm consisted of forty nine genotypes including four checks and two triticale varieties collected from DWR, Karnal through All India Coordinated Wheat & Barley Integrated Project

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of Kalyani centre, BCKV The experiment was conducted in randomized block design with two replication at 2 locations, District Farm, AB Block, BCKV. Kalyani, West Bengal and Instructional Farm, BCKV, Jaguli, Nadia, West Bengal during *rabi* seasons in two consecutive years 2010-2011 and 2011-2012. The gross plot was divided in two blocks and passages of 1 m width were left between the blocks. The blocks were taken as the replications and each block in turn was divided into 49 equal plots. There were six rows of 6 m length in each plot at spacing of 23cm between the rows for each genotype. Data on different characters *viz.* days to heading, days to flowering, days to maturity, plant height (cm), number of tillers plant^{-1}, spike length (cm), number of spikelets spike^{-1}, number of grains spike^{-1}, weight of grains spike^{-1}, flag leaf area, chlorophyll-a content, chlorophyll-b content, total chlorophyll content, thousand grain weight, grain protein content and yield plant^{-1} were taken from ten randomly selected plants from each replication. The principal component analysis method explained by Harman (1976) was followed in the extraction of the components. Principal Component Analysis was performed using Minitab 14 software.

Table 1: Studies on Principal component for 49 varieties on 18 characters in wheat

Variables	PC_1	PC_2	PC_3	PC_4	PC_5
Days to heading	0.365	-0.223	0.192	0.234	-0.160
Days to flowering	0.364	-0.224	0.193	0.238	-0.162
Days to maturity	0.148	-0.080	0.270	0.368	-0.176
Plant height (cm)	0.329	0.005	-0.173	0.091	0.389
No. of tillers plant^{-1}	0.044	0.096	-0.377	0.302	-0.527
Spike length (cm)	0.326	0.220	-0.006	0.045	0.038
No. of spikelets spike^{-1}	0.339	0.005	0.322	-0.125	0.279
No. of grains spike^{-1}	0.296	0.158	0.121	-0.475	-0.219
Wt. of grains spike^{-1}	0.376	0.221	-0.104	-0.147	0.177
Flag leaf area (cm^2)	0.072	0.068	-0.490	-0.170	-0.008
Chlorophyll- a (mg g^{-1})	-0.152	0.450	0.285	0.103	0.037
Chlorophyll-b (mgg^{-1})	0.000	0.449	0.062	0.157	-0.081
Total chlorophyll (mgg^{-1})	-0.128	0.513	0.256	0.129	-0.022
1000 grain wt. (g)	-0.011	0.064	-0.241	0.439	0.535
Grain protein (%)	0.113	0.097	-0.040	-0.315	-0.059
Yield plant^{-1} (g)	0.307	0.275	-0.317	0.127	-0.178
Eigenvalue	4.138	2.732	2.135	1.599	1.378
Individual percentage	25.9	17.1	13.3	10.0	8.6
Cumulative percentage	25.9	43.0	56.3	66.3	74.9

RESULTS AND DISCUSSION

Principal component analysis (PCA) reflects the importance of the largest contributor to the total variation at each axis of differentiation (Sharma, 1998). The eigenvalues are often used to determine how many factors to retain. The sum of the eigenvalues is usually equal to the number of variables. Therefore, in this analysis the first factor retains the information contained in 4.138 of the original variables. PCA for the first five principal components of these data are given in table1.

Five principal components PC_1 to PC_5, which are extracted from the original data and having latent roots greater than one, accounting nearly 75% of the total variation. Suggesting these principal component scores might be used to summarize the original 16 variables in any further analysis of the data. Out of the total principal components retained, PC_1, PC_2 and PC_3 with values of 25.9%, 17.1% and 13.3% respectively contributed more to the total variation.

According to Chahal and Gosal (2002), characters with largest absolute value closer to unity within the first principal component influence the clustering more than those with lower absolute value closer to zero. Therefore, in the present study, differentiation of the genotypes into different clusters was because of relatively high contribution of few characters rather than small contribution from each character.

Accordingly, the first principal component had high positive component loading from weight of grain spike^{-1}, days to heading, days to flowering, number of spikelets spike^{-1}, plant height, spike length and yield plant^{-1}; and high negative loading from chlorophyll-a and total chlorophyll content. The positive and negative loading shows the presence of positive and negative correlation trends between the components and the variables. Therefore, the above mentioned characters which load high positively or negatively contributed more to the diversity and they were the ones that most differentiated the clusters.

Hence, the major contributing characters for the diversity in the second principal component (PC_2) were total chlorophyll content, chlorophyll-b content and days to flowering; number of tillers plant^{-1}, number of spikelets spike^{-1} and yield plant^{-1} grain filling period and days to heading in principal component three (PC_3).

Usually it is customary to choose one variable from these identified groups. Hence, for the first group weight of grains spike^{-1} is best choice, which had the largest loading from component ones, total chlorophyll content for the second and number of tillers plant^{-1} for the third group.

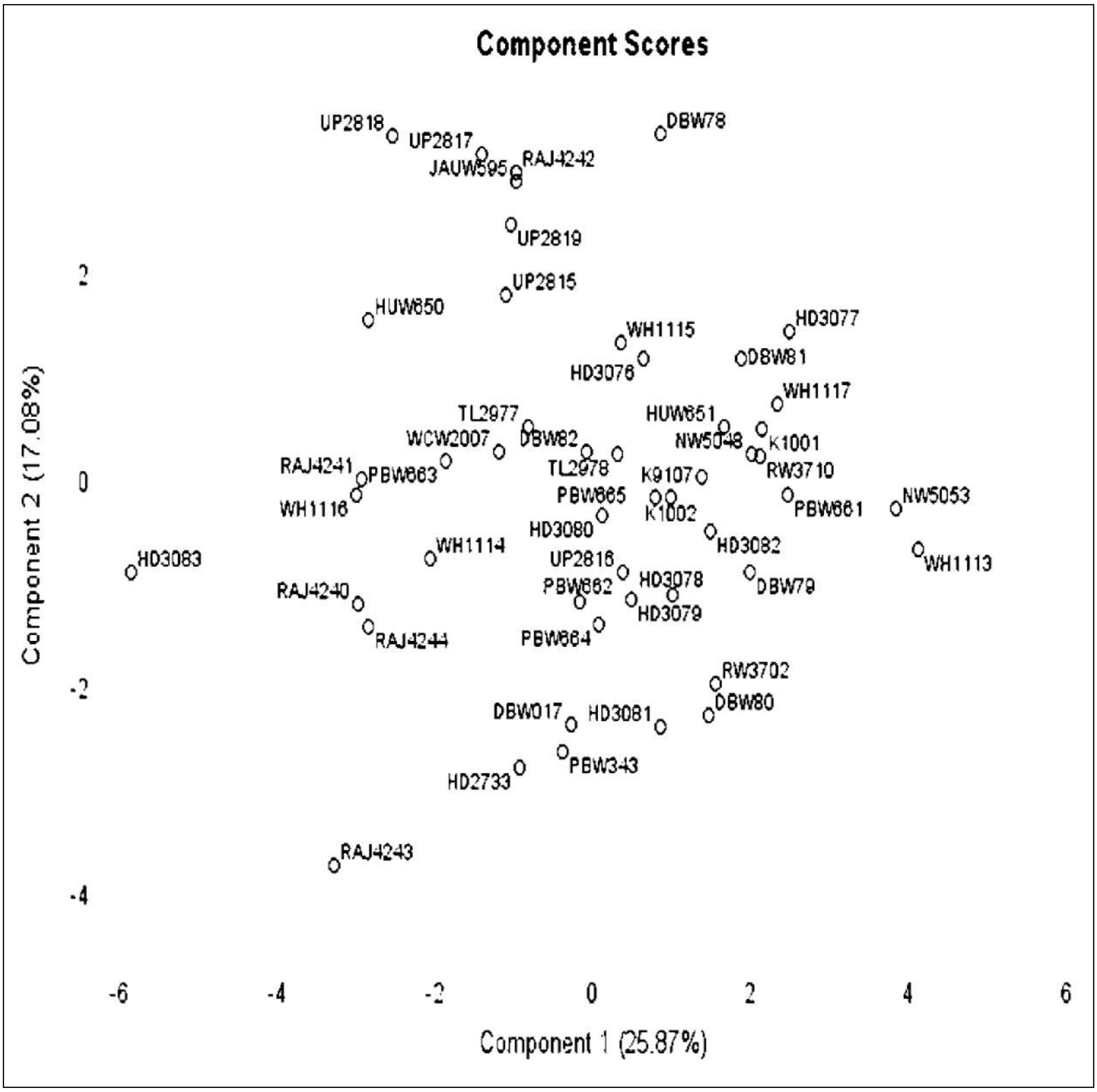

Fig 1: Score plot of 49 genotypes of *Triticum aestivum* L

These findings revealed that first three principal components were related to various morphological and physiological traits in wheat mostly associated with early genotypes and also these traits can identify the diverse genotypes which could be employed in hybridization programme for improvement of wheat.

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Character association, genetic variability and component analysis in sweet sorghum [*Sorghum bicolor* (L. Moench)]

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ABSTRACT

To assess the extent of genetic variability and heritability of 12 genotypes and 4 standard checks of sweet sorghum (Sorghum bicolor (L.) Moench), the present experiment was conducted. The observations were recorded for 7 quantitative traits. The phenotypic co-efficient of variation (PCV) was greater than genotypic co-efficient of variation (GCV) for most of the characters studied indicating influence of the environmental effect on the characters. But the GCV values were close to PCV values for the characters like days to fifty per cent flowering, days to physiological maturity and grain yield, indicating very little effect of environment on the genotype, on the phenotypic expression for these traits. The genotypes under study showed high heritability for days to 50% flowering. High heritability combined with high genetic advance (as per cent of mean) was observed for grain yield, total biomass, days to 50% flowering, green cane weight. The correlation analysis indicating the days to 50% flowering. Days to physiological maturity showed significant positive association with plant height at 50% flowering and plant height at physiological maturity, while significant negative association was observed for grain yield.

***Keywords*:** Correlation coefficient, genetic variability, path analysis, *Sorghum bicolor*

Sorghum [*Sorghum bicolor* L. (Moench)] is an important food and feed crop in the semi-arid regions of the world where it is grown under rainfed and irrigated conditions. Sorghum is one of the main staple for the world's poorest and most food insecure people. The crop is genetically suited to hot and dry agro-ecologies, where it is difficult to grow other food grains and these are also areas subject to frequent drought. In Barani areas sorghum is truly a dual-purpose crop, both grain and stalk are highly valued outputs. Therefore, it can play a vital role for the uplift of socio-economic status of the farmers of Barani areas through development of high yielding varieties along with reasonable amount of dry fodder during winter season for the livestock. Sweet sorghum similar to grain sorghum with sugar rich stalk and water use efficiency and it is an alternative feed stock for ethanol production.

Yield is a complex character which depends upon several component characters. Therefore, direct selection for yield is often not effective. Thus, it is essential to study the association of yield components with yield which is less influenced by environmental factors. Path coefficient analysis (Wright, 1921) provides an effective means of finding direct and indirect causes of association. In the present investigation, genetic variability in quantitative characters, association of certain characters and their direct and indirect contribution to green cane yield is analysed. According to Briggs and Knowles (1967), the heritability of quantitative characters is usually high, because breeding behavior can be predicted. Furthermore, high heritability coupled with genetic advance indicates that additive gene effects are operating and selection for superior genotype is possible (Arunkumar *et al*., 2004). In addition to correlation and heritability the knowledge of genetic variability existing among different parameters contributing to yield is also an important criterion for yield enhancement.

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MATERIAL AND METHODS

The experiment comprising of 12 genotypes and 4 standard checks of sorghum was laid out in a randomized block design with three replications during *kharif* , 2005 at Sorghum Research Station farm, Marathwada, Krishi Vidyapeeth, Parbhani. Each genotype was sown with spacing of 60 and 15 cm. Normal agronomic practices recommended to the region were followed timely. Data on five randomly selected plants in each entry were collected for days to first flowering, plant height at 50% flowering, days to physiological maturity, plant height at physiological maturity, fresh cane weight at physiological maturity, total biomass at physiological maturity, Grain yield. The analysis of GCV and PCV were estimated by using the respective mean square from variance. (Joohnson *et al.,* 1995). Covariance analysis between all pairs of characters under study was carried out as per the analysis of variance and covariance as declared by Sing and Chowdary (1977).

RESULTS AND DISCUSSION

The analysis of variance revealed significant differences among the genotypes for all the seven characters under study. The GCV and PCV were comparatively high for grain yield (Table 1). Moderate values of GCV and PCV were observed for green cane yield, total biomass yield. The wider the differences between the values of GCV and PCV were observed for green cane yield and total biomass which indicated that this trait was that high influenced by environmental factors. High heritability values were recorded for days to 50% flowering and low at plant height at physiological maturity which indicates the selection was effective for all the traits except plant height at physiological maturity which indicated that selection was effective. A high estimate of heritability together with high genetic advance as percent of mean was recorded for grain yield, total biomass revealing the influence of additive gene action for these two traits. Hence, the improvement of these traits can be made through direct phenotypic selection. Johnson *et al.* (1955) suggested that heritability estimates along with genetic advance would be more useful in predicting yield under phenotypic selection than heritability estimates alone. High heritability is always not an indication of high genetic gain characters which showed high heritability coupled with wider variability would be successfully improved by direct selection. For plant height at 50% flowering, plant height at physiological maturity, days to physiological maturity, the high heritability estimates were accompanied by low genetic advance indicating non-additive gene action and breeding methods to exploit non-additive gene action like heterosis breeding may be tried for these three traits.

The genotypic and phenotypic correlation coefficients between yield and yield components are presented in table 2. The present study indicates that significant and positive correlation was observed between green cane yield and total biomass, plant height at physiological maturity and plant height at 50% flowering, days to 50% flowering showed significant positive association with day to physiological maturity indicating that there was

Table 1: Estimation of parameters of GV and PV for various characters in sweet sorghum

Sr. No.	Character	Range	GCV	PCV	H^2 (bs)%	Genetic advance as % mean
1.	Days to 50% flowering	81.33-104.33	7.64	7.95	92.3	15.12
2.	Days to physiological maturity	125-135.33	2.61	2.67	89.1	5.07
3.	Plant height at 50 per cent flowering (cm)	246.67-324	7.78	11.15	48.7	11.19
4.	Plant height at physiological maturity(cm)	252-340	7.90	11.70	45.6	10.99
5.	Green cane weight (t ha^{-1})	28.78-53.03	16.95	21.89	60	27.04
6.	Total biomass(t ha^{-1})	31.67-57.33	16.66	20.12	68.6	28.42
7.	Grain yield(Kg ha^{-1})	96.33-657.67	52.75	55.95	88.9	102.48

Table 2: Genotypic correlation coefficient for seven growth characters in sweet sorghum

Sr. No.	Genotypes	Days to 50% flowering	Days to physiological maturity	Plant height at 50% flowering	Plant height at physiological maturity (cm)	Green cane weight (t ha^{-1})	Total biomass (t ha^{-1})	Grain yield (Kg ha^{-1})
1.	Days to 50% flowering	1.000	0.946	0.425	0.439	0.374	-0.786**	0.330
2.	Days to physiological maturity		1.000	0.575*	0.604*	0.449	-0.675**	0.402
3.	Plant height at 50 per cent flowering (cm)			1.000	1.003**	0.935**	-0.253	0.947
4.	Plant height at physiological maturity(cm)				1.000	0.975**	-0.198	0.987**
5.	Green cane weight (t ha^{-1})					1.000	-0.214	1.005**
6.	Total biomass (t ha^{-1})						1.000	-0.199
7.	Grain yield (Kg ha^{-1})							1.000

***, * significant at 1%, 5% level respectively*

Table 3: Genotypic path analysis of six components on green cane yield in sweet sorghum

Sr. No.	Genotypes	Days to 50% flowering	Days to physiological maturity	Plant height at 50% flowering	Plant height at physiological maturity (cm)	Green cane weight (t ha^{-1})	Total biomass (t ha^{-1})	Grain yield (Kg ha^{-1})
1.	Days to 50% flowering	**0.0585**	-0.108	0.183	-0.155	0.366	-0.014	0.330
2.	Days to physiologicalmaturity	0.055	**-0.114**	0.248	-0.214	0.440	-0.012	0.402
3.	Plant height at 50 percent flowering(cm)	0.024	-0.066	**0.431**	-0.356	0.917	-0.004	0.947**
4.	Plant height at physiological maturity(cm)	0.025	-0.069	0.432	**-0.355**	0.957	-0.003	0.987**
5.	Total biomass (t ha^{-1})	0.021	-0.051	0.402	-0.346	**0.982**	-0.003	1.005**
6.	Grain yield (Kg ha^{-1})	-0.046	0.077	-0.108	0.070	0.070	**0.018**	-0.199

***, *significant at 1%, 5% level respectively, Bold figures indicates the direct effect, Residual effect =0.1173*

certain inherent relationship between these characters. Days to physiological maturity showed significant positive association with plant height at 50% flowering and plant height at physiological maturity while significant negative association was observed for grain yield. Plant height at 50% flowering was significantly associated with plant height at physiological maturity and total biomass yield. Similarly plant height at physiological maturity has significantly associated with total biomass yield. Therefore, desirable plant type in sweet sorghum should be more biomass yield, high plant height at 50% flowering and at physiological maturity.

The path coefficients analysis of yield components and their effect on yield are presented in Table 3. In the present study plant height at 50% flowering and total biomass yield had high positive direct effect on green cane yield at the same time these traits also had significant and positive association with green cane yield. The character plant height at 50% flowering had high positive indirect effect on green cane yield via plant height at physiological maturity and total biomass yield. Indicating importance of these two characters. Days to physiological maturity had high negative direct effect and it was positively correlated with green cane yield. Plant height at physiological maturity has high negative direct effect on green cane yield, its positive indirect effect via total biomass yield was also significant. The most desirable character in sweet sorghum should have less days required to 50% flowering, more biomass yield and more plant height at 50% flowering for more green cane yield.

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Evaluation of pre-released bold seeded lentil varieties for growth and yield potentiality in the Gangetic plains of West Bengal

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ABSTRACT

A study was conducted for two consecutive year (2012-2013 and 2013-2014) to assess the performances of sixteen pre-released and two standard varieties of bold seeded lentil for their growth and productivity potential. Germination of seed required 4 to 7 days. The duration of germination to branch initiation phase was 11 to 13 days; flower initiation required 32 to 57 days, in first year and 29 to 36 days in the second year. Significant differences were observed in plant height, nodule number, dry matter accumulation, yield and yield attributes of the crop. The dry matter accumulation was better in the second year. The seed yield was maximum in PL-129 in both the year. The second year yield was lower than the first year, as it was exposed to higher temperature during the reproductive phase of the crop. The maximum productivity of lentil would be archived when the maximum and minimum temperature during 100% flowering ranged from 24.6 to 28.6 and 10.1 to 10.9ÚC respectively.

***Keywords*:** Growth attributes, lentil, pre-released variety, yield attributes

Lentil is a winter season crop growing in the span of November- March in West Bengal. The Gangetic plains of West Bengal is marked by short winter and mild temperature.Because of the temperature sensitivity of this crop, selection of proper varieties of lentil is important for better productivity of this crop. Bhattacharyya (2009) assessed several lentil genotypes for their yield variability under non-irrigated and irrigated conditions. Ellis *et al.* (1995) observed that the duration from sowing to flowering is an important parameter for yield variability in pulses. However the impact of temperature on lentil varieties has not been evaluated elaborately in the Indo Gangetic Plains of West Bengal. The present experiment has been framed to address this vacuum.

MATERIALS AND METHODS

The experiment was carried out during winter (November-March) seasons of 2012-13 and 2013-14 at the District Seed Farm, AB block, Kalyani, BCKV, (Latitude 22Ï58′ N and Longitude 88Ï32′ E), West Bengal, India. The study site is flat and is located at an

Table 1: Description of lentil genotypes and varieties used in the experiment

Sl. No.	Entry	Source	Pedigree
1	L 4076	IARI, New Delhi	Pl 234 x PL 639
2	IPL -324	IIPR, Kanpur	(IIL 7659 X DPL 58) X KL-178
3	KLB-314	CSA, Kanpur	KL 225 X KLB 97-6
4	L 4707	IARI, New Delhi	L 4650 X L 4076
5	VL 521	VPKAS, Almora	VL 501X(Precoz x L 4076)
6	SKUA-L-9	Srinagar	Sel. From EC 3109
7	LH 07-27	CCS HAU, Hisar	LH 84-8 X L 4641
8	LL 1210	PAU, Ludhiana	LL 699 X FLIP 91 – 51 L
9	IPL 325	IIPR, Kanpur	(IIL 101 X EC 362) X DPL 62
10	PL 129	Pantnagar	PL 639 X L 4188
11	RVL 48	Sehore	JL 1 X DPL 62
12	PL 122	Pantnagar	PL 01 X FLIP 96 – 51
13	LL 1204	PAU, Ludhiana	LL 148 X DPL 58
14	L 4706	IARI, New Delhi	PL 234 X PL 639
15	KLB 345	CSA, Kanpur	Precoz X KLB 231
16	SKUA-L-2-96	Srinagar	KLF 221 X L 1
17	K-75 (Check variety)	CSAU, Kanpur	Sel. From Bundelkhand Local
18	DPL-62 (Check variety)	IIPR, Kanpur	JL 1 x LG 171

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altitude of 9.75 m above mean sea level (AMSL). The experimental site falls under tropical humid climate, experiences three distinct seasons (summer, rainy and winter). The mean annual temperature falls below 20 ÚC in November and continued up to early part of February. The maximum and minimum RH ranged from 85-100% and 22-96% respectively. The soil contents 51% sand, 18.7% silt and 30.4% clay and is classified as sandy loam. The pH of the soil is 7.35 having total nitrogen, available phosphorus, available potassium and organic carbon as 298 kg ha^{-1}, 30.2 kg ha^{-1}, 195 kg ha^{-1} and 0.48%, respectively.The experiment was conducted in the winter season of 2012-2013 and 2013-2014 in RBD with sixteen pre released bold seeded varieties and two check varieties (K-75, DPL-62) for their growth and productivity. Each treatment was allotted in a plot of 4×2.0 m with two replications. Each treatment received 20, 40 and 40 kg N, P_2O_5 and K_2O ha^{-1} through urea, SSP and MOP. The description of pre released lentil varieties is given in table 1. The duration of the different phenophases, plant height, nodule number, dry matter accumulation, yield attributes and yield were estimated.

RESULTS AND DISCUSSION

Germination

The germination phase required 4 to 7 days in 1st year. Out of 16 pre released varieties 9 required 5 days, and 5 required 6 days for germination. The varieties VL 521 and SKUAL-9 needed 4 days but KLB-314, LL-1210 required 7 days. In the 2nd year the range of duration for germination remained same (Table 2). However the maximum and minimum temperature differed in two different years (Table 3). During germination, maximum temperature ranged from 28.7 to 30.8 ÚC and minimum temperature ranged from 15.5 to 21.6 ÚC in the 1st year which was quite higher than 2nd year temperature during the phenophase. The duration of germination to branch initiation was 11 to 13 days in the 1st year and 6 to 12 days in the 2nd year. During this phase, the maximum temperature ranged from 26.5 to 27.2 ÚC in the 1st year and 25.7 to 26.9ÚC in the 2nd year. The minimum temperature ranged from 10 to 14 ÚC in 2nd year where as 11.4 to 12 ÚC in the 1st year. The wide variation in the duration observed in the 2nd year was due to variation of minimum temperature.Flower initiation recorded wide variation. The variety K-75 initiated the flower 25 days earlier in the 2nd year than the 1st year. During this phenophase the minimum temperature ranged from 4.2 to 14.2 ÚC in the 1st year but in the 2nd year it ranged from 9.2 to 11.6 ÚC. The fluctuation in the minimum temperature helped the crop to initiate flower earlier in the 2nd year than the 1st year. Parya *et al.* (2010) observed that the higher minimum temperature in winter season shortened the duration of phenophase of winter crop.

Table 2: Duration of different phenophases (in days) of lentil genotypes

Genotypes	Germination		Branch initiation		Flower initiation		50% flowering		100% Flowering		Maturity		Total	
	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14
L 4076	5	5	12	10	33	34	16	28	12	17	20	29	98	123
IPL -324	6	4	11	10	33	36	16	26	10	17	22	28	98	121
KLB-314	7	6	12	9	46	34	4	31	15	17	18	21	102	118
L 4707	6	5	11	6	32	36	18	27	9	15	22	22	98	111
VL 521	4	5	12	11	46	33	19	32	12	17	32	33	125	131
SKUA-L-9	4	6	12	10	46	32	19	32	12	16	32	20	125	116
LH 07-27	5	7	12	11	32	29	19	35	10	15	24	32	102	129
LL 1210	7	6	12	11	38	32	24	33	14	16	11	30	106	128
IPL 325	6	5	12	11	46	34	6	34	13	16	19	28	102	128
PL 129	5	5	12	12	41	33	8	35	16	16	20	26	102	127
RVL 48	6	7	11	9	43	33	6	33	10	16	26	11	102	109
PL 122	5	6	12	12	34	30	28	35	13	17	22	25	114	125
LL 1204	5	5	12	12	43	30	15	35	18	18	9	25	102	125
L 4706	6	5	13	12	46	31	7	36	17	14	13	12	102	110
KLB 345	5	7	13	12	40	30	17	34	19	16	13	27	107	126
SKUA-L-2-96	5	6	12	12	48	32	6	35	22	16	13	28	106	129
K-75	5	6	12	11	57	32	17	32	4	19	19	28	114	128
DPL-62	5	6	12	11	43	33	21	15	12	17	21	29	114	108

Plant height

The plant height recorded a continuous increase throughout the period of observation (up to 65 DAE in most of the genotypes) (Table-4). In some of the genotypes the plant height recorded less on 72 DAE because of the drying up of stem. The pooled mean result showed that significant difference existed among the different genotypes throughout the growth phase. On 30 DAE the IPL-324 recorded the maximum plant height which was at par with L4076 and L4707. The minimum plant height was recorded in PL-122. Among the different genotypes KLB-314, VL-521, SKUA-L-9, PL-129, VL-48 and L-4706 had no significant difference among themselves. The dwarf varieties were LH-07-27, LL-1210, LL-1204, KLB-345 and DPL-62 had also no significant differences in the plant height. On 72 DAE the maximum height was recorded in IPL-324 followed by L-4076 although these two genotypes differ significantly in plant height. The rate of increment of height was maximum during 44 to 51 DAE in case of the genotypes L-4076, L-4707, SKUA-L-9, PL-129, LL-1204, L-4706, KLB-345, K-75 and DPL-62. However IPL-324 recorded the maximum rate of increment during 65 to 72 DAE. During 44 to 51 DAE maximum temperature ranged from 20 to 26.9 ÚC hovered around 10.6 to 14 ÚC. This temperature

Table 3: Ambient temperature (ÚC) during the phenophases of lentil genotypes in 2012-13

Genotypes	Germination		Branch initiation		Flower initiation		50% Flower initiation		100% Flower initiation		Maturity	
	Max. temp.	Min. temp.	Max. temp.	Min. temp.	Max. temp.	Min. temp.	Max. temp.	Min. temp.	Max. temp.	Min. temp.	Max. temp.	Min. temp.
L 4076	30.4	15.6	26.5	11.4	26	10.5	29.1	13.2	25.2	7.2	25.5	12.2
IPL -324	30.8	15.5	26.5	11.4	26	10.5	29.1	13.2	22.6	5.6	25.5	12.2
KLB-314	29	21.6	26.9	12	28.7	12.5	23.4	12.6	29.2	12.6	31.1	12.9
L 4707	30.8	15.5	26.5	11.4	25.5	9.2	28	13.2	25	7	25.5	12.2
VL 521	28.7	15.5	26.8	11	25.9	6.9	26.2	10	30.2	14.1	33.8	15.6
SKUA-L-9	28.7	15.5	26.8	11	25.9	6.9	26.2	10	30.2	14.1	33.8	15.6
LH 07-27	30.4	15.6	26.5	11.4	25.5	9.2	25.4	13.1	25.2	7.2	31.1	12.9
LL 1210	29	21.6	26.9	12	18.6	4.2	26.2	10	25	13.4	31	14.7
IPL 325	30.8	15.5	27.2	12	27	11.7	23.6	9	28.7	10	31.1	12.9
PL 129	30.4	15.6	26.5	11.4	21.5	5.7	29.1	13.2	28.6	10.1	31.1	12.9
RVL 48	30.8	15.5	26.5	11.4	22	6.7	29.1	13.2	25	7	31.1	12.9
PL 122	30.4	15.6	26.5	11.4	23.5	14.2	26	9.4	28.5	14.8	34.9	16.9
LL 1204	30.4	15.6	26.5	11.4	22	6.7	22.6	5.6	30.2	14.1	31.1	12.9
L 4706	30.8	15.5	26.9	12	28.7	12.5	24.1	7.2	26.9	8.6	31.1	12.9
KLB 345	30.4	15.6	26.5	11.4	18.6	4.2	23	6	30.2	14.1	31	14.7
SKUA-L-2-96	30.4	15.6	26.5	11.4	28.7	12.5	24	7.3	30.2	14.1	31	14.7
K-75	30.4	15.6	26.5	11.4	22	6.7	28	10.4	25	13.4	34.9	16.9
DPL-62	30.4	15.6	26.5	11.4	22	6.7	26.2	10	30.2	14.1	34.9	16.9
L 4076	27.5	13.2	25.7	12.5	20	11.3	21.5	9	28.5	13.6	33	16.6
IPL -324	27.7	15.6	26.6	12.4	20	10.6	21.5	9	28.5	13.6	32.5	19.9
KLB-314	27.4	13.8	25.7	12.5	20	11.3	24.6	9.7	22.5	16.5	31	14.9
L 4707	27.5	13.2	26.5	14	24	9.6	23.5	8.7	27	12.2	29.6	16
VL 521	27.5	13.2	26.9	11.8	20	11.3	24.6	9.7	22.5	16.5	32.5	19.6
SKUA-L-9	27.4	13.8	26.9	11.8	20	11.6	25.5	9.5	25.4	16.5	29.6	16
LH 07-27	27.6	15.5	25.4	10.9	24	9.6	25.5	9.5	28.5	13.6	35.2	16.6
LL 1210	27.4	13.8	25.5	12.5	20	11.3	24.6	9.7	21	16.4	35.2	16.6
IPL 325	27.5	13.2	26.9	11.8	20	10.6	25.2	8.2	24.6	10.9	34	18.6
PL 129	27.5	13.2	25.5	12.5	20	10.6	25.2	8.2	24.6	10.9	31	14.9
RVL 48	27.6	15.5	26.9	11.8	20	11.3	25.2	10.5	22.5	16.5	28.5	16.5
PL 122	27.4	13.8	25.4	10.9	20	11.6	24.6	9.7	22.5	16.5	33	16.6
LL 1204	27.5	13.2	25.5	12.5	24	9.6	24.6	9.7	23.7	10.3	34	16.6
L 4706	27.5	13.2	25.5	12.5	20	11.6	24.4	9.2	21	16.4	28.5	16.5
KLB 345	27.6	15.5	26.5	10	20	11.3	25.5	9.5	25.4	16.5	33	16.6
SKUA-L-2-96	27.4	13.8	25.4	10.9	20	10.6	24.4	9.2	23.7	10.3	35.2	16.6
K-75	27.4	13.8	25.5	12.5	20	11.3	25.5	9.5	23.7	10.3	35.2	16.6
DPL-62	27.4	13.8	25.5	12.5	20	10.6	24.6	9.7	22.5	16.5	35.2	16.6

ranged was congenial for height increment in most of these genotypes. In case of IPL-324 and L-4076 the rate of height increment was maximum during 65 to 72 DAE, when the maximum and minimum temperature was 28.5 and 13.6 ÚC respectively. This showed that these two genotypes could tolerate a bit higher temperature then the other genotypes. He and Rajaram (1993) observed that the plant height is more sensitive to the temperature in winter crop. The plant height was higher in 2nd year than the 1st year.

Nodule number

Nodule number increase from 30 to 44 DAE in L-4076, KLB-314, IPL-325, PL-129, LL-1204, L-4706, KLB-345, SKUA-L-96, K-75 AND DPL-62 there after the nodule number decline gradually (Table 5). But in the genotypes SKUA-L-9, LH-07-27, LL-1210, PL-122 nodule number increased up to 51 DAE. There after it decline. The genotypes L-4707 and VL-521 showed an increment in nodule number up to 58 DAE. Significant differences existed among the genotypes. On 44 DAE maximum nodule number per plant was noted in KLB-314. Which was significantly higher than all the genotypes except LL-1204. The genotypes L-4706 and IPL-324 had no significant differences. The two check genotypes also did not differ significantly in nodule number. The rate of nodule initiation was highest in between 30 to 37 DAE that is during branch initiation to flower initiation. When the maximum temperature ranges in between 23.5 to 28.7 ÚC and the minimum temperature ranged from 9.2 to 12^{0}C

Dry matter accumulation

The dry matter accumulation increased throughout the growth phases and the maximum increment was noted SKUA-L-2-96 on 72 DAE which was significantly higher in all the varieties. During initial phase (up to 58 DAE) the KLB-314 recorded maximum dry matter accumulation followed by L-4076 and SKUA-L-9 (Table 6). Minimum dry matter accumulation on 72 DAE was observed in PL-122. These genotypes recorded the low dry matter accumulation throughout the growth phases. On 72 DAE the high dry matter accumulation genotypes were SKUA-L-296, KLB-314, LL1210, SKUA-L-9, VL-521 and LH-0727 which produce the dry matter above 200 gm per m^2. Among this high producing genotypes VL-521, SKUA-L -9 did not differ significantly. Similarly LL-1210 and KLB-314 also had no significant different. The rate of dry matter accumulation was maximum during 30 to 37 DAE in

Table 4: Changes in plant height (cm) in lentil genotypes (Pooled)

Genotypes	Day after emergence						
	30	37	44	51	58	65	72
L 4076	17.1	20.9	24.4	29.3	32.1	36.2	42.9
IPL -324	17.8	22.5	27.0	29.4	33.4	37.3	45.5
KLB-314	14.9	18.5	23.8	27.6	29.8	42.7	38.7
L 4707	17.0	20.6	23.9	30.3	33.8	37.1	36.5
VL 521	15.5	16.1	21.2	24.4	26.9	36.6	35.6
SKUA-L-9	15.1	19.1	22.2	27.0	31.7	41.1	38.1
LH 07-27	11.9	13.9	18.7	23.1	26.4	37.7	35.1
LL 1210	12.5	16.5	19.6	23.6	26.4	44.2	40.3
IPL 325	14.2	18.1	25.1	27.8	31.5	43.8	39.2
PL 129	14.8	17.0	21.8	27.8	31.3	39.7	38.4
VL 48	15.3	18.9	23.8	27.9	29.4	35.4	35.8
PL 122	10.5	13.4	16.4	20.8	24.7	33.3	32.3
LL 1204	12.8	15.6	19.0	27.8	31.6	42.5	38.2
L 4706	15.9	20.2	23.6	32.5	35.1	45.6	42.5
KLB 345	12.0	16.3	20.4	27.6	31.1	41.6	37.8
SKUA-L-2-96	16.4	20.4	25.0	29.6	34.1	43.0	41.4
K-75	14.5	18.6	21.7	27.5	30.9	39.6	40.1
DPL-62	12.7	17.4	21.8	26.8	29.1	38.4	40.0
SEm (±)	**0.4**	**0.6**	**0.6**	**0.8**	**0.7**	**1.0**	**0.5**
LSD(0.05)	**1.3**	**1.6**	**1.8**	**2.3**	**2.0**	**2.8**	**1.5**

Table 5: Changes in nodule number indifferent lentil genotypes (Pooled)

Genotypes	Day after emergence						
	30	37	44	51	58	65	72
L 4076	13.3	22.0	25.2	23.9	17.9	13.3	10.3
IPL -324	18.0	21.8	25.0	27.5	27.1	17.2	15.5
KLB-314	14.5	20.5	31.7	30.0	23.1	17.0	13.0
L 4707	8.8	13.2	16.3	18.9	24.4	10.9	8.5
VL 521	10.2	14.3	17.5	20.0	22.7	14.3	12.5
SKUA-L-9	9.8	14.5	18.6	23.3	13.8	12.3	11.3
LH 07-27	13.8	15.2	19.9	25.0	17.4	12.9	8.7
LL 1210	16.4	18.8	21.6	29.3	18.3	12.0	7.7
IPL 325	14.9	19.2	22.1	17.0	14.5	12.3	9.5
PL 129	15.2	19.6	28.2	18.3	13.9	12.3	8.3
RVL 48	7.7	11.5	15.0	18.3	12.4	10.0	8.4
PL 122	7.4	12.8	16.0	26.7	14.7	12.0	9.2
LL 1204	11.2	17.8	30.8	16.6	12.0	10.8	8.6
L 4706	11.8	17.4	28.5	17.5	13.5	12.3	9.0
KLB 345	8.8	14.4	28.7	19.0	16.5	12.6	9.3
SKUA-L-2-96	15.6	21.8	28.5	15.8	12.7	10.3	7.0
K-75	11.9	19.9	27.8	20.3	12.7	10.8	7.2
DPL-62	11.6	18.3	26.7	15.3	13.0	10.8	8.3
SEm (±)	**0.8**	**0.5**	**0.6**	**0.5**	**0.7**	**0.6**	**0.6**
LSD(0.05)	**2.3**	**1.6**	**1.9**	**1.6**	**2.1**	**1.7**	**1.8**

L-4076, SKUA-L-9, RVL-48 and P-122. Dry matter accumulation differs due to temperature differences during the different phenophase. Basu *et al.,* 2012 also reported that the thermal regimes or the significantly predicted the stem and dry matter accumulation in wheat during winter season.

Table 6: Changes in dry matter accumulation in lentil genotypes (gm^{-2}) (Pooled)

Genotypes	Day after emergence						
	30	37	44	51	58	65	72
L 4076	34.9	60.9	86.6	112.9	141.4	146.2	151.8
IPL -324	48.5	57.3	80.9	104.8	129.6	141.5	177.4
KLB-314	59.5	75.3	113.5	146.5	163.1	189.4	231.0
L 4707	43.1	55.3	80.4	112.0	133.0	137.6	172.2
VL 521	34.5	41.5	52.1	73.4	77.7	87.5	215.6
SKUA-L-9	35.9	63.9	74.1	109.1	138.8	152.3	217.4
LH 07-27	31.1	47.4	68.1	79.8	88.9	112.0	200.2
LL 1210	33.9	41.0	49.1	68.8	83.3	107.4	226.6
IPL 325	25.1	38.0	82.3	75.7	114.9	119.4	149.7
PL 129	52.9	68.8	86.2	106.3	120.0	127.9	177.6
RVL 48	37.9	62.0	67.8	89.9	105.4	112.3	145.3
PL 122	31.9	60.2	64.9	74.0	79.0	85.1	93.1
LL 1204	36.9	65.4	73.4	103.4	111.6	117.4	148.6
L 4706	40.0	65.3	65.2	88.3	96.5	106.2	148.5
KLB 345	31.1	43.0	43.8	64.4	81.7	85.9	160.3
SKUA-L-2-96	40.1	56.3	80.7	107.8	113.8	150.2	277.3
K-75	37.8	46.9	56.5	69.2	74.5	93.3	148.9
DPL-62	39.3	46.6	63.2	72.9	78.9	89.4	195.1
SEm (±)	**1.6**	**1.9**	**6.4**	**1.6**	**1.5**	**1.4**	**2.8**
LSD(0.05)	**4.7**	**5.5**	**18.3**	**4.6**	**4.4**	**4.0**	**8.1**

Yield and yield attributes

The number of branches per plan at maturity was highest in L-4707, VL-521, SKUA-L-296 and DPL-62. No significant differences did exist among the genotypes KLB-314, L-4707, VL-521, SKUA-L-9, PL-129, RVL-48, PL-122, SKUA-L-296, K-75 and DPL-62 (Table7). The maximum no of pods per plant was recorded in PL-129 which was significantly higher in all the varieties. The high yielder genotypes were PL-129, L-4706, SKUA-L-9, AND IPL-325 which produce 50 or higher no of pods per plant. The lowest no of pod was recorded in VL-521. The test weight was maximum in SKUA-L-296 but yield was low because of lower no of pods per plant.

The seed yield differed in two different years (Table 7), first year crop recorded higher yield than the second year crop in all genotypes. During the reproductive phase the 2nd year crop was exposed to higher minimum temperature which led to flower drop, drying of the floral part and ultimate reduction of yield (Tzudir *et al.,* 2014). Erskine *et al.* (1989) observed that the productivity was related to the temperature during reproductive period. Summerfield *et al.* (1989) observed that the higher temperature during the reproductive phase accelerated progress towards reproductive maturity and reduced seed yield. In the present experiment the minimum temperature during the reproductive phase in the 1st year ranged in between 11.2 and 14.1 ÚC where as in the 2nd year, it was in between 14.1 and 16.8 degree Celsius; there was an approximate rise of 3 ÚC in the 2nd year. The maximum productivity of lentil would be achieved if the maximum and minimum temperatures ranged from 24.6 to 28.6 ÚC and 10.1 to 10.9 ÚC during 100% flowering stage. Two years pooled mean result showed that the maximum seed yield was obtained in PL-129 (1657.40 kg ha^{-1}) because of highest no of pods per plant, higher no of branch per plant and the moderate test weight. Among the different genotypes the high yielder genotypes were PL-129, L-4706, SKUA-L-9, IPL-325, IPL-324, RVL-48 and K-75 which produced above 1000 kg ha^{-1} on an average. The medium yielder genotypes were L-4707, KLB-314, SKUA-L-296, DPL-62, LL-1204 and KLB-325 whose productivity exceeded 800 kg ha^{-1}. The low yielder group comprised of VL-521, LH-0727, L-4076, LL-1210 and PL-122. These genotypes had lower no of pods per plant, branch per plant and test weight. The maximum yield was recorded in VL-521 (387.55 kg ha^{-1}).

Table 7: Yield attributes and seed yield in lentil genotypes (Pooled)

Genotypes	Yield attributes and seed yield					
	No. of branch plant^{-1}	No. of pods plant^{-1}	Test Wt. (gm.)	Seed yield (kg ha^{-1})		
				2012-2013	2013-2014	Pooled
L 4076	9	19	2.80	732.4	482.6	607.48
IPL -324	9	49	2.95	1203.3	1089.2	1146.20
KLB-314	11	41	2.20	1152.3	783.6	967.95
L 4707	12	43	2.35	1155.7	838.5	997.08
VL 521	12	13	2.08	336.7	438.4	387.55
SKUA-L-9	11	51	3.75	1372.6	1135.6	1254.10
LH 07-27	10	19	2.40	729.7	483.7	606.70
LL 1210	9	23	2.20	1019.9	529.9	774.86
IPL 325	7	50	3.60	1372.3	1129.4	1250.83
PL 129	11	61	3.60	1712.4	1602.4	1657.40
RVL 48	11	47	2.20	1164.2	864.5	1014.35
PL 122	11	27	1.70	1027.5	548.2	787.84
LL 1204	8	33	2.50	1058.2	590.4	824.28
L 4706	9	59	2.60	1547.9	1219.5	1383.65
KLB 345	9	27	1.85	1049.5	564.7	807.05
SKUA-L-2-96	12	37	3.95	1122.3	774.3	948.25
K-75	11	45	2.60	1159.4	864.5	1011.94
DPL-62	12	35	2.65	1066.9	693.1	879.98
SEm (±)	**0.4**	**0.4**	**0.138**	**1.4**	**1.1**	**0.885**
LSD (0.05)	**1.2**	**1.0**	**0.398**	**4.1**	**3.3**	**2.544**

In the Gangetic West Bengal Pl-129, L-4706, SKUA-L-9 and IPL-325 may be selected for their better productivity potential.

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Influence of pre-harvest spray of growth regulators on the quality and shelf life of baby corn during storage at room temperature

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ABSTRACT

Pre harvest spray of growth regulators on the quality and shelf life of baby corn was studied. All the growth regulators extended shelf life for 2 days at room temperature. Among the growth regulators tried, pre-harvest spray of GA_3 40 ppm followed by cycocel 1000 ppm was proved to be promising in reducing the PLW (Physiological Loss in weight), spoilage per cent, better retention of TSS, reducing sugars, titrable acidity, ascorbic acid and crude protein content.

Keywords: Baby corn, preharvest sprays, quality, shelf life

Baby corn or mini corn is a new economic product of recent origin. It refers to the tender flowering maize ears harvested 1-2 days after silk emergence before fertilization. Baby corn can be used as a readymade food like egg or any other fresh vegetable with best nutritional quality and is even competing with likes of mushroom etc. in the International market. Baby corn is a highly perishable product because of the highest respiration rate among vegetables. Pre-harvest application of growth regulators have known to play a spectacular role in improving growth and quality of many vegetables and fruits. 1.Higher production of summer season vegetable cowpea can be achieved by foliar spray of gibberalic acid (150 ppm) at 30 and 60 daysafter planting at terai zone of West Bengal (*Chatterjee* and *Choudhuri*, 2012) Information relating to extension of storage life of baby corn by sprays of growth regulators is very scarce hence, the present investigation was aimed at finding the suitable growth regulator in extending the shelf life of baby corn.

MATERIALS AND METHODS

The present investigation was undertaken during the kharif season with sixteen treatments composed of 3 growth promoters GA_3 (20, 40 and 60 ppm), Benzyl adenine (10, 20 and 30 ppm), Indole acetic acid (10, 20 and 30 ppm) and growth retardants cycocel (500, 1000 and 1500 ppm) and paclobutrazol (200,400 and 600 ppm) including control (water spray) were sprayed twice. Later the cobs were harvested at optimum picking stage (2 nd day after silking) and tested for shelf life and quality at room temperature. The chemical parameters like TSS, titrable acidity, vitamin C, crude protein, reducing sugars are estimated by the standard procedures (Ranganna, 1986).

RESULTS AND DISCUSSION

There was an increase in physiological loss in weight (Table 1) as the storage period increased. Pre-harvest application of growth regulators reduced the PLW as compared to control. It was observed that GA_3 40 ppm reduced the moisture loss to a grater extent. This may be attributed to the increasing affinity of the cell to water which can retain more water against forces of evaporation resulting in lesser weight loss during storage by altering some of the pertinacious constituents of the cell (Mitchell, 1949). Spoilage was in the form of pathogen attack, denting and shrivelling of com due to reduction of losses of moisture (Table 1). In general, the pre-harvest spray of growth regulators reduced the percentage of spoilage over control. The effectiveness of growth regulators in reduction of spoilage may be due to the decrease in biochemical changes in the cobs. This in turn have imparted resistance against penetration and growth of pathogen in the cobs and thus resulted in lesser spoilage (Kumar and Singh, 1987).

Quality parameters

There was a initial rise in the TSS (Table 2) and later a decline was observed in the cobs stored at room temperature. Pre-harvest spray of GA_3 40 ppm under all conditions of storage resulted in better retention of TSS due to the increased inhibitory effect of the

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Table 1: Effect of pre harvest spray of growth regulators on PLW, shelf life and spoilage of baby corn

Treatments	**Storage days**							
(ppm)	**Physiological loss in weight (%)**				**Shelf**	**Spoilage (%)**		
	1	**3**	**5**	**Mean**	**life**	**1**	**3**	**5**
T_1-GA_3 20	2.30	13.33	17.29	10.97	4.33	0.0	31.33	66.66
T_2-GA_3 40	2.06	13.14	17.10	10.77	5.00	0.0	27.00	60.33
T_3-GA_3 60	2.31	13.30	17.39	11.00	4.00	0.0	32.00	66.67
T_4-BA 10	2.41	13.43	17.54	11.13	4.00	0.0	33.67	66.67
T_5- BA 20	2.34	13.31	17.49	11.05	4.33	0.0	30.33	36.67
T_6- BA 30	2.43	13.39	17.52	11.11	4.00	0.0	33.67	66.67
T_7- IAA 10	2.43	13.44	17.65	11.17	4.00	0.0	34.00	67.33
T_8- IAA 20	2.34	13.35	17.469	11.05	4.33	0.0	31.33	64.33
T_9- IAA 30	2.42	13.45	17.52	11.13	4.00	0.0	34.00	67.33
T_{10}- Cycocel 500	2.44	13.34	17.40	11.06	4.00	0.0	31.30	64.67
T_{11}- Cycocel 1000	2.14	13.20	17.27	10.87	5.00	0.0	28.33	63.33
T_{12}- Cycocel 1500	2.24	13.37	17.39	11.00	4.33	0.0	32.33	65.33
T_{13}- Paclobutrazol 200	2.44	13.42	17.64	11.16	4.00	0.0	33.00	65.67
T_{14}- Paclobutrazol 400	2.33	13.33	17.56	11.07	4.33	0.0	31.67	63.333
T_{15}- Paclobutrazol 600	2.47	13.41	17.64	11.77	4.00	0.0	33.33	66.33
T_{16}- Control	2.97	14.59	19.71	12.42	3.00	0.0	52.00	84.67
Mean	**2.38**	**13.43**	**17.59**					
		SEm(±)	**LSD (0.05)**					
Days (D)		**0.02**	**0.04**	**SEm(±)**	**0.27**		**0.68**	**1.29**
Treatments (T)		**0.05**	**0.10**	**LSD (0.05)**	**0.55**		**1.35**	**2.56**
D×T		**0.09**	**0.17**					

Ba - Benzyl Adenine

chemicals on enzymes responsible for degradation of soluble fraction. There was a gradual decline in the titrable acidity (Table 2) with the increase in the storage period due to the utilization of acids in the respiratory process (Pool *et al.*, 1972).

Pre-harvest application of GA_3 was found to retain significantly higher acidity which explains the effectiveness of GA_3 on the slower degradation of organic acids for increased shelf life as suggested by Ahalawat *et al.* (1984). With the progress in storage period there was a continuous decline in the reducing sugars (Table 2). This may be due to heavy moisture losses and utilization of sugars for respiration as suggested by Pool *et al.*(1972). Pre-harvest spray of GA_3 40 ppm resulted in better retention of sugars during storage due to the lower rate of respiration, lower enzymatic activity which resulted in slower utilization of sugars for the respiration.

There was a gradual decline in the protein content (Table 3) with the advancement of storage period under all the conditions of storage. However, the process of reduction of crude protein in all treatments is not understood properly. During storage under all conditions, there was a decline in the ascorbic acid content (Table 3). This may be due to the activity of the oxidizing enzymes like ascorbic acid oxidase, peroxidase and catalase which might have converted ascorbic acid to dehydro ascorbic acid. Pre-harvest application of GA_3 might have slowed the activity of these enzymes (Khader, 1991) and led to better retention of ascorbic acid.

Fresh baby corn has a crisp taste and subtle slightly

Table 2: Effect of pre harvest spray of growth regulators on biochemical parameters of baby corn

Treatments (ppm)	Storage days											
	Total soluble solids (º Brix)				Titrable acidity (%)				Reducing sugars (%)			
	1	3	5	Mean	1	3	5	Mean	1	3	5	Mean
T_1- GA_3 20	10.1	10.6	9.1	10.0	0.3	0.2	0.2	0.2	2.3	1.2	0.9	1.5
T_2- GA_3 40	10.2	10.7	9.2	10.1	0.4	0.3	0.2	0.3	2.5	1.3	1.0	1.6
T_3- GA_3 60	10.1	10.6	9.1	10.0	0.3	0.2	0.2	0.2	2.3	1.2	0.8	1.5
T_4- BA 10	10.1	10.5	9.0	9.9	0.3	0.2	0.2	0.2	2.3	1.2	0.8	1.4
T_5- BA 20	10.1	10.6	9.0	9.9	0.3	0.2	0.2	0.2	2.3	1.2	0.8	1.5
T_6- BA 30	10.0	10.5	8.9	9.8	0.3	0.2	0.2	0.2	2.3	1.2	0.8	1.4
T_7- IAA 10	9.9	10.5	8.9	9.8	0.3	0.2	0.2	0.2	2.2	1.2	0.8	1.4
T_8- IAA 20	10.0	10.6	9.0	9.9	0.3	0.2	0.2	0.2	2.3	1.2	0.8	1.4
T_9- IAA 30	9.9	10.5	8.9	9.8	0.3	0.2	0.2	0.2	2.2	1.2	0.8	1.4
T_{10}- Cycocel 500	10.1	10.6	9.0	9.9	0.3	0.2	0.2	0.2	2.3	1.2	0.8	1.4
T_{11}- Cycocel 1000	10.1	10.7	9.1	10.0	0.3	0.3	0.2	0.3	2.4	1.3	0.9	1.5
T_{12}- Cycocel 1500	10.1	10.6	8.9	9.9	0.3	0.2	0.2	0.2	2.3	1.2	0.9	1.5
T_{13}- Paclobutrazol 200	10.0	10.4	8.9	9.7	0.3	0.2	0.2	0.2	2.2	1.1	0.8	1.4
T_{14}- Paclobutrazol 400	10.0	10.5	8.9	9.8	0.3	0.2	0.2	0.2	2.2	1.2	0.8	1.4
T_{15}- Paclobutrazol 600	9.9	10.4	8.7	9.7	0.3	0.2	0.2	0.2	2.2	1.1	0.8	1.4
T_{16}- Control	9.6	10.3	8.0	9.3	0.3	0.2	0.1	0.2	2.2	1.0	0.6	1.2
Mean	**10.0**	**10.5**	**8.9**		**0.3**	**0.2**	**0.2**		**2.3**	**1.2**	**0.8**	
		Sem(±)	**LSD (0.05)**			**SEm(±)**	**LSD (0.05)**			**Sem(±)**	**LSD(0.05)**	
Days (D)		**0.01**	**0.03**			**0.00**	**0.01**			**0.01**	**0.02**	
Treatments (T)		**0.03**	**0.06**			**0.01**	**0.02**			**0.02**	**0.05**	
D×T		**0.05**	**0.10**			**NS**	**NS**			**0.04**	**0.08**	

Table 3: Effect of pre harvest spray of growth regulators on biochemical parameters of baby corn

Treatments	Storage days											
	Crude protein(%)				Ascorbic acid content (mg 100^{-1} g)				Organoleptic score(10 scale)			
	1	3	5	Mean	1	3	5	Mean	1	3	5	Mean
T_1- GA_3 20	12.3	9.6	5.9	9.3	12.2	8.6	4.9	8.6	9.7	6.7	5.0	7.1
T_2- GA_3 40	12.8	10.5	7.6	10.3	12.7	9.1	6.5	9.4	10.0	8.0	6.0	8.0
T_3- GA_3 60	12.3	9.9	5.9	9.4	12.2	8.6	4.9	8.6	9.3	6.7	4.7	6.9
T_4- BA 10	12.0	9.6	5.9	9.2	12.2	8.3	4.7	8.4	9.3	6.7	5.0	7.0
T_5- BA 20	12.3	9.9	6.3	9.5	12.2	8.6	5.5	8.8	9.7	7.0	5.3	7.3
T_6- BA 30	12.0	9.6	5.9	9.2	12.2	8.3	4.7	8.4	9.7	6.7	4.7	7.0
T_7- IAA 10	12.0	9.6	5.6	9.5	12.0	7.8	4.9	8.2	9.3	6.7	5.3	7.1
T_8- IAA 20	12.3	9.9	6.3	9.2	12.2	8.1	4.9	8.4	9.7	7.0	5.3	7.3
T_9- IAA 30	12.0	9.6	5.6	9.1	12.5	7.8	4.7	8.3	9.3	7.0	5.0	7.1
T_{10}- Cycocel 500	12.3	9.6	5.9	9.3	12.2	8.6	5.2	8.7	9.7	7.3	5.3	7.4
T_{11}- Cycocel 1000	12.5	10.2	6.8	9.8	12.5	8.8	5.7	9.0	10.0	7.7	5.7	7.8
T_{12}- Cycocel 1500	12.3	9.6	5.9	9.3	12.2	8.6	5.2	8.7	9.3	7.0	5.3	7.2
T_{13}- Paclobutrazol 200	11.7	9.6	5.6	9.0	12.0	7.3	4.9	8.1	9.3	7.0	5.3	7.2
T_{14}- Paclobutrazol 400	12.3	10.2	5.9	9.5	12.5	7.8	4.9	8.4	9.7	6.7	5.0	7.1
T_{15}- Paclobutrazol 600	12.0	9.6	5.6	9.1	12.2	7.5	4.7	8.1	9.3	7.0	4.7	7.0
T_{16}- Control	11.4	7.0	3.5	7.3	12.0	6.5	3.1	7.2	8.7	5.3	3.0	5.7
Mean	**12.1**	**9.6**	**5.9**		**12.3**	**8.1**	**4.9**		**9.5**	**6.9**	**5.0**	
		Sem(±)	**LSD (0.05)**			**SEm(±)**	**LSD (0.05)**			**Sem(±)**	**LSD(0.05)**	
Days (D)		**0.09**	**0.18**			**0.09**	**0.17**			**0.17**	**0.33**	
Treatments (T)		**0.21**	**0.41**			**1.20**	**0.39**			**0.39**	**0.77**	
D×T		**0.36**	**0.71**			**0.34**	**0.68**			**NS**	**NS**	

sweet corn flavour and these attributes are considered as earmarks of high quality baby corn. Quality is a measure of the degree of excellence or degree of acceptability by the consumer. The acceptance of baby corn depends solely on consumer preference. Sensory characteristics of quality include appearance in terms of appearance, taste, crispness and colour. With the progress in the storage period, there was a decline in the organoleptic score (Table 3) in all the treatments. Highest organoleptic score was observed in cobs sprayed with GA_3 40 ppm in terms of as compared to all other treatments.

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Estimating the correlates of employment and income generation through bamboo enterprise in Tripura

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ABSTRACT

A study was carried out to assess the correlates of employment and income generation through bamboo enterprise in Tripura. Here, 96 respondents were selected randomly from the Hezamara block of Tripura; total numbers of predictor variables were 19. The study revealed that the predictor variables namely family size, land under agricultural crop, land under bamboo, annual income before bamboo, energy consumption, cost incurred in bamboo cultivation had recorded significant association with employment and wage generation from bamboo enterprise. The variables like age, family size, land under agricultural crop, cropping intensity, land under bamboo, material possessed, energy consumption, cost incurred in bamboo cultivation, had been retained in the step down regression to imply that these variables were extremely important to these causal variables to interpret the reason and spectrum of variance of the consequent variable in its behavior and performance. It has been found that the variable family size has exerted the highest direct effect and routed highest indirect effect, the variable land under bamboo has been exerted the highest indirect effect, to characterize the man-days and wages generation from bamboo enterprise. From the cross loading of the canonical covariates, it can be inferred that, while the entire Y set of variable are in interactive relationship, the three left side variables i.e. man-days generated from bamboo enterprise and wages generated from bamboo enterprise have respondent and dovetailed some of the X set of variable.

***Keywords*:** Bamboo enterprise, climate change, livelihood

Bamboo has been a familiar natural resource to the local communities over the millenniums with 1500 documented applications. Known, as *venu* in Sanskrit, it was used for construction of *yajna shalas* (prayer shelter for religious rituals) and consecration of saintly persons in *vedic* era (circa 1000 BC). It has been often been referred to as a "poor man's timber", due to its ubiquitous distribution and ease of working with the simplest of tools, and this diminished the attention of the planners and resource managers (Anitha *et al*., 2012). However, with the disquieting loss of forest cover and overall environmental degradation, it has again emerged as a panacea for wood substitution and promoting ecological and environmental security. The bamboo industry with immense economic potential in a labour surplus Indian economy has an important role in both the traditional and non-traditional sectors (Anitha and Sajayan, 2011) In Tripura, bamboo has many domestic, agricultural and commercial uses and cultural linkage with the bamboo dependent and indigenous people. The artisans in this sector make bamboo products for their sustenance and they are endowed only with traditional skills, tools and work experience (Anon., 2010).Their bamboo based productive activities mainly involve the four stages of procurement, processing, production and marketing. The raw material requirement of the bamboo dependents is mainly sourced from natural areas/forest depots, private depots, local market and home gardens.

The experiment was carried with the objectives to assess the productive performance of bamboo enterprise in terms of livelihood, to assess the agro-economic, socio-personal and management characteristics of respondents as the causal variables, to assess and evaluate the relation between the causal and consequent variables both at inter and intra level and to derive some strategies for micro level interventions.

MATERIALS AND METHODS

The present study was conducted at Hezamara block of West district (Tripura). The district, block and village were selected purposively due to the availability of the bamboo entrepreneurs in this area. The purposive as well as simple random sampling techniques were adopted for the present study. It may be termed as multistage and random sampling procedure. The districts, blocks and villages were purposively selected for the study. The West district and the block Hezamara were considered. Under the Hezamara block Sharat chowdhury para village was selected. From Sharat Chowdhury Para village 96 bamboo growers had been selected out of 1500 bamboo growers following simple random

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sampling(list sampling and class interval). Various dependent and independent variables namely age (X1), education (X2), family size (X3), average cost of farm implements when purchased (X4), average cost of farm implements at present (X5), homestead land (X6), land under agricultural crop (X7), cropping intensity (X8), land under bamboo (X9), material possessed (X10), annual income before bamboo (X11), mass media exposure (X12), number of rhizome planted (X13), number of rhizome grown to the fullest (X14), training received (X15), energy consumption (X16), distance to market (X17), cost incurred in bamboo cultivation (X18), Mode of selling (X19), man-days generated in bamboo enterprise (Y1),Wages generated in bamboo enterprise (Y2) were selected in the present study. Livelihood generated from bamboo enterprise is measured by per year wages and mandays generated from bamboo enterprise.

The primary data in the present study were collected directly from the farmers with the help of structured schedule through personal interview methods. Only the functional head of the household were taken as respondents for the study. The personal interview method was followed during the month of May and October 2013 to collect the relevant information from targeted respondents. Statistical Package for the Social Sciences (SPSS) had been used for the analysis of the data.

RESULTS AND DISCUSSION

Correlation between the man-days generation from bamboo enterprise and other independent variables

The variable family size (X3) have been found negatively but significantly correlated to imply that man-days generated from bamboo enterprise (Y1) has gone higher for a small size family. Small size family has got relatively less family cost to incur and hence higher level of savings and surplus. X3 has recorded highest significant association. Land under agricultural crop (X7) and land under bamboo (X9) , on the other hand, have recorded a positive but significant correlation to imply that all type of lands are providing the resource support for the optimum farm operation and the generation of farm income. The size of land acts in the form of a volume of operational resources and hence can ensure better income and absorb any kind of risk. Annual income before bamboo (X11) has been found to have positive but significant correlation with man-days generated from bamboo enterprise (Y1). This is to imply that it has got congenital impact.

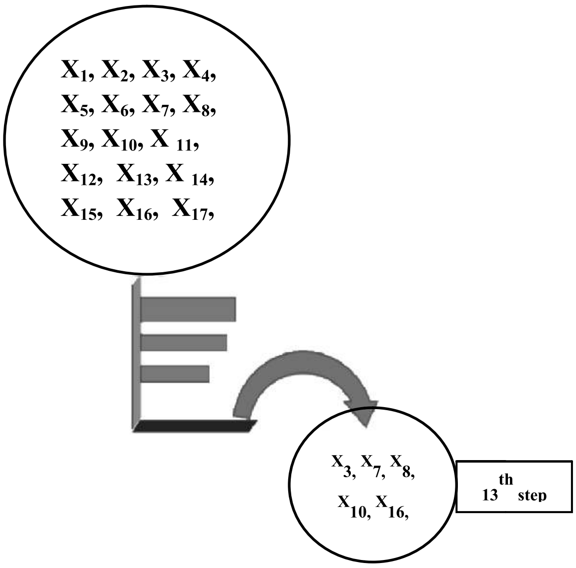
Energy consumption (X16) has been emerged as an important economic indicator to estimate the income from man-days generated from bamboo enterprise (Y1) of the respondents. This implies that the mechanization *vis-a-vis* energy intensification has gone positively to generate higher per unit man-days generation from bamboo enterprise. Cost incurred in bamboo cultivation (X18) has recorded to have positive but significant correlation with man-days generated from bamboo enterprise (Y1). This implies that respondents those who have invested high amount in bamboo plantation got higher income as well as higher man-days generated thereafter.

Correlation between wage generation from bamboo enterprise and other independent variables

The variable family size (X3) have been found negatively but significantly correlated to imply that wages generated from bamboo enterprise (Y2) has gone higher for a small size family. Small size family has got relatively less family cost to incur and hence higher level of savings and surplus. X3 has recorded highest significant association. Land under agricultural crop (X7) and land under bamboo (X9) , on the other hand, have recorded a positive but significant correlation to imply that all type of lands are providing the resource support for the optimum farm operation and the generation of farm income. The size of land acts in the form of a volume of operational resources and hence can ensure better income and absorb any kind of risk. Annual income before bamboo (X11), have been found to have positive but significant correlation with wages generated from bamboo enterprise (Y2). This is to imply that it has got congenital impact. Energy consumption (X16) has been emerged as an important economic indicator to estimate the income from wages generated from bamboo enterprise (Y2) of the respondents. This implies that the mechanization vis-a-vis energy intensification has gone positively to generate higher per unit wages generation from bamboo enterprise. Cost incurred in bamboo cultivation(X18) has recorded to have positive but significant correlation with wages generated from bamboo enterprise (Y2). This implies that those respondents who have invested high amount in bamboo plantation got higher income as well as higher Wages also.

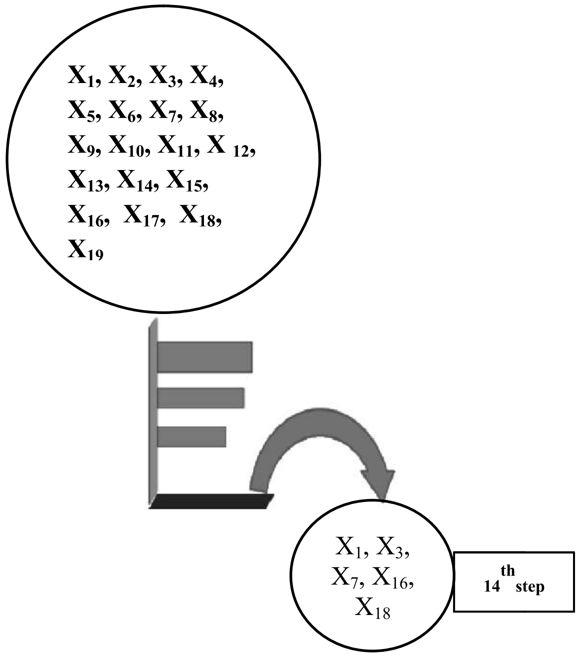
Paradigm of step down regression: causal effect of independent variables on man-days generated from bamboo enterprise (Y1), the consequent variable

The step down regression analysis imply that, which are the few variable out of the whole plethora of variables have been retained at the last step (13th) to contribute substantially on the consequent variable that is mandays generated from bamboo enterprise. So, Family size (X3), Land under agricultural crop(X7),Cropping intensity(X8), Material possessed(X10), Energy consumption(X16), Cost incurred in bamboo cultivation(X18)are the 6 most important causal variable to interpret the variance embedded with the mandays generated from bamboo enterprise.



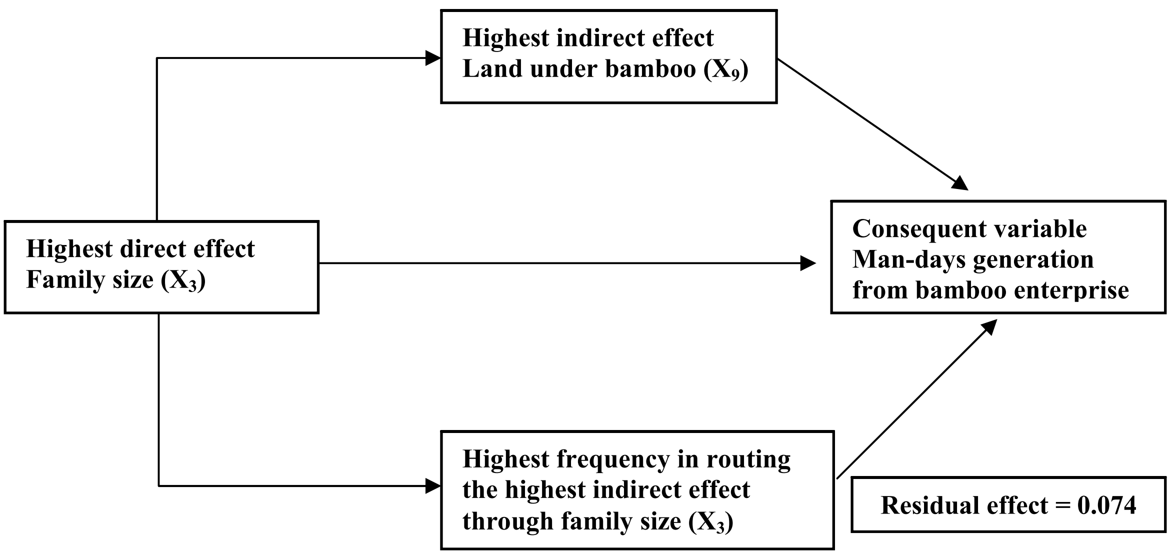
The variables retained at the last and 13th step

Paradigm of step down regression: causal effect of independent variables on wages generated from bamboo enterprise (Y2), the consequent variable.



The variables retained at the last and 14th step

The step down regression analysis to imply that, which are the few variables out of the whole plethora of variables have been retained at the last step (14th) to contribute substantially on the consequent variable that is Wages generated from bamboo enterprise. So, age (X1), family size (X3), land under agricultural crop (X7), energy consumption(X16), Cost incurred in bamboo cultivation(X18)are the 6 most important causal variable to interpret the variance embedded with the wages generated from bamboo enterprise.



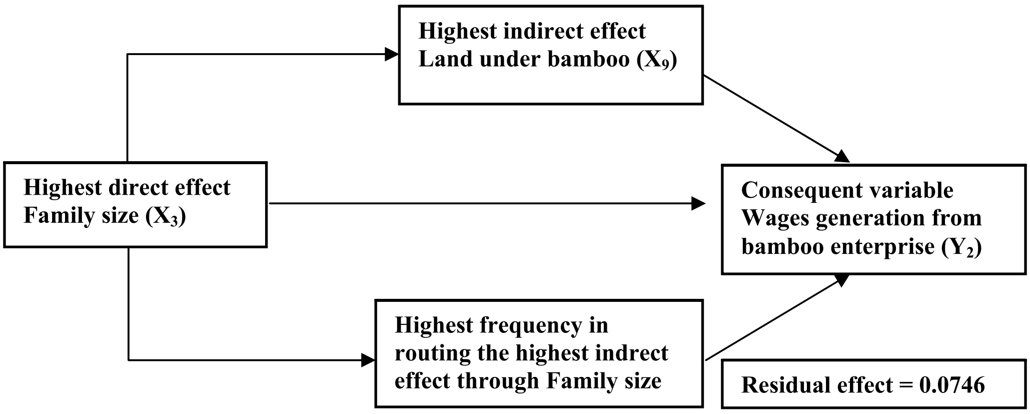
Path analysis: man-days generated from bamboo enterprise (Y_1) and other 19 exogenous variables

It has been found that the variable family size(X3) has exerted the highest direct effect to characterize the mandays generation from Bamboo enterprise. It is well discernible that family size presents both stress and motivation to go for labour intensive work in individual to elicit a better choice out of basket of commodity to support the family and earn better social status for the family.

The variable land under bamboo(X9) has also been exerted the highest indirect effect to imply that this variable has got highest associational property to characterize the mandays generation from of bamboo enterprise.

Again, it has been found that the variable family size(X3) has routed highest indirect effect of all the variables to ultimately functionalize the performance of mandays generation from bamboo enterprise. This indicates the behavioral as well as operational viscosity of this variable. The value of the residual effect indicates that with the combination of these 19 variables, more than 98 per cent variance of mandays generation from bamboo enterprise (Y1) has been explained.

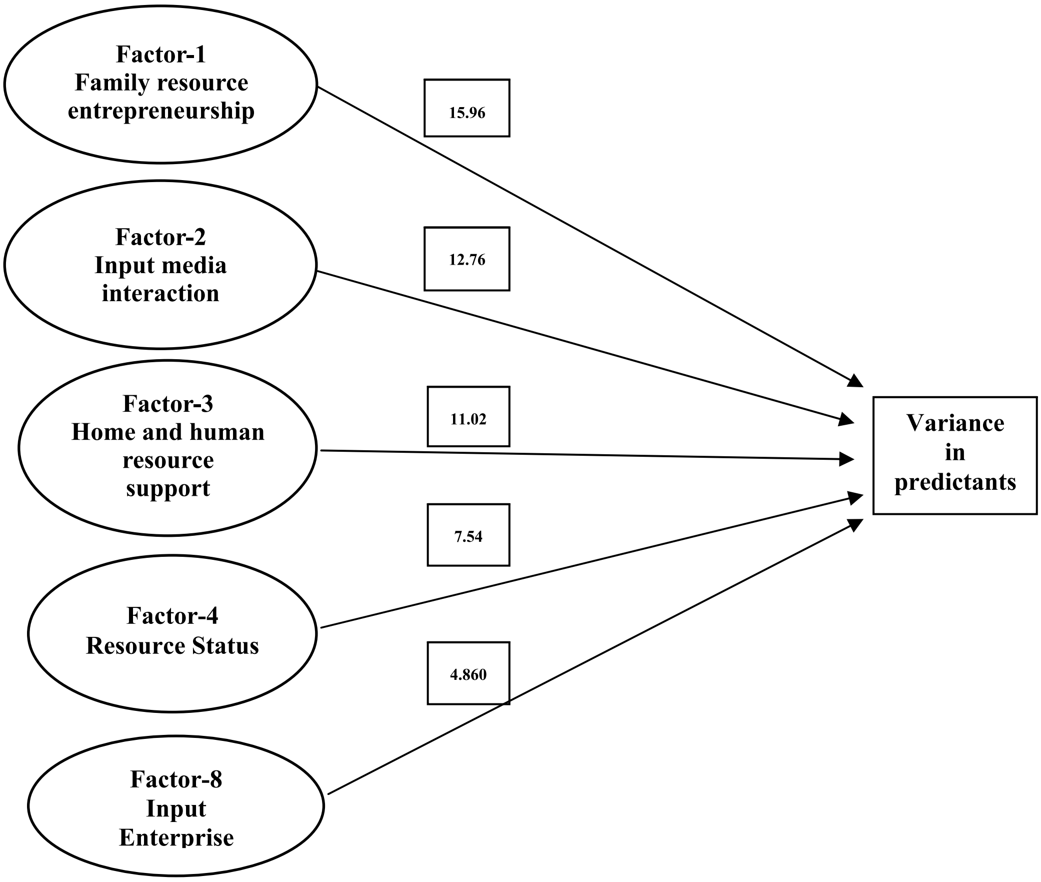
It has been found that the variable family size(X3) has exerted the highest direct effect to characterize the wages generation from bamboo enterprise. It is well discernible that family size presents both stress and motivation to go for labour intensive work in individual to elicit a better choice out of basket of commodity to support the family and earn better social status for the family. The variable land under bamboo(X9) has also been exerted the highest indirect effect to imply that this variable has got highest associational property to characterize the wages generation from bamboo enterprise. Again, it has been found that the variable family size(X3) has routed highest indirect effect of all the variables to ultimately functionalize the performance of wage generation from bamboo enterprise. This indicates the behavioral as well as operational viscosity of this variable. The value of the residual effect indicates that with the combination of these 19 variables, more than 98 per cent variance of wages generation from (Y2) has been explained.



Path analysis: wages generated from bamboo enterprise (Y_2) and other 19 exogenous variables

It presents the factor analysis to estimate the degree of conglomeration of apparently different exogenous variables, based on Eigen values into some discernible factor. It has been found that factor-1 has accommodated the following variables: family size (X3), land under agricultural crop (X7), area under bamboo (X9), energy consumption (X16), mode of selling (X19). And this factor can be renamed as Family Resource entrepreneurship. This has contributed 15.96% of variance. Factor-2 has accommodated the following variables: mass media exposure (X12), number of rhizome planted (X13), number of rhizome grew to the fullest (X14). And this factor can be renamed as Input media interaction. This has contributed 12.761% of variance. Factor-3 has accommodated the following variables: age (X1), education (X2), homestead land (X6). And this factor can be renamed as Home and human resource support. This has contributed 11.017% of variance. Factor-4 has accommodated the following variables: material possessed (X10), annual income before bamboo (X11). And this factor can be renamed as resource status. This has contributed 4.86% of variance. Factor-8 has accommodated the following variables: Average cost of farm implements when purchased (X4), Mode of selling (X19). And this factor can be renamed as Input enterprise. This has contributed 7.541% of variance. Since the rest of the factor have accommodated solitary variable in each of the cases, no renaming is required.

The cumulative variance is 87% which is fairly enough to explain any kind of interpretative variation as well as interaction amongst and between the whole plethora of variable including both dependent and independent variables.



Factor analysis: conglomeration of variables based on factor loading and renaming of factors

Canonical covariate analysis has been carried out to depict the clandestine interactive and combination between two sets of variables i.e., left and right side sets of variables. This analysis has got tremendous strategic importance.

The model depicts that from the left side (Set-I) the following consequent variables *viz*. Y1= Family income from bamboo enterprise,Y3= Productivity of bamboo, have got clear choices to select the following exogenous variable *i.e.* from right set of variables *viz.* X1=Age, X3 =Family size, X4= Average cost of farm implements when purchased, X5= Average cost of farm implements at present,X9= Land under bamboo, X12= Mass media exposure, X13= Number of rhizome planted,X14= Number of rhizome grown to the fullest, X15= Training received, X18 = Cost incurred in bamboo cultivation.

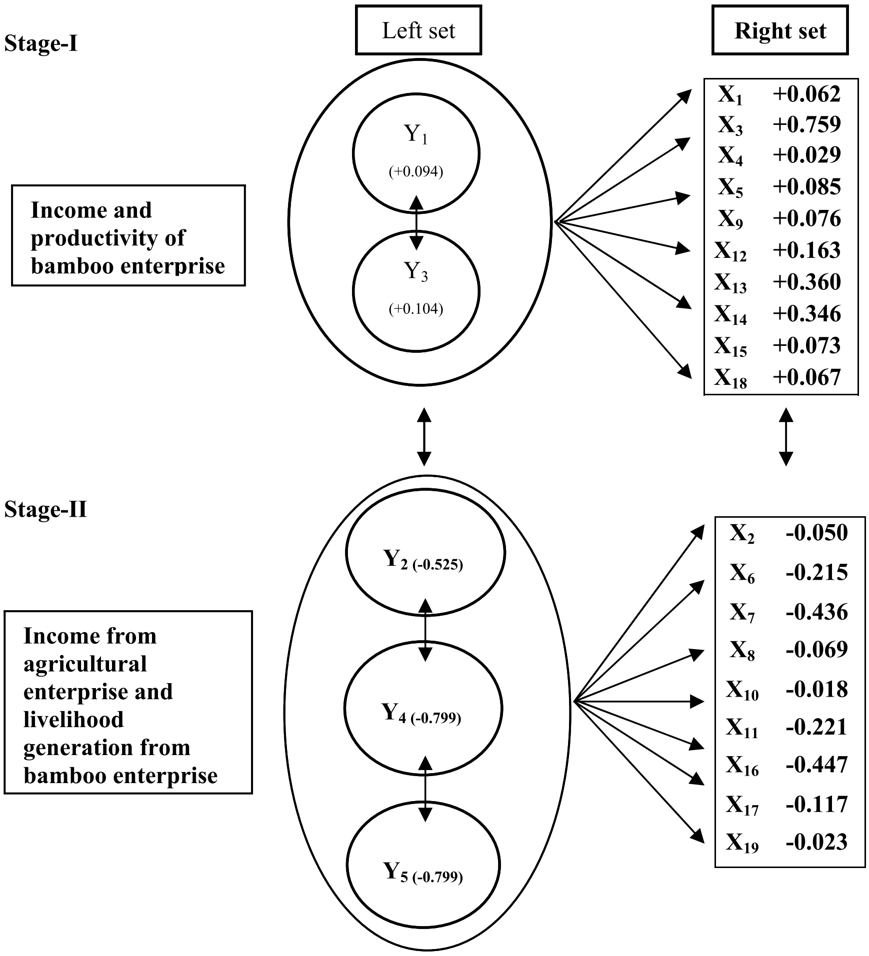
From the cross loading of the canonical covariates, it can be inferred that, while the entire Y set of variable are in interactive relationship, the two left side variables *i.e.* Family income from bamboo enterprise(Y1) and Productivity of bamboo(Y3) have respondent and dovetailed these X set of variable.

So, it can be concluded that the increase of income through increase of productivity needs a collective support from the causal variable like Age (X1), Family size (X3), Average cost of farm implements when purchased (X4)

Average cost of farm implements at present(X5), Land under bamboo (X9), Mass media exposure(X12), Number of rhizome planted(X13), Number of rhizome grown to the fullest (X14), Training received(X15), Cost incurred in bamboo cultivation(X18). So the left set of variable (Y1 & Y3) combined can be branded as *Productive Economy of Bamboo Enterprise* with a clandestine support from *Resource-Investment Factor.*

In case of Set-II From the cross loading of the canonical covariates, it can be inferred that, while the entire Y set of variable are in interactive relationship, the three left side variables i.e. family income from agricultural enterprise (Y2), mandays generated from bamboo enterprise (Y4) and wages generated from bamboo enterprise (Y5) have respondent and dovetailed these X set of variable.

So, it can be concluded that the increase of income through increase of productivity needs a collective



Canonical correlation analysis

support from the causal variable like education (X2), homestead land (X6), land under agricultural crop (X7), cropping intensity (X8), material possessed (X10), annual income before bamboo (X11), energy consumption (X16), distance to market (X17), mode of selling (X19). So the left set of variable (Y2, Y4, Y5) in combination can be branded as *Farm Family Economy* with a clandestine support from right side variable which also can be branded combined as *Management–Communication Variable.*

Livelihood generation is a complex process that undergoes a plethora of socio-economic and techno-ecological functions. In studding the livelihood generation from bamboo enterprises, the variables contributed to it are institutional and managerial in nature, consisting of family size, land resources, cropping intensity, cost and energy consumption. This multidimensional interaction means and implies that livelihood planning needs to consider not only the enterprise it deals with but also the ecology it confronts with. A constructive livelihood process whatsoever basically keeps integrating resource- time - cost and technology while a coercive livelihood keeps depleting the resource base and creates a discord with the surrounding ecosystem. The same research can be cloned in different ecological and social set up in as much to develop a model based on bamboo enterprise towards prescribing a sustainable livelihood generation process.

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Estimation of variability for grain yield, quality and some agronomic traits in bread wheat and triticale

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ABSTRACT

The investigation was carried out to study the genetic variability of quantitative traits and their contribution towards seed yield that may be used as criteria for yield improvement in wheat. The experiment was conducted with forty nine genotypes including two triticale in Nadia district of West Bengal during rabi season in two consecutive years 2012-2013 and 2013-2014 following RBD design with two replications. A wide spectrum of variability for all the characters except days to maturity within the genotypes were evident which could provide scope for improvement on the characters following selection and most of the characters like plant height, days to heading, days to flowering, 1000 grain weight, number of grains spike^{-1} and yield plant^{-1} were associated with high heritability along with high genetic advance which suggested that the characters are predominantly controlled by additive gene effect and direct selection on the basis of phenotypic data may response positively to desired direction.

Keywords: Genetic advance, heritability, *Triticale*, wheat

Wheat is the king of all cereals because of its high nutrient content and its suitability to all agro-ecological regions. Wheat crop has wide adaptability as it can be grown in the tropical, sub-tropical and in the temperate zone and the cold tracts of the far north, beyond even 60 degree north latitude. Wheat is 2nd most important cereal in west Bengal as well as in India. The annual production of wheat in West Bengal during 2011-12 was 0.88 mt with 2800 kg/ ha productivity in 0.32 m ha cultivated area. It provides more calories and protein to human diet than any other crop. Protein content is a key quality factor that determines the suitability of wheat for a particular type of product as it affects other factors including mixing tolerance, loaf volume and water absorption capacity (Shah *et al.,* 2008). Both protein quantity and quality are considered important in estimating the potential of flour for its end use quality (Farooq *et al.,* 2001). Wheat proteins (12-16%) are of special important. Hard wheat is high in protein (10-17%) and yields a flour rich in gluten, making it particularly suitable for yeast breads. The low-protein (6 to 10%) softer type yields flour lower in gluten and therefore, better suited for tender baked products, such as biscuits, pastries and cakes. *Triticum durum* wheat, although high in gluten, is not suitable for baking, but suitable for semolina, the basis for excellent pasta, such as spaghetti and macaroni preparation.

The success of a crop improvement program depends upon the amount of genetic variability existing in the germplasm. To bring the heritable improvements in economic characters through selection and breeding, estimation of genetic parameters must be made before starting a program. There are different techniques available to compute the genetic parameters and the index of transmissibility of characters. Heritability estimates provide information about the extent to which a particular character can be transmitted to the successive generations. Knowledge of heritability of a trait thus guides a plant breeder to predict behavior of succeeding generations and helps to predict the response to selection. High genetic advance coupled with high heritability estimates offer a most suitable condition for selection (Larik *et al*., 1989). Therefore, availability of good knowledge of heritability and genetic advance existing in different yield parameters is a pre-requisite for effective plant improvement exercise (Haq *et al*., 2008).

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MATERIALS AND METHODS

The wheat germplasm consisted of forty nine genotypes including two triticale were collected from Directorate of Wheat Research, Karnal through All India Coordinated Wheat & Barley Integrated Project of Kalyani centre, BCKV. Field experiments were conducted at two locations, District Farm, AB Block, BCKV, Kalyani, West Bengal and Instructional Farm, BCKV, Jaguli, Nadia, West Bengal during rabi seasons in two consecutive years 2012-2013 and 2013-2014 following RBD design with two replications. The important characters considered in the present investigation were days to heading, days to flowering, days to maturity, plant height, number of tillers plant^{-1}, number of spikes plant^{-1}, spike length, number of spikelets spike^{-1}, number of grains spike^{-1}, weight of grain spike^{-1}, flag leaf area, chlorophyll-a content, chlorophyll-b content, total chlorophyll content, 1000 grain weight, amylose content, grain protein content and yield plant^{-1}. Genotypic and phenotypic variances, genotypic and phenotypic coefficient of variability, broad sense heritability and genotypic and phenotypic correlation were computed according to the method suggested by Singh and Chaudhary (1985).

RESULTS AND DISCUSSION

The analysis of variance showed wide spectrum of variability for all the characters except days to maturity within the genotypes which provided sufficient scope for further on these traits through selection. Wide range in mean value was observed in days to heading, days to flowering, plant height, number of tillers plant^{-1}, number of spikelets spike^{-1}, number of grains spike^{-1}, flag leaf area, chlorophyll content, 1000 grain weight, grain protein content, grain yield plant^{-1} which supported the variant nature of the genotypes considered in the present investigation for most of the characters and may provide success in selection on the basis of phenotypic value of component characters. The average performances of the genotypes for all the characters under study are presented in table 1. As revealed by the LSD value, significantly early heading was noticed in genotypes JAUW 616 and UP 2856 (55.50 days) and early flowering was noticed in UP 2856 (61.00 days) followed by HD 3133 and JAUW 616. Early maturing genotype was identified as JAUW 616 (111.25days) alongwith DBW 115, NW 5095, RAJ 4329 and RAJ 4330 and UP2858 (119.25 days) was found to be late in maturity. Maximum plant height was observed in genotype WH 1154 (104.75cm) followed by WH 1155, JAUW 616 and WH 1151. Maximum number of tillers plant^{-1} was noticed in DBW 115 followed by RAJ 4333, PBW 692 and RAJ 4332. Genotype PBW 694 was recorded maximum number of spike plant^{-1} (11.50), it was followed by RAJ 4332, PBW 692 and HD 2733© and found within the critical range of RAJ 4332. Maximum spike length in HUW 670 (11.79cm) followed by HD 3130 and DBW 17© and fall within critical difference of HUW 670. The same genotype HUW 670 showed maximum number of spikelets spike^{-1} (20.25) and it was followed by NW 6002, K 0307©, DBW 17©, WH 1151 and UP 2858 and showed no significance difference from HUW 670. Highest number of grains spike^{-1} was recorded in genotype HD 3129 (40.25) and was being followed by NW 5095, UP 2857 and DBW 113. Genotype HD 3128 (1.27g) exhibited least weight of grain spike^{-1} and its highest value was shown by DBW 116 (2.27g) alongwith WH 1151 and DBW 114. The highest chlorophyll-a content was observed in genotype HD 3129 (0.278 mg^{-1} g) closely followed by HD 3130 and DBW 115, while highest amount of chlorophyll-b content was recorded on genotype UP 2856 (0.378mg^{-1} g) noticed no significance different from UP 2856. Thousand grain weight was least in genotype UP 2856 (24.70g) and highest in genotype NW 6002 (43.40g) it was followed by WH 1154, RAJ 4329, TL 2995, HD 3130 and JAUW 611. Maximum protein percentage was recorded in genotype HD 3133 (15.70%) followed by PBW 696, RAJ 4330, RAJ 4329 and WH 1152 and showed no significant difference from HD 3133. Highest amylose percentage was recorded in HD 3127 (27.60 %) followed by TL 2995, HD 3131 and HD 3126. Lowest grain yield plant^{-1} was noticed in genotype HD 3128 (12.70g) followed by HD 3133, UP 2854 and WH 1154. The highest grain yield plant^{-1} was recorded by PBW 692 (24.60g) followed by DBW 115, HD 2967©, NW 6002 and RAJ 4332 and the following genotype either from minimum or maximum yielder showed no significant variations.

The range, mean values, variances due to phenotype, genotype and environment, coefficient of variation (CV), genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability (h^2), genetic advance (GA) and genetic advance as percentage mean are presented in table 2. The phenotypic and genotypic variances were found to be high for days to flowering, plant height and days to heading and it was substantial high for 1000 grain weight, number of grains spike^{-1} and yield plant^{-1} and other characters showed small variances due to genotype and phenotype. The characters with high variances due to genotype and phenotype also showed high environmental variance and similarly small environmental variances was noticed in character with small variance with respect to these parameters. Characters with high variances also highlighted high environmental variances which suggested that selection on the basis of phenotypic characters may not produce desirable result for which progeny selection may constitute desirable component for effective selection. On the other hand the characters like number of tillers plant^{-1}, number of spikes plant^{-1}, spike length, flag leaf area, chlorophyll content with

Table 1: Mean performance estimated on pooled data of the different characters among the genotypes of wheat

Varieties	Days to heading	Days to flowering	Days to maturity	Plant height (cm)	No. of tillers plant^{-1}	No. of spike plant^{-1}	Spike length (cm)	No. of spikelet spike^{-1}	No. of grains spike^{-1}	Wt. of grain spike^{-1} (g)	Flag leaf area (cm^2)	Chl- a (mgg^{-1})	Chl-b (mgg^{-1})	Total chl. (mgg^{-1})	1000 grain wt.(g)	Grain protein (%)	Amy-lose (%)	Yield plant^{-1} (g)
DBW113	73.25	79.25	117.00	93.15	11.00	9.25	10.96	18.75	38.50	1.70	19.74	0.206	0.100	0.337	38.80	12.90	25.10	18.60
DBW114	73.50	79.75	118.00	58.00	10.75	10.25	10.60	17.75	34.75	1.95	22.53	0.199	0.060	0.260	33.50	13.30	23.40	20.90
DBW115	68.50	74.50	114.25	77.69	14.25	10.50	10.71	18.25	37.00	1.74	21.78	0.251	0.097	0.372	38.80	13.10	26.20	24.50
DBW116	71.50	76.00	117.75	92.60	10.00	8.50	9.26	17.25	38.00	2.27	18.92	0.230	0.081	0.309	39.00	13.20	26.40	22.60
DBW117	67.00	71.00	116.75	99.16	12.50	9.75	9.91	16.25	30.50	1.57	21.44	0.163	0.069	0.236	37.90	13.80	24.10	19.50
DBW118	72.50	78.00	116.25	92.82	12.00	9.75	9.12	15.00	34.00	1.70	24.29	0.164	0.069	0.234	41.70	13.70	23.70	20.30
HD3130	68.50	73.75	118.25	92.46	11.50	9.00	11.62	15.25	31.25	1.63	24.15	0.253	0.065	0.301	42.10	14.30	23.50	18.40
HD3133	62.50	66.75	116.25	93.28	10.50	8.25	10.89	16.50	33.75	1.45	18.25	0.193	0.082	0.288	39.40	15.70	24.00	15.20
HD3128	66.75	72.25	115.50	92.75	10.00	8.75	9.14	13.50	30.00	1.27	17.24	0.226	0.065	0.268	36.90	14.00	24.80	12.70
HD3129	68.75	72.50	116.25	98.25	9.50	8.75	11.23	15.75	40.25	1.78	22.26	0.265	0.103	0.402	37.30	13.00	26.50	16.70
HD3132	66.50	71.00	116.25	94.40	12.00	9.75	9.25	15.75	35.00	1.60	21.26	0.187	0.067	0.253	38.40	13.90	24.60	19.20
HD3127	65.50	71.00	117.25	92.85	12.00	10.25	9.44	16.75	37.25	1.66	21.92	0.155	0.063	0.213	36.20	14.30	27.60	19.80
HD3126	70.00	75.25	117.75	98.40	10.50	9.25	10.14	18.50	36.00	1.61	23.07	0.235	0.048	0.278	33.80	13.30	27.00	16.80
HD3131	68.75	72.50	116.75	65.51	11.00	10.50	10.39	17.75	36.25	1.72	20.97	0.192	0.071	0.255	41.60	12.80	27.10	18.80
HUW671	67.25	71.25	115.75	86.97	12.00	10.25	10.99	16.75	34.25	1.70	22.82	0.151	0.066	0.215	39.60	13.10	23.90	20.40
HUW670	72.00	76.75	118.50	63.83	10.25	9.00	11.79	20.25	34.75	1.73	21.78	0.278	0.073	0.376	38.80	12.80	25.20	17.70
JAUW611	72.00	77.00	115.50	87.00	12.00	10.00	10.48	16.25	31.50	1.52	18.09	0.196	0.070	0.285	42.10	14.50	24.50	18.20
JAUW616	55.50	66.00	111.25	102.25	10.75	8.50	8.02	13.25	30.75	1.56	19.75	0.233	0.049	0.264	40.20	13.20	24.70	17.00
K1201	66.50	69.50	116.25	94.10	10.75	9.00	9.13	18.50	29.00	1.59	22.15	0.191	0.072	0.274	33.10	14.20	22.40	17.10
K1202	71.75	75.00	115.25	74.56	11.75	10.25	9.38	16.50	29.00	1.75	20.57	0.183	0.071	0.264	40.60	13.00	24.40	20.60
NW5095	69.50	74.00	114.25	73.60	11.50	9.50	10.64	18.75	39.00	1.73	20.31	0.217	0.080	0.274	32.80	13.40	24.20	19.80
NW6000	65.25	70.00	115.50	90.64	11.50	9.75	10.31	17.25	33.00	1.44	22.47	0.223	0.073	0.311	40.10	14.50	24.20	16.50
PBW692	71.75	76.50	116.25	75.50	13.25	11.00	10.21	17.25	34.25	1.87	22.62	0.224	0.083	0.303	38.10	12.90	25.90	24.60

contd...

Table 1 contd......

PBW693	69.75	74.25	116.50	93.60	11.50	9.25	9.56	16.50	35.75	1.77	20.63	0.253	0.106	0.394	38.20	13.40	24.50	20.00
PBW694	72.75	77.75	117.75	93.78	12.75	11.50	10.78	18.25	34.50	1.61	22.25	0.153	0.091	0.243	38.70	12.70	26.20	20.50
PBW695	62.75	69.00	115.75	92.50	12.00	9.50	10.28	17.50	31.75	1.60	19.77	0.212	0.067	0.278	40.50	13.90	23.80	19.20
PBW696	71.50	75.75	116.25	96.25	10.25	8.50	8.82	15.00	30.50	1.64	20.13	0.216	0.089	0.301	40.00	14.80	23.90	16.70
RAJ4329	70.50	75.00	114.50	72.55	12.25	10.00	10.20	17.00	38.00	1.76	21.30	0.139	0.067	0.510	42.20	14.70	24.30	21.40
RAJ4330	67.00	71.25	114.50	98.61	11.25	9.00	10.42	17.50	30.50	1.78	19.38	0.171	0.073	0.254	39.40	14.70	24.40	19.70
RAJ4331	64.50	70.75	117.00	98.97	10.00	9.75	10.40	17.00	28.25	1.73	21.97	0.201	0.078	0.290	37.30	14.00	26.40	17.00
RAJ4332	67.50	72.50	115.00	71.59	13.00	11.25	10.11	16.50	34.50	1.84	19.62	0.188	0.072	0.272	32.60	14.00	26.00	23.70
RAJ4333	65.25	69.75	115.25	96.25	13.50	10.50	8.12	12.25	30.00	1.48	21.37	0.150	0.051	0.214	34.90	14.70	22.80	20.00
TL2995	63.25	68.25	115.75	97.25	11.50	9.00	9.55	16.25	31.00	1.77	21.90	0.227	0.056	0.271	42.10	14.10	27.30	20.30
UP2854	67.50	72.25	117.50	94.00	11.00	9.00	10.71	15.25	30.50	1.46	18.78	0.200	0.070	0.272	33.90	14.60	23.10	15.80
UP2855	65.75	76.50	117.25	93.75	10.75	8.00	10.19	17.50	37.75	1.64	20.14	0.193	0.075	0.277	32.70	13.10	24.80	17.50
UP2856	55.50	61.00	116.25	79.30	11.00	10.25	9.13	17.75	34.00	1.56	20.04	0.194	0.378	0.280	24.70	12.90	24.80	17.10
UP2857	73.25	77.50	116.50	94.07	10.75	9.50	9.98	17.00	38.75	1.61	21.43	0.167	0.079	0.243	40.80	13.20	24.60	17.40
UP2858	75.00	80.50	119.25	66.71	10.50	9.00	10.07	19.00	37.50	1.66	21.65	0.218	0.080	0.278	33.70	13.20	24.40	17.50
UP2875	64.75	69.25	117.50	66.02	12.00	10.75	10.06	17.25	32.00	1.54	19.70	0.206	0.083	0.282	36.50	12.80	24.50	18.40
WH1151	71.25	77.00	115.75	100.00	11.00	9.75	10.59	19.00	35.75	1.96	22.76	0.139	0.100	0.203	38.70	14.50	24.90	21.50
WH1152	70.75	77.75	115.50	97.00	10.25	8.75	10.23	17.75	33.50	1.74	20.96	0.154	0.059	0.213	38.70	14.70	24.20	17.70
WH1153	72.75	76.25	117.00	93.95	11.00	9.25	9.57	17.25	38.25	1.76	22.32	0.234	0.099	0.346	38.40	13.10	25.30	19.30
WH1154	72.75	79.25	117.00	104.75	9.50	8.25	9.21	17.75	30.50	1.63	16.13	0.158	0.065	0.234	43.10	13.30	25.30	15.50
WH1155	70.00	78.25	118.75	103.16	12.50	10.25	10.82	18.75	37.00	1.50	20.64	0.196	0.060	0.263	38.70	12.90	23.70	18.70
DBW17©	66.25	70.50	116.25	68.19	12.00	9.00	11.17	19.00	34.75	1.72	23.38	0.215	0.092	0.318	40.20	12.70	24.60	20.50
HD2733©	65.00	69.50	117.75	74.42	13.00	11.00	9.91	16.75	28.75	1.57	22.62	0.209	0.088	0.299	39.50	12.70	24.90	20.40
HD2967©	76.25	80.50	118.75	97.92	12.75	9.75	10.72	17.00	34.00	1.88	22.65	0.194	0.073	0.262	41.00	13.40	24.20	24.00
K0307©	65.50	70.75	119.00	90.89	11.75	10.00	10.84	19.00	33.25	1.72	20.93	0.193	0.082	0.283	37.10	13.70	25.70	20.20
Mean	**68.49**	**73.67**	**116.51**	**87.00**	**11.46**	**9.617**	**10.10**	**17.08**	**34.03**	**1.68**	**21.17**	**0.199**	**0.081**	**0.284**	**38.10**	**13.60**	**24.90**	**19.20**
LSD(0.05)	**6.469**	**7.181**	**3.268**	**11.489**	**2.612**	**2.029**	**1.200**	**2.710**	**5.060**	**0.33**	**4.060**	**0.035**	**0.126**	**0.111**	**6.832**	**2.059**	**3.112**	**3.770**

Table 2: Mean, range and other genetic parameters estimated on pooled data of the different characters among the genotypes of wheat

Characters	Range	Mean	SED	Variances			CV	GCV	PCV	H^2 broad sense	Genetic advance (GA)	GA as % of mean (at 5%)
				Geno typic	Pheno typic	Environ mental						
Days to heading	55.50-76.25	68.49	0.840	13.745	24.094	10.349	1.227	6.291	6.410	96.337	8.712	12.720
Days to flowering	61.00-80.50	73.668	0.885	11.384	24.139	12.755	1.201	5.657	5.784	95.685	8.398	11.400
Days to maturity	111.25-119.25	116.505	0.765	277.862	280.503	2.641	0.656	1.170	1.341	76.034	2.448	2.101
Plant height (cm)	58.00-104.75	87.767	0.826	133.930	166.575	32.645	0.941	13.95	13.982	99.547	25.165	28.673
No. of tillers plant^{-1}	9.50-14.25	11.459	0.520	0.295	1.983	1.687	4.543	8.742	9.851	78.747	1.831	15.981
No. of spikes plant^{-1}	8.00-11.50	9.617	0.063	0.197	1.215	1.018	6.897	7.249	10.006	52.479	1.040	10.817
Spike length (cm)	8.02-11.79	10.101	0.289	0.481	0.837	0.356	2.869	7.780	8.290	88.073	1.519	15.041
No. of spikelet spike^{-1}	12.25-20.25	17.082	0.716	1.637	3.453	1.816	4.193	8.857	9.799	81.684	2.817	16.489
No. of grains spike^{-1}	28.25-40.25	34.026	0.724	7.178	13.511	6.333	2.129	9.332	9.572	95.052	6.377	18.742
Wt. of grain spike^{-1} (g)	1.27-2.27	1.681	0.054	0.013	0.040	0.027	3.258	9.376	9.918	89.368	0.307	18.259
Flag leaf area (cm^2)	16.13-26.23	21.166	0.561	1.406	5.483	4.077	2.647	8.566	8.966	91.270	3.568	16.858
Chlorophyll a (mg/g)	0.139-0.278	0.199	0.009	0.001	0.001	0.000	0.000	16.353	16.947	93.119	0.065	32.508
Chlorophyll b (mg g^{-1})	0.048-0.378	0.081	0.006	0.000	0.004	0.004	78.081	17.122	77.518	4.879	0.006	7.791
Total chlorophyll(mg g^{-1})	0.203-0.510	0.284	0.053	0.002	0.005	0.003	19.286	14.269	23.564	36.665	0.051	17.798
1000 grain wt. (g)	24.70-43.40	38.123	0.538	6.477	18.021	11.544	1.410	9.126	9.235	97.667	7.083	18.579
Grain protein (%)	12.70-15.70	13.623	0.431	0.025	1.073	1.049	3.166	4.957	5.881	71.062	1.173	8.609
Amylose (%)	22.40-27.60	24.873	0.824	0.232	2.627	2.395	3.313	4.197	5.347	61.621	1.688	6.787
Yield plant^{-1} (g)	12.70-24.60	19.175	0.608	4.578	8.094	3.516	3.168	12.934	13.317	94.335	4.962	25.878

GCV=Genotypic coefficient variation; PCV=Phenotypic coefficient variation; H^2=Heritability (broad sense); GA= Genetic advance.

different pigment and protein content showed little environmental influence and the direction selection on the basis of phenotypic value may provide desirable result.

The phenotypic coefficient of variation (PCV) was found to be marginally higher than genotypic coefficient of variation (GCV) for most of the characters except number of spikes plant^{-1}, total chlorophyll content which suggested the presence or little influence on the expression of most of the characters due to environment where phenotypic selection may provide desirable result but for other two character evaluation on the basis of progeny testing considered to be prerequisite to derive success in selection. Ali *et al*. (2008) found high amount of PCV and GCV for grain yield plant^{-1}, whereas remaining traits like number of grains spike^{-1} and 1000 grain weight exhibit moderate to low PCV and GCV estimates.

Heritability of the characters ranged from 4.879 mg/g in chlorophyll -b to 99.547 cm for plant height and genetic advance as percentage of mean 2.101 percent in days to maturity to 32.508 mg/g chlorophyll-a. High heritable characters were found to be days to heading, days to flowering, plant height, spike length, number of spikelet's spike^{-1}, number of grains spike^{-1}, weight of grains spike^{-1}, flag leaf area, chlorophyll a content, 1000 grain weight and grain yield plant^{-1}. Whereas low heritable characters were number of spike plant^{-1}, chlorophyll b content and total chlorophyll content. Other characters showed heritability at intermediate level.

High heritability associated with moderate to low genetic advance were observed for plant height, days to heading, days to flowering, 1000 grain weight, and number of grains spike^{-1}. Similar observations were also recorded by Dhanda and Sheti (2003) and Sarkar *et al.* (2011). Yadav *et al.* (2006) reported that high heritability for days to heading was not associated with high genetic advance. Moderate heritability coupled with high genetic advance was recorded in plant height followed by grain yield plant^{-1}, number of grains spike^{-1} and the characters may be predominantly controlled by additive gene effect and characters may improved by simple breeding methods. Kumar *et al.* (2003) reported high heritability coupled with high genetic advance for number of grains spike^{-1}, the result corroborated to the above finding. The above finding on yield plant^{-1} was supported by Sidharthan *et al.* (2007) and Bhanu Priya *et al.* (2013) which had high heritability along with high genetic advance. Characters bearing high heritability with moderate genetic advance was observed in the character days to heading, days to flowering, number of tillers plant^{-1}, number of spike plant^{-1}, number of grains spike^{-1}, flag leaf area and these characters could be influenced by both additive and non additive gene action for which a complex breeding method like population improvement method suggested to obtain success in breeding. Low to moderate heritability coupled with low genetic advance was noticed in the characters like chlorophyll a and grain protein and the characters may be predominantly controlled by non-allelic gene action and improvement following breeding on these traits could have remote possibility.

According to the present findings it is concluded that the characters plant height, days to heading, days to flowering, 1000 grain weight, number of grains spike^{-1} and yield plant^{-1} were associated with high heritability coupled with high genetic advance which suggested that the characters are predominantly controlled by additive gene effect and direct selection on the basis of phenotypic data may response positively to desired direction.

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Empowering the rural people through entrepreneurship development and management

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ABSTRACT

In the realm of appropriate entrepreneurship development and management, the present study has undertaken to analyse the Entrepreneurship Development and Management Index (EDMI) and the relation of the same with the socio- psychological, socio-personal and communication related determinants associated with the enterprise. The present study was conducted in three villages under Cooch Behar-II block in Cooch Behar district of West Bengal. Purposive as well as multistage sampling and random sampling procedures were followed for the selection of the respondents. The Entrepreneurship Development and Management Index (EDMI) is considered as the consequent variable for the study and the sixteen other variables were considered as antecedent variables for the study. The data were collected with the help of structured interview schedule through personal interview method. The collected data were processed into statistical analyses like coefficient of correlation, multiple regression and factor analysis. The variables annual income, land holding, material possession, house type, adoption leadership, management orientation, risk orientation, social participation, cosmopolitenes and mass media exposure are positively and significantly associated with the Entrepreneurship Development and Management Index of the entrepreneurs. The variables annual income, management orientation and risk orientation are contributing positively and significantly in case of characterising the Entrepreneurship Development and Management Index (EDMI) of the entrepreneurs. The R^2 value being 0.554, it is to infer that the sixteen predictor variables put together have explained 55.40% variation embedded with the predicted variable EDMI. The five factors namely economic and social competency, family and farm interaction, educational exposure, capacity orientation and personal trait are identified which reflect the conglomeration of predictor variables in explaining the variations embedded with the Entrepreneurship Development and Management Index (EDMI).

Keywords: Attitude, entrepreneurship development and management, innovativeness, profit maximisation

The changed global scenario arouses the ultimate requirement for fulfilling the need of grown up global market demand. The concept of 'entrepreneurship development' is becoming global phenomenon today not only because of industrial growth and business ventures but also a solution of unemployment and for the socio-economic prosperity of the community (Adhikary *et al*, 2010). The rural entrepreneurship development and management implies the development and management of small scale enterprises which can play a pivotal role towards value added market led economy, augmentation of rural earning and generation of rural employment.

Rural development is more than ever before linked to entrepreneurship. Institutions and individuals promoting rural development now see entrepreneurship as a strategic development intervention that could accelerate the rural development process. Further, more institutions and individuals seem to agree on the urgent need to promote rural enterprises; development agencies see rural entrepreneurship as an enormous employment potential; politicians see it as the key strategy to prevent rural unrest; farmers see it as an instrument for improving farm earnings; and women see it as an employment possibility near their homes which provides autonomy, independence and a reduced need for social support. To all these groups, however, entrepreneurship stands as a vehicle to improve the quality of life for individuals, families and communities and to sustain a healthy economy and environment (Petrin, 1994).

As an aftermath of globalization and free trade liberalization the entrepreneurial activity is playing a swashbuckling role in socio-economic development of the nation. In the ever developing countries like India, for uplifting the standard of living of the populace in the backward region, the policy making, planning and implementation of entrepreneurial development programmes are very much in need because of their over dependence of agriculture for employment and business. Consequently the entrepreneurship development in the rural areas

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emerges to be the best possible alternative to find employment opportunities and income augmentation for the rural population. Although the fast growing economies generated new private non-farm wage jobs at high rates, household enterprises generated most new jobs outside agriculture. Household enterprises should be seen as part of an integrated job and development strategy (Fox and Sohnesen, 2012). Not only that but also the development of entrepreneurship depends on state aid and the entrepreneurs themselves. (Markevicius and Griskeviciute, 2007). The successful innovation for entrepreneurship development demands both strong personal characteristics such as will and determination, good cooperation with others, both within and outside the business, and an emphasis on an environment that promotes knowledge development and the establishment of a variety of networks and support from many other parties (Gotvassli, 2008). The market opportunities and uncertainties facing by farmers; the link between rural entrepreneurship and sustainable land use; farmer empowerment; and the facilitation of rural entrepreneurship are the primary concern for rural entrepreneurship development (Maatman and Schrader, 2009).

To improve and promote issues of rural entrepreneurship development and management the need of the hour is to rethink the activities and determinants associated with the concepts and operationalisation of rural entrepreneurship development and management. The entrepreneurship development process is scientific and judicious blend of innovativeness of the entrepreneur, profit maximisation of the enterprise and risk bearing capacity of the entrepreneur. In such a research niche the present study has undertaken to analyse the Entrepreneurship Development and Management Index (EDMI) and the relation of the same with the socio- psychological, socio-personal and communication related determinants associated with the enterprise.

MATERIALS AND METHODS

The present study was conducted in three villages namely Kalarayer kuthi, Basdaha Natibari and Sajherpar Ghoramara under Cooch Behar-II block of Cooch Behar district of West Bengal. Purposive as well as multistage sampling and random sampling procedures were followed for the selection of the respondents. The Entrepreneurship Development and Management Index (EDMI) is considered as the consequent variable for the study and the sixteen other variables were considered as antecedent variables for the study. The EDMI is conceptualised and operationalised as the judicious blend of innovativeness of the entrepreneur, profit maximisation of the enterprise, attitude towards enterprise development and risk bearing capacity of the entrepreneur and it is measured as the composite score of net profit from the enterprise, innovativeness, attitude towards enterprise development and risk taking ability of the entrepreneurs. The data were collected with the help of structured interview schedule through personal interview method. The collected data were processed into statistical analyses like coefficient of correlation, multiple regression and factor analysis.

RESULTS AND DISCUSSION

Table- 1 presents the distribution of the entrepreneurs in Terai region of West Bengal according to their Entrepreneurship Development and Management Index (EDMI). The result shows that majority of the respondents are under the medium level of enterprise development and management skill with an EDMI score 19.18-21.85 (52%) followed by loe level of enterprise development and management skill with an EDMI score 16.50-19.17 (36%) and high level of enterprise development and management skill with an EDMI score 21.86-24.53 (12%) respectively. The mean score of total distribution is 19.87 and standard deviation of the distribution is 1.73. The coefficient of variation value within the distribution 8.71% signifies the very high consistency level of the distribution for the variable 'EDMI'.

Table 1: Distribution of the respondents according to their entrepreneurship development and management index

Category	Score	Frequency	Percentage	Statistics
Low	16.50-19.17	36	36	Mean = 19.87, SD= 1.73,
Medium	19.18-21.85	52	52	Range= 16.50-24.50, C.V= 8.71%
High	21.86-24.53	12	12	

Table- 2 reflects the Pearson's coefficient of correlation among the dependent variable *i.e.* Entrepreneurship Development and management Index (EDMI) of the respondents and sixteen causal variables. The result shows that the variable annual income, land holding, material possession, house type, adoption leadership, management orientation, risk orientation, social participation, cosmopoliteness and mass media exposure are positively and significantly associated with the EDMI.

Annual income, land holding, material possession, house type and entrepreneurship development and management index (EDMI)

All these four variables reflect the resource endowment of an entrepreneur in the rural social system. The resource rich entrepreneurs always invest more in case of averting the risk of the enterprise. The uncertainties within an enterprise can be overcome with the help of investment through contingency planning. The investment pattern of an entrepreneur can be determined through their resource belongingness. The high level investment of resource rich entrepreneur can create an environment for maximize profit contributes to the development and management of enterprise. That is why the variables annual income, land holding, material possession, house type are positively and significantly associated with the Entrepreneurship Development and management Index (EDMI) of the entrepreneurs.

Table 2: Correlation co-efficient of entrepreneurship development and management index of the respondents with sixteen causal variables

Variables (X)	Coefficient of correlation (r)
Age (X_1)	-0.041
Education (X_2)	0.178
Family size (X_3)	0.033
Family education status (X_4)	0.130
Primary occupation (X_5)	0.184
Annual income (X_6)	0.491^{**}
Land holding (X_7)	0.337^{**}
Material possession (X_8)	0.295^{**}
House type (X_9)	0.326^{**}
Adoption leadership (X_{10})	0.315^{**}
Management orientation (X_{11})	0.570^{**}
Risk orientation (X_{12})	0.559^{**}
Social participation (X_{13})	0.316^{**}
Cosmopliteness (X_{14})	0.307^{**}
Training exposure (X_{15})	0.095
Mass media exposure (X_{16})	0.415^{**}

Note: $^{*,\,**}$ *Significant at 5% and 1% level, respectively*

Adoption leadership, management orientation, risk orientation and Entrepreneurship Development and Management Index (EDMI) of the entrepreneurs:

Adoption leadership, management orientation and risk orientation are the three psychological attributes of an individual. The persons having good adoption leadership quality for an innovation can manage and develop their enterprise in efficient manner. For an entrepreneur risk taking ability plays the pivotal role in proper development and management of enterprise for its sustainability. These three factors are the backbone of the entrepreneurship development and management which directs the enterprise to reach to the highest peak of profit.

Social participation, cosmopoliteness, mass media exposure and entrepreneurship development and management index (EDMI)

These are the indicators of exposure towards communication sources. All these variables also build the capacity which deals with the complex occurrence in the enterprise. The information gathering, information sharing as well as capacity building develops a positive attitude towards entrepreneurship development and management in an efficient manner. That may be the possible reason behind the significant and positive association between the social participation, cosmopoliteness, mass media exposure and Entrepreneurship Development and management Index (EDMI) of the entrepreneurs.

Table- 3 reflects the multiple regression analysis of the predicted variable *i.e.* Entrepreneurship Development and Management Index (EDMI) of the entrepreneurs with sixteen predictor variables. From the table it is observable that the variables annual income, management orientation and risk orientation are positively and significantly contributing towards characterizing the EDMI.

Annual income and entrepreneurship development and management index (EDMI)

Annual income reflects the resource endowment of an entrepreneur in the rural social system. The capital is the financial power of an entrepreneur to manage the enterprise in an efficient manner. The investment pattern of an entrepreneur can be determined through their resource belongingness. The high level investment of resource rich entrepreneur can create an environment for maximization of profit which contributes to the development and management of enterprise. That is why the variable annual income is significantly and positively contributing in case of characterizing the Entrepreneurship Development and Management Index (EDMI) of the entrepreneur in presence of other fifteen predictor variables.

The variable annual income is directly contributing 50.00% in case of characterizing Entrepreneurship Development and Management Index (EDMI) of an entrepreneur. One unit change of the variable annual income is delineating the 0.069 unit change in the predicted variable, Entrepreneurship Development and Management Index (EDMI).

Table 3: Multiple regression analysis of entrepreneurship development and management index of the entrepreneurs with sixteen predictor variables

Variables	(β)	B	S.E of 'B'	t-value
Age (X_1)	0.042	0.006	0.013	0.497
Education (X_2	-0.024	-0.038	0.159	-0.241
Family size (X_3)	0.000	-0.001	0.311	-0.002
Family education status (X_4)	0.068	0.134	0.187	0.717
Primary occupation (X_5)	-0.046	-0.077	0.155	-0.496
Annual income (X_6)	0.500	0.069	0.025	2.730**
Land holding (X_7)	-0.219	-0.051	0.042	-1.214
Material possession (X_8)	-0.029	-0.013	0.043	-0.298
House type (X_9)	0.082	0.181	0.216	0.838
Adoption leadership (X_{10})	0.099	0.066	0.060	1.109
Management orientation (X_{11})	0.338	0.150	0.046	3.271**
Risk orientation (X_{12})	0.211	0.085	0.043	1.960*
Social participation (X_{13})	0.092	0.169	0.172	0.983
Cosmopliteness (X_{14})	-0.150	-0.080	0.067	-1.209
Training exposure (X_{15})	-0.030	-0.016	0.043	-0.373
Mass media exposure (X_{16})	0.115	0.056	0.059	0.948

*Note: R^2= 0.554, *, ** Significant at 5% and 1% level, respectively*

Management orientation and Entrepreneurship Development and Management Index (EDMI)

Management orientation is the psychological pursuit of individual to become conversant for managing his enterprise in effective manner by taking proper decision in proper time. Management orientation is a goal directed psychological trait of an individual. The goal of the enterprise is to maximize the profit for its future sustainability. With the help of management inclination an entrepreneur develops his decision making ability through skill, knowledge and reasoning ability. That is why the variable management orientation is significantly and positively contributing incase of characterizing the EDMI of the entrepreneur in presence of other fifteen predictor variables.

So, the management orientation is positively and significantly contributing incase of characterizing the EDMI of the entrepreneur. The variable management orientation is directly contributing 33.80% in case of characterizing EDMI of an enterprise. One unit change of the variable management orientation is delineating the 0.150 unit change in the predicted variable, Entrepreneurship Development and Management Index (EDMI).

Risk orientation and entrepreneurship development and management index (EDMI)

Risk orientation is the psychological attribute of an individual to take risk and bear the risk for development of any new enterprise. For an entrepreneur risk taking ability plays the pivotal role in proper development and management of enterprise for its sustainability. This is the backbone of the entrepreneurship development and management which directs the enterprise to reach to the highest peak of profit. That is why the variable risk orientation is positively and significantly contributing in case of characterizing the Entrepreneurship Development and Management Index.

The variable risk orientation is directly contributing 21.10% in case of characterizing EDMI of an enterprise. One unit change of the variable risk orientation is delineating the 0.085 unit change in the predicted variable, EDMI.

The R^2 value being 0.554, it is to infer that the sixteen predictor variables put together have explained 55.40% variation embedded with the predicted variable EDMI. Still 44.60% variable embedded with predicted one are unexplained. Thus it would be suggested that inclusion of some more contextual variables possessing direct bearing on the EDMI of the entrepreneurs could have increased the level of explicability.

The factor analysis was carried out to predict the intrinsic conglomeration of different predictor variables for constructing a homophiles group of predictor variables or factors. The minimum level of factor loadings (> 0.550) is considered to have conglomeration. It is found that the association of variables of factor I has been comprised of annual income (X_6), material possession (X_8), house type (X_9), management orientation (X_{11}), risk orientation (X_{12}), cosmopoliteness (X_{14}), mass media exposure (X_{16}) and the factor can be renamed as "economic and social competency". The percent of variance explained by this factor has been 25.606 and the eigen value is found 4.097 (Table 4).

The factor II has encompassed two factors *viz.* family size (X_3) and land holding (X_7) and can be renamed as "family and farm interaction". This has explained 15.825 percent of variance with eigen value 2.532 (Table 4).

Table 4: Factor analysis of the predictor variables through principal component analysis

Factor	Variables	Factor loadings	Eigen values	% of variance	Cumulative % of variables	Rename
I.	Annual income (X_6)	0.68	4.097	25.606	25.606	Economic and social competency
I.	Material possession (X_8)	0.65				
I.	House type (X_9)	0.55				
I.	Management orientation (X_{11})	0.63				
I.	Risk orientation (X_{12})	0.68				
I.	Cosmopoliteness (X_{14})	0.64				
I.	Mass media exposure (X_{16})	0.66				
II.	Family size (X_3)	0.56	2.532	15.825	41.431	Family and farm interaction
I.	Land holding (X_7)	0.65				
III.	Education (X_2)	0.79	1.652	10.323	51.754	Educational exposure
I.	Family education status (X_4)	0.74				
IV.	Training exposure (X_{15})	0.76	1.174	7.337	59.091	Capacity orientation
V.	Age (X_1)	0.60	1.023	6.394	65.485	Personal trait

Note: Factor loadings >0.550