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A Collocation Method for Second Order Boundary Value

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A B S T R A C T

This paper is an extension of Mamadu and Ojobor (2017) were the efficiency of the collocation method was considered based on the type of basis function in developing the scheme. Here, we investigate the convergence of the method as applied to second boundary value problems (BVPs) at the various collocation points: Gauss-Lobatto (G-L), Gauss-Chebychev (G-C) and Gauss-Radau (G – R) collocation points. Also, the class of Chebychev polynomials of the first kind have been adopted as basis function. We have employed Maple 18 software in our analysis and computations.
Keywords: *Collocation method, basis functions, boundary value problems, collocation points, Chebychev polynomials*

I. 1NTRODUCTION

Let the generalized form of a differential equation be given as

$$L[y(x)] = g(x),\ \varphi[y(a_1)] = a,\ \tau[y(a_2)] = b, \tag{1.0}$$

where α, φ and τ are considered as differential operators.

Differential equation are often applied in the construction and development of most mathematical models such as predictive control in AP monitor (Hedengen et. al., 2014), temperature distribution in cylindrical conductor (Fortini et. al., 2008), dynamic optimization (cizinar et. al., 2015), etc. Modeling is the bridge between the subject and real-life situations for students realization. Differential equations model real-life situations, and provide the real-life answers with the help of computer calculations and graphics.

Investigation into methods for solving these problems has been on the increase in recent years. Obviously, many methods (analytical or numerical methods) have been developed and implemented by many researchers. Of these methods, the numerical methods seem to be more popular than their analytic counterpart due to their adequate approximation of the analytic solution in a rapid converging series. Popular numerical methods include; the Tau method (Adeniyi, 2004), orthogonal collocation method (Mamadu and Ojobor, 2017), TauCollocation method (Mamadu and Njoseh, 2016), Variation iteration decomposition method (Ojobor and Mamadu, 2017), Elzaki transform method (Mamadu and Njoseh, 2017), Power series approximation method (Njoseh and Mamadu, 2016a), Modified power series approximation method (Njoseh and Mamadu, 2017), etc.

However, the collocation method remains one of the best numerical method due to its level of simplicity and accuracy. Moreover, the efficiency of the method is dependent on the class of basis function and the collocation point adopted in constructing the scheme. There exist different types of basis functions that

can be adopted to construct the scheme such as; canonical polynomials, Chebychev polynomials, Bernoulli polynomials, Lagrange polynomials (Fox and Pascal, 1968; Lanczos, 1938). And, the different collocations that can be adopted include; the equally spaced points; Gauss-lobotto points, Gauss-Chebychev points, Gauss-Radau point, etc. These points improves better than one another in terms of convergence.

This present study is an extension of Mamadu and Ojobor (2017) were the efficiency of the method was dependent on the type of basis function employed in constructing the scheme. Here, we investigate the convergence of the method as applied to the differential equation (1) at the various collocation points: Gauss-Lobatto (G-L), Gauss-Chebychev (G-C) and Gauss-Radau collocation points. We have also adopted the class of Chebychev polynomials of the first kind as our basis function in this study.

2. Chebychev polynomial of the first Kind

The Chebychev polynomial of the first kind is defined as (Njoseh and Mamadu, 2016b)

$$T_n(x) = cos(ncos^{-1}x) = \sum_{r=0}^{n} C_r^{(n)} x^r, \ -1 \le x \le 1, \quad (1.1)$$

with

$$T_{n+1}(x) = 2xT_n(x) - T_{n-1}(x), \quad (1.2)$$

satisfying the initial conditions $T_0(x) = 1$ and $T_1(x) = x$.

Now, if $-1 \le x \le 1$ mapped objectively to $a_1 \le x \le a_2$, then equation (1.2) becomes

$$T^*_{n+1}(x) = 2xT^*_n(x) - T^*_{n-1}(x), \quad (1.3)$$

satisfying the initial conditions $T^*_0(x) = 1$ and $T^*_1(x) = \frac{2x-a_1-a_2}{a_2-a_1}$.

Equation (1.3) is called the nth degree shifted Chebychev polynomials.

The Maple 18 execution code for generating the first kind Chebychev polynomials is given below:

```
> restart :
> N := ?
> ChebyshevT(n, x)
        (2)
> T[n + 1] := simplify((2), 'ChebyshevT') ,
```

Thus, the first ten Chebychev polynomials of the first kind as given as follows:

$> T_0 := 1$

$> T_1 := x$

$> T_2 := 2x^2 - 1$

$> T_3 := 4x^3 - 3x$

$> T_4 := 8x^4 - 8x^2 + 1$

$> T_5 := 16x^5 - 20x^3 + 5x$

$> T_6 := 32x^6 - 48x^4 + 18x^2 - 1$

$> T_7 := 64x^7 - 112x^5 + 56x^3 - 7x$

$> T_8 := 128x^8 - 256x^6 + 160x^4 - 32x^2 + 1$

$> T_9 := 256x^9 - 576x^7 + 432x^5 - 120x^3 + 9x$

$> T_{10} := 512x^{10} - 1280x^8 + 1120x^6 - 400x^4 + 50x^2 - 1$

2.1 Colloaction Points

In this section, we outline our collocation points relevant to this research. Thus, our collocation points shall be:

2.1.1 Gauss-Radau (G – R).

Here, we collocate equation (1.5) at

2.1.2 Gauss-Lobatta (G – L).

Here, we collocate equation (1.5) at

2.1.3 Gauss-Chebychev (G – C).

Here, we collocate equation (1.5) at

3. Mathematical Formulation of the problem

Let define the approximate solution as

$$y(x) = \sum_{r=0}^{N} a_i T_i(x) \tag{1.4}$$

where $a_i, i = 0(1)N$, are unknown coefficients to be determined.

The major requirement in collocation method is that equation (1.0) must satisfy the collocation points in the interval $a_1 < x < a_2$.

The method is now given in detail.

Substituting equation (1.4) into equation (1.0), we have

$$L[y(x_i)] = g(x_i), \;\; x_i \in (a_1, a_2), \qquad i = 1(2)(N-1) \tag{1.5}$$

$$\varphi[y(x_0)] = a, \;\; \tau[y(x_N)] = b, \tag{1.6}$$

We then collocate equation (1.5) at the different collocation points: G - L, G - C and G – R. Note that i must equal the number of $a_i, i = 0(1)N$ in the approximate solution to overcome over-determination (Mamadu and Njoseh, 2016). Thus, we obtain (N-1) set of equations in (N-1) unknowns. Two more equations come from using the boundary conditions

$$\sum_{r=0}^{N} a_i T_i(a_1) = a, \;\; \sum_{r=0}^{N} a_i T_i(a_2) = b. \tag{1.7}$$

We thus solve the resulting (N+1) equations for $a_i, i = 0(1)N$ using the Gaussian elimination method.

Readers are referred to Mamadu and Ojobor (2017) for the error analysis of the method.

3.1 Maple 18 Execution code for the Problem

We collocate (1.5) with the Maple 18 executive code as given below:

```
restart :

t := [ ] :# Please insert the collocation points ( be it G-L, G-R or G-C) for any value of N
for i from 1 to N do

x := t[i] :
A[i] := evalf(sort(simplify(L[y(x)])))
end do:

for i from 1 to N do

printf("\n Collocating at t=%f, we have: ", t[i]);

A[i];
end do;
```

Thus, solving the equations obtained after collocation and those in (1.7) with the help of Maple 18 code below

```
values := solve( {A[1], A[2], A[3], A[4], A[5], A[6] ... A[N], B[1], B[2]}, {a[1], a[2], a[3],
    a[4], a[5], a[6] ...a[N + 2], }) :

assign(values) :
```

we obtain the unknown constants $a_i, i = 0(1)N$.

Implementing the command

```
printf("\n subtituting our values of a_1 = %f, a_2 = %f, a_3 = %f ,a_4=%f,a_5=%f , a_6=%f,..
    ., a_N+1=%f; we obtain the table below \n \n", a[1], a[2], a[3], a[4], a[5], a[6],...a[N
    + 2])
```

We obtain our approximate solution.

4. Numerical Experiment

We solve some second order boundary value problems (BVPs) using the collocation method with Chebychev basis function at G – L, G – C and G – R collocation points.

Example 4.1

Consider the second order BVP

$$(1 + x^2)\frac{d^2y}{dx^2} + 4x\frac{dy}{dx} + 2y = 0, x \in [-1,1], \tag{1.8}$$

$$y(-1) = y(1) = \frac{1}{2} \tag{1.9}$$

The Exact solution is given as $(x) = \frac{1}{1+x^2}$.

If N=4, the Maple 18 execution at the various collocation points for (1.8), we obtain the plot:

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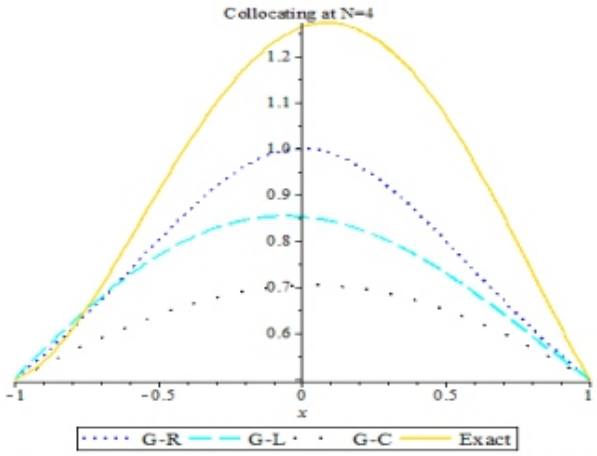

Figure 1. Comparison of the exact and approximate solutions at various collocation points for Example 4.1

Similarly at N=8, we obtain

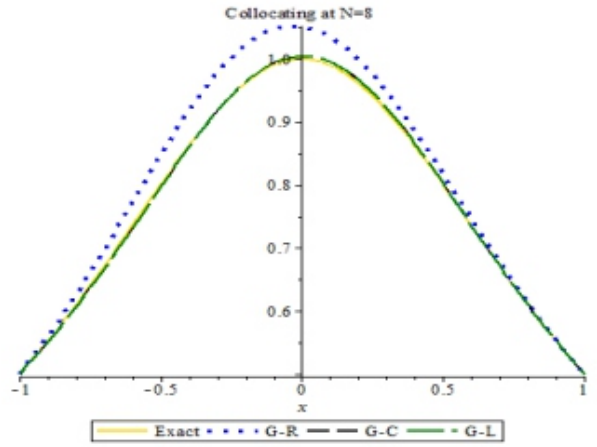

Figure 2. Comparison of the exact and approximate solutions at various collocation points for Example 4.1

Example 4.2.

Solve the linear initial value problem in second order ordinary differential equation

$$y''(x) + y(x) = 0, y(0) = 1, y'(1) = 3. \quad (2.0)$$

The exact solution is given as $y(x) = cosx - \frac{sinx\,(cos1-3)}{sin1}$.

If we let N=8, the Maple 18 execution at the various collocation points for (2.0) ,we obtain the plot:

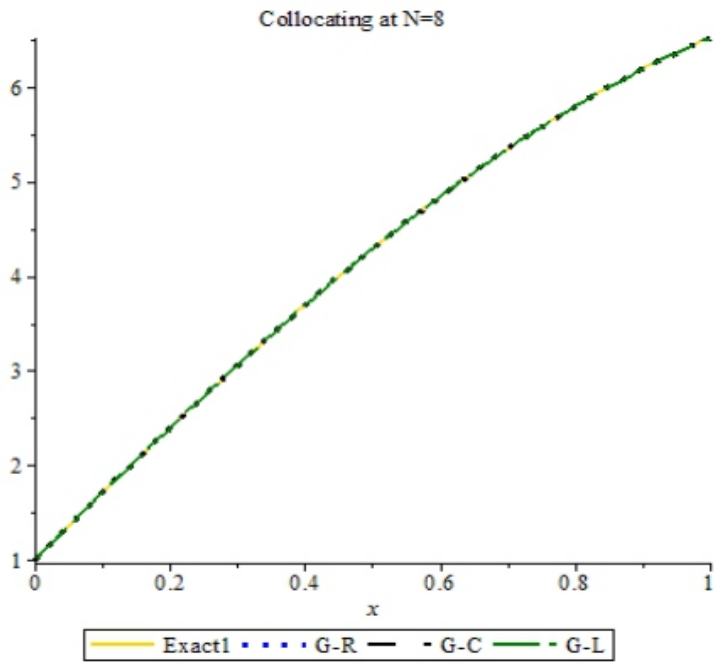

Figure 3. Comparison of the exact and approximate solutions at various collocation points for Example 4.2

5. Discussion of Results

We have demonstrated the collocation method at different points as in Example 4.1.and 4.2. In Example 4.1, at N=4, the G – R collocation point converges better than the others with a maximum error of $3.0000E-10$ as shown in figure 1. Also, when N=8, the approximate solution blow up for G – R collocation point, while G-R converges better than the G-C collocation point with a maximum error of $3.0000E-10$ as shown in figure 2. Similarly, at N=8, there is an absolute convergent at all collocation points considered for Example 4.2 as shown in figure 3.

6. Conclusion

We have vividly implemented the collocation method for solving second order boundary value problems at various collocation points, namely, G – R, G – L and G – C. From the resulting numerical evidences with the aid of Maple 18 software, we conclude that;

i. whenever N is small, the G – R collocation point is more preferable; and

ii. when N is Large, either G – L or G – C collocation points is more preferable in ensuring a rapidly convergent series solution.

Further Research

Future researchers should be enable to investigate how small N will be for the G – R collocation point to be preferred, or how large N will be for G – L or G – C collocation points to be preferable in ensuring a rapidly convergent series solution.

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A Geographical Analysis of Organic Fertilizers Application in Shirpur Tehsil of Maharashtra (MS), India

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2Bharat D Patil
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A B S T R A C T

Dhule district of Maharashtra state comprises four tehsils viz. Dhule, Shirpur, Sakri, and Shindkheda. The soil quality and productivity are being affected badly in the southern parts of Shirpur tehsil. It is necessary to evaluate the adverse impacts of chemical fertilizers in the Shirpur tehsil. The present study is organized in order to find out the farmers attitude towards organic fertilizer application in the Shirpur. 598 farmers from 12 villages of four tehsils were questioned for their perspective towards organic and chemical fertilizer application in the farm. The research outcome reveals different attitudes for organic fertilizer application and benefits in different groups i.e. education levels of farmers, farm size, and villages. The large farm size farmers and educated farmers are more in numbers compared to small size farmers and illiterate farmers. Therefore an attempt has been made to find out the attitude of farmers towards utilization of organic fertilizer in the farms for sustainable farming.

Keywords*:Agriculture;Fertilizers;Organic;Productivity;Soil;farm size etc.*

I. 1NTRODUCTION

The soil quality and productivity are being badly affected by the overconsumption of chemical fertilizers in the southern part of Shirpur tehsil. The soil and environment protection are one of the basic principles of the organic farming and it advocates the natural ways of improvement in the environment. In the organic farming the synthetic fertilizers, herbicides, and medicines are hardly applied [12]. The concept of organic agriculture builds on the efficient use of locally available resources, and the use of technologies like soil fertility management, the closing of nutrient cycles, control of pests and diseases by means of natural antagonists. From the mixed farming point of view, it is necessary to investigate the opportunities and limitations of stockless organic farming with regard to both agro-ecological, economic stability, and sustainability of farming systems [2]. The mixed farming concept opens up new ways of achieving sustainable development [11]. The share of corn, sunflower, and rape in crop mix the investment in precision farming is paid off after six years under Hungarian conditions [4]. The implementation of precision farming promotes the rational application of chemicals but requires capital investment. According to K. Takács-György, the reduction of chemical use and environmental load in agriculture is increasingly desired. Developed countries promote the minimum use of pesticides and

farmers have to change traditional practices accordingly. Organic agriculture has the potential to improve the soil fertility, biodiversity conservation, and sustainable agricultural production. It also improves agronomic and economic performance to yield more stable tropical ecosystems, especially in risk-prone tropical ecosystems. Organic farming is having good potential to achieve better food quality and food security [5]. Chemical farming or conventional agriculture often creates an unstable ecosystem in which the potential for maximum yield is inevitably associated with risks due to ecosystem instability [10].

Farmers' groups are increasingly adopting organic techniques as a method of improving productivity and food security in these systems. However, no systematic attempt has hitherto been made to track the extent to which these approaches are being employed, or their effectiveness compared to other approaches, in meeting economic, social and environmental objectives [8], [11]. An important issue with the development of organic farming is tillage, tillage intensity in particular. Despite the suggestions of mentors of the organic farming theory and of farmers associations to reduce tillage intensity, the majority of organic farmers still apply deep inversion tillage with a plough [3],[6], [9].

1.1 Location and Extent of Study Region

Shirpur tehsil is located in Dhule district of the northern part of Maharashtra state. Dhule district comprises four tehsils. The Shirpur tehsil has covered an area of 804.02 sq. km. Shirpur tehsil is lying between 21011' north and 21038' north latitudes and 74041 'east and 75011' east longitudes

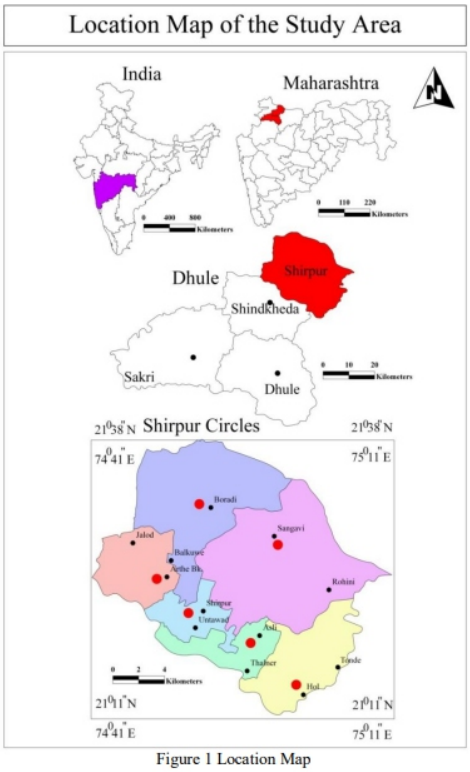

Figure 1 Location Map

2. Research Method

2.1 Source of Data

The relevant primary data are obtained from the respondents (farmers) by administering a well-structured interview schedule. The researcher has made a visit to each and every household and relevant data are obtained from them by establishing a good rapport with them.The interview questionnaire covers topics such as irrigation, use of inorganic, organic inputs, attitudes of the farmers and their awareness on sustainable development practices. In addition, Focus Group Discussions was held with the farmers to gain insights and obtain more qualitative data. Official statistical data were obtained through secondary sources such as official records and census reports.

2.2 Data Analysis

The important independent variable for the analysis of the data is farm size, respondent's education level and size of the village. The collected data are classified and tabulated. The chi-square test is applied to examine the association between socioeconomic status of farmers and their awareness and adoption of organic farming practices. Further percentages and averages are applied depending on the requirement of the situation.

2.3 Methodology

The primary data was collected through questionnaire and interactions with farmers (respondents) of four villages in Shirpur tehsil. The data was processed for estimation of organic fertilizer application level in the study area. Then Chi-square test has been used to find out the correlation of organic fertilizers application to farm size and education level of farmers.

2.4 Sampling Locations

Shirpur tehsil of Dhule district is focused on the present study. The tehsil is predominantly an agrarian region. Agricultural is done in all villages of the tehsil. Shirpur tehsil has six circles Arthe, Shirpur, Thalner, and Holnanthe are agriculturally developed in terms of yield potential and irrigational facilities. Boradi and Sangavi are agriculturally backward because most of the areas of it consist by Satpura mountain ranges.

The size of the study sample is limited to two villages of each circle the tehsil and ten percent of the farmers from the sample villages. The study sample villages and the respondents (farmers) were drawn by adopting Multi-Stage Stratified Random Sampling Technique to represent marginal, small, medium

and large farmers. Accordingly, a survey of twelve villages in Shirpur tahsil named Boradi, Balkuwe, Sangavi, Rohini, Arthe Bk, Jalod, Shirpur, Untawad, Thalner, Asli, Hol, and Tonde was undertaken and a total of 598 farmers were studied.

2.5 Sampling Procedure

In the first phase, the researcher has selected one developed village one backward village from each circle of the study region.According to the Table. 1 in the second phase is the selection of sample villages from each circle. There are six blocks or revenue circles in Shirpur tehsil. Shirpur tehsil has 147 revenue villages. Thus, a total of 12 villages are selected from six blocks representing 10% of the farmers in each village.Tables and Figures are presented center, as shown below and cited in the manuscript.

Table 1. In the third stage involves the selection of farmers from study villages.

Sr. No.	Circle / Block	Sampling Village	No. of farmers	10 % Selected Farmers
01	Boradi	Boradi	611	61
		Balkuwe	528	53
02	Sangavi	Sangavi	749	75
		Rohini	688	69
03	Arthe	Arthe	376	38
		Jalod	274	27
04	Shirpur	Shirpur	1034	103
		Untawad	236	24
05	Thalner	Thalner	699	70
		Asli	356	36
06	Holnanthe	Hol	165	17
		Tonde	251	25
Total			**5967**	**598**

Source: Collected and Tabulated by Researcher

From each village 10% of the farmers are selected as sample, thus totally 598 farmers are selected from six blocks of Shirpur tehsil.

3. Results and Analysis

3.1 Application Level of Organic Fertilizers

The application of organic inputs (fertilizers) is discussed in relation to use of green manure, compost, ash and animal dung. Data presented in Table. 2 indicate the farm size wise respondent's application of organic fertilizers.

It is noticed that out of the total 598 respondents 11.37% farmers used bio-fertilizers for cultivation. More than 70 % of the respondents of Arthe, Thalner, Hol and Tonde Village apply cow dung and ash as bio fertilizer for cultivation. Out of 598 respondents, 23.58 % of them use chemical fertilizer for cultivation. 65.05% farmers in the Shirpur tehsil are utilizing both bio and chemical fertilizers. This

s level of application is prominent among the farmers of Shirpur, Boradi, Hol, Asli, Jalod and Balkuwe villages.

Table 2. Village wise number of consumers of organic fertilizers and chemical fertilizer

Villages	Bio-fertilizers	Chemical Fertilizers	Both	Total
Boradi	4 (6.56)	17 (27.87)	40 (65.57)	61
Balkuwe	5 (9.43)	15 (28.30)	33 (62.27)	53
Sangavi	11 (14.67)	16 (21.33)	48 (64.00)	75
Rohini	11 (15.94)	14 (20.29)	44 (63.77)	69
Arthe	5 (13.16)	6 (15.79)	27 (71.05)	38
Jalod	3 (11.11)	7 (25.93)	17 (62.96)	27
Shirpur	11 (10.68)	31 (30.10)	61 (59.22)	103
Untawad	3 (12.50)	5 (20.83)	16 (66.67)	24
Thalner	6 (8.57)	14 (20.00)	50 (71.43)	70
Asli	5 (13.89)	8 (22.22)	23 (63.89)	36
Hol	1 (5.88)	4 (23.53)	12 (70.59)	17
Tonde	3 (12.00)	4 (16.00)	18 (72.00)	25
Total	**68 (11.37)**	**141 (23.58)**	**389 (65.05)**	**598**

Source: Collected and Tabulated by Researcher

Chi square value = 12*

df =22

* = Significant at 5 percent level= 33.92

The chi-square test is applied for to verify the significance. The computed chi-square value is 12 which is smaller than its tabulated value at 5 percent (33.92) level of significance. Hence, there is a significant difference among the farmers of different villages with respect to their choice of crop cultivation. It implies a homogeneous trend among the farmers of the study villages. Most of the farmers in Shirpur tahsil used organic as well as chemical fertilizers because of boi fertilizers like oil cake, green manure, compost, ashes and animal dung easily available in villages

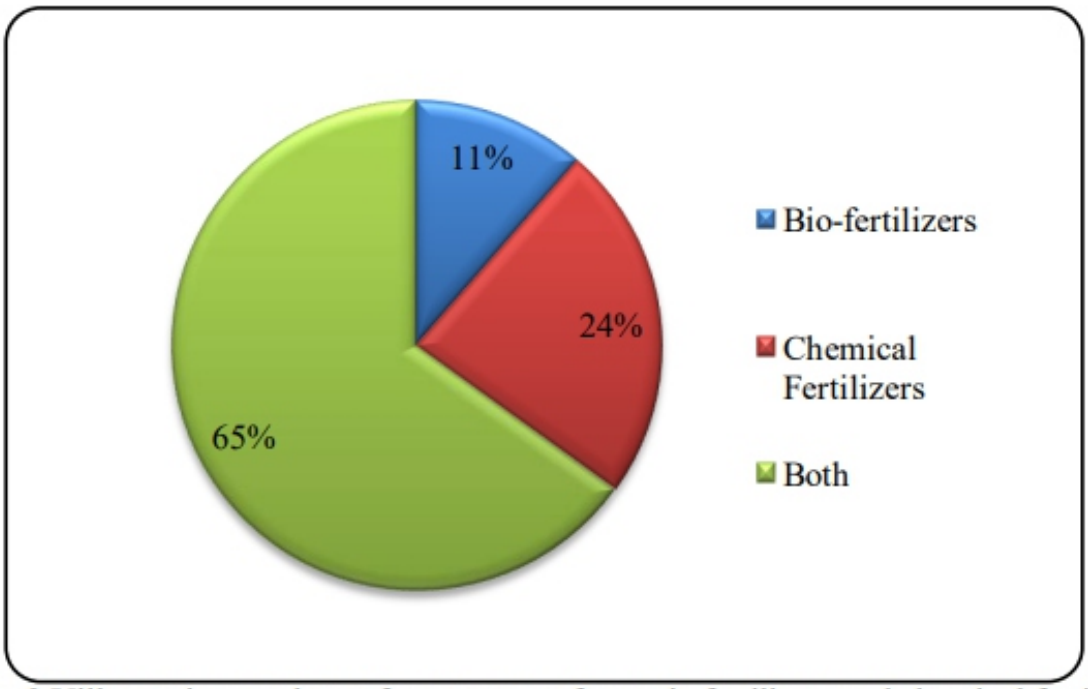

Figure 2 Village wise numbers of consumers of organic fertilizers and chemical fertilizer

Moreover, 65.05 percent of the farmers apply bio-fertilizer as well as chemical fertilizers for cultivation. This level of mixed application of fertilizers is reported by more than a half of the respondents of all sampled villages.

Table 3. Farm size wise Respondents' Application Level of Organic Fertilizers

Farm Size	Bio-fertilizers	Chemical Fertilizers	Both	Total
Marginal	31 (40.79)	18 (23.68)	27 (35.53)	76
Small	25 (9.47)	87 (32.95)	152 (57.58)	264
Medium	8 (4.23)	27 (14.29)	154 (81.48)	189
Large	4 (5.80)	9 (13.04)	56 (81.16)	69
Total	**68 (11.37)**	**141 (23.58)**	**389 (65.05)**	**598**

Source: Collected and Tabulated by Researcher

Chi-square value = 112

df = 6

* = Significant at 1 percent level = 16.81

Table 3 presents data on the farm size wise respondents' application level of bio-fertilizers for crop cultivation. A half of the large and medium farmers (50%) apply mixed fertilizers for cultivation. A more than half of the small farmers (57.58%) also used mix fertilizer and 40.79 % of marginal farmers giving preference to the use of biofertilizer.

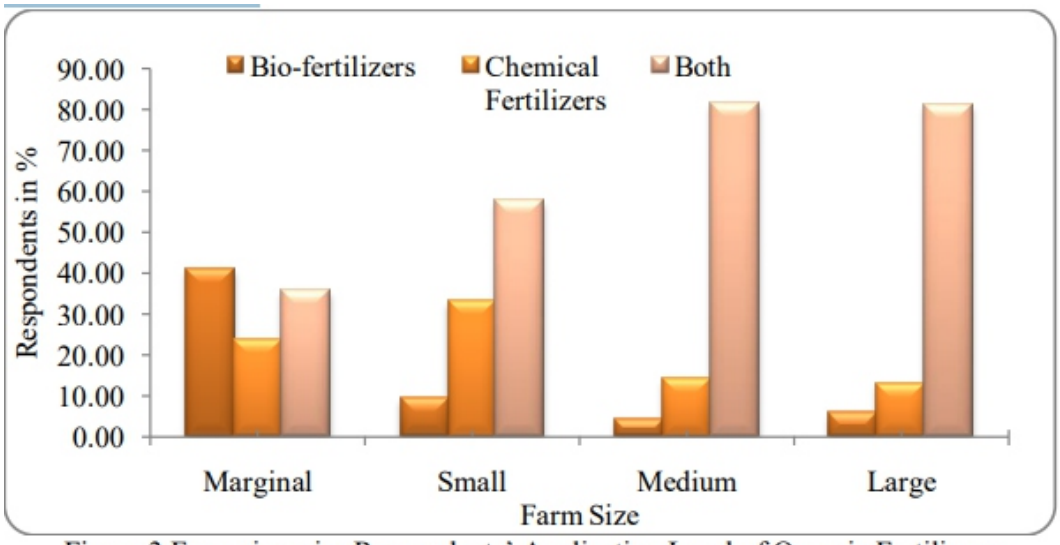

Figure 3 Farm size wise Respondents' Application Level of Organic Fertilizers

The data analysis from this study shows, the bio-fertilizers are mostly used by the medium and small-scale farmers and the multiple fertilizers is the applied by the medium and large farmers in the study region.

The chi-square test reveals positive association. The computed chi-square value is 112 which is greater than the tabulated value (16.81) at 1 percent level of significance. Hence, the difference in farm size is statistically significant with respect to farmers' application level of cow dung and ash as bio-fertilizer. A similar result has been observed with respect to the application of oil cake as bio-fertilizer and also green manure and compost as bio-fertilizer.

The marginal farmers apply more quantity of cow dung and ash as bio-fertilizer per hectare cropped area than others. This is due to easy availability in their farms as bio-waste. The medium farmers and large farmers apply more quantity of oil cake and green manure as bio-fertilizer compared to others.

Table 4. Education wise Respondents Application Level of Organic Fertilizers

Education	Bio-fertilizers	Chemical Fertilizers	Both	Total
Illiterate	27 (17.76)	49 (32.24)	76 (50.00)	152
Primary	20 (11.05)	50 (27.62)	111 (61.33)	181
Secondary	10 (5.35)	26 (13.90)	151 (80.75)	187
Degree	11 (14.10)	16 (20.51)	51 (65.38)	78
Total	**68 (11.37)**	**141 (23.58)**	**389 (65.05)**	**598**

Source: Collected and Tabulated by Researcher

Chi-square value = 39*

df = 6

* = Significant at 1 percent level= 16.81

The computed chi-square value for table 4 is 39 which is greater than its tabulated value (16.81) at 1 percent level of significance. Hence, the difference in educational status is statistically identified as significant with respect to farmers' choice of fertilizers selection.

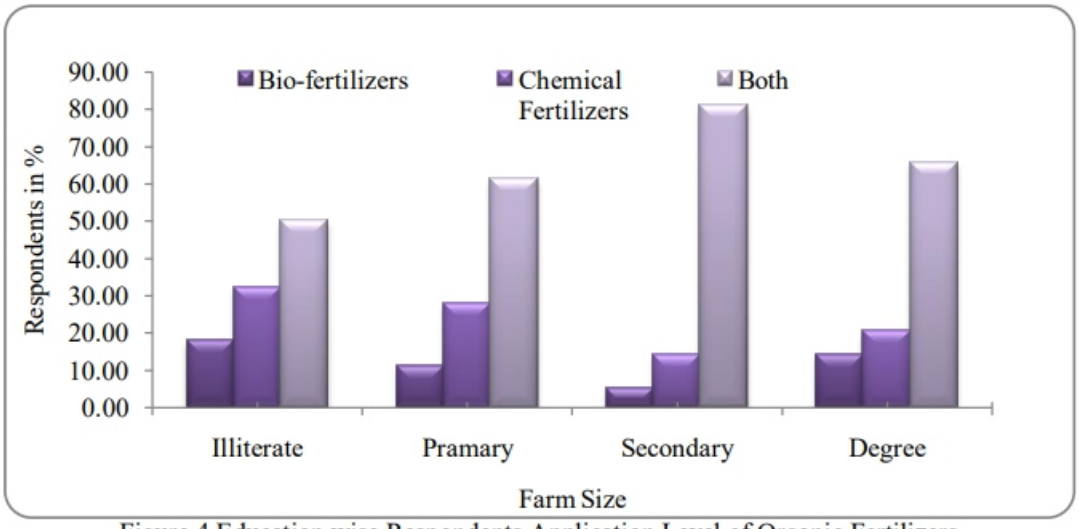

Figure 4 Education wise Respondents Application Level of Organic Fertilizers

Table 5. Village Wise Respondents' Views on Advantages of Bio-fertilizers

Village	Advantages of Bio-fertilizers				Total
	Production of Nutritious food	Free from disease	Eco-friendly method	All	
Boradi	23 (52.27)	3 (6.82)	4 (9.09)	14 (31.82)	44
Balkuwe	16 (42.11)	3 (7.89)	4 (10.53)	15 (39.47)	38
Sangavi	25 (42.37)	8 (13.57)	5 (8.47)	21 (35.59)	59
Rohini	25 (45.45)	4 (7.28)	3 (5.45)	23 (41.82)	55
Arthe	16 (50.00)	3 (9.38)	4 (12.50)	9 (28.12)	32
Jalod	11 (55.00)	2 (10.00)	1 (5.00)	6 (30.00)	20
Shirpur	25 (34.72)	10 (13.89)	8 (11.11)	29 (40.28)	72
Untawad	12 (63.16)	1 (5.26)	2 (10.53)	4 (21.05)	19
Thalner	17 (30.36)	7 (12.50)	9 (16.07)	23 (41.07)	56
Asli	13 (46.43)	3 (10.71)	2 (7.14)	10 (35.72)	28
Hol	6 (46.15)	2 (15.38)	1 (7.69)	4 (30.77)	13
Tonde	11 (52.38)	3 (14.29)	2 (9.52)	5 (23.81)	21
Total	**200 (43.76)**	**49 (10.72)**	**45 (9.85)**	**163 (35.67)**	**457**

Chi-square value = 20*

df = 33

* = Significant at 1 percent level = 16.81

The degree of freedom is more than 30, therefore, the significance of chi-square value is 20 which is greater than the calculated value (16.81) 1 percent level of significance. Hence, the difference among the villages is statistically identified as significant with respect to respondents' views on advantages of the use of bio-fertilizers for cultivation and maintenance the fertility of the land.

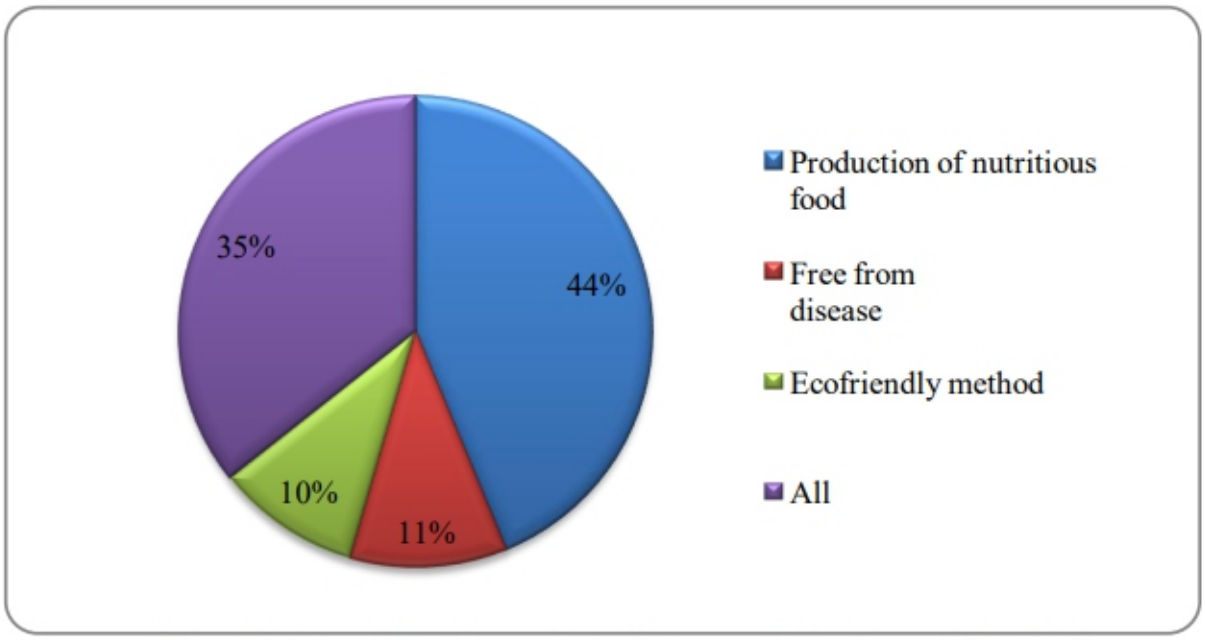

Figure 5 Village Wise Respondents' Views on Advantages of Bio-fertilizers

3.2 Views on Bio-fertilizers

Data presented in Table 5 reveals the village-wise respondents' views on advantages of applying bio-fertilizers. Out of total respondents, 457 respondents having a positive view on advantages of bio fertilizer application for crop cultivation. Out of total respondents (457), some are used only organic fertilizers for cultivation while some are used mixed fertilizers (organic and chemical).

Out of the total 457 respondents, 43.76 % of them hold the view that through the application of bio fertilizers, they can produce food with high nutritious value. More than 52 % respondents from Untawad, Jalod, Boradi, and Tonde believe that the application of bio-fertilizer leads high crop yield with good nutrition values.

10.72 % of total and 15.38 % respondents of the Hol village think that bio-fertilizers can produce disease-free food.

9.85 % of the total and more than 11% of Thalner, Arthe and Shirpur villagers feel the advantage of applying bio-fertilizers in terms of eco-friendly method of cultivation than other advantages.

Moreover, 35.67% of the respondents believe the multiple advantages of applying bio-fertilizers, such

as the production of production of disease-free food, food raised through bio-fertilizers give more strength and stamina to consumers. The majority of the respondents of Rohini village (41.52%) Thalner village (41.07%) Shirpur village (40.28%), Balkuwe village (39.47%) and Asli village (35.72%) prefer all multiple advantages of applying bio-fertilizers to raise their crops.

Table 6. Farm size wise Respondents' Views on Advantages of Bio-fertilizers

Farm Size	Advantages of Bio-fertilizers				Total
	Production of nutritious food	Free from disease	Eco-friendly method	All	
Marginal	41 (70.69)	4 (6.90)	7 (12.07)	6 (10.34)	58
Small	91 (51.41)	32 (18.08)	15 (8.47)	39 (22.03)	177
Medium	51 (31.48)	8 (4.94)	16 (9.88)	87 (53.70)	162
Large	17 (28.33)	5 (8.33)	7 (11.67)	31 (51.67)	60
Total	**200 (43.76)**	**49 (10.72)**	**45 (9.85)**	**163 (35.67)**	**457**

Chi-square value = 75*

df = 9

= Significant at 1 percent level=21.66

Data presented in Table 6 indicates the farm size wise respondents views on advantages of applying bio-fertilizers to raise their crops. It could be noted that a considerable majority of the marginal farmers (70.69 %) prefer the advantage of applying bio-fertilizers in terms of possession more strength and stamina

by consuming food raised through bio-fertilizers and 18.08% of the small farmers say it as the production of disease-free food. A considerable majority of the medium farmers (53.70 %) and large farmers (51.67 %) opine the multiple advantages of applying bio-fertilizer to raise their crops, such as production of nutritious food, disease-free food, food raised through bio-fertilizers gives more strength and stamina to consuming human beings and animals and it is an eco-friendly method.

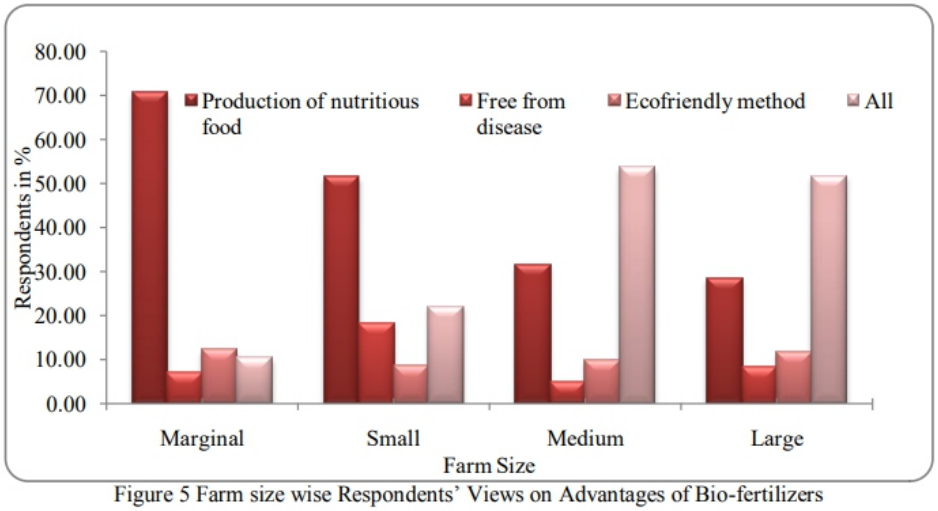

Figure 5 Farm size wise Respondents' Views on Advantages of Bio-fertilizers

The computed chi-square value for table 6 is 75 which is greater than its tabulated value at 1 percent (21.66) level of significance. Hence, the difference in farm size is statistically found to be significant with respect to respondents' views on advantages of applying bio-fertilizers to raise their crops. A similar result has been observed with respect to the application of chemical fertilizers. It is obvious from the above analysis that the medium and large farmers mainly refer the multiple advantages of applying bio-fertilizers and chemical fertilizers. Whereas the majority of the small farmers and marginal farmers highlight the individual advantage of applying bio-fertilizers and also chemical fertilizers.

Table 7. Education-wise Respondents' Views on Advantages of Bio-fertilizers

Education	Advantages of Bio-fertilizers				Total
	Production of Nutritious food	Free from disease	Eco-friendly method	All	
Illiterate	73 (70.87)	9 (8.74)	7 (6.80)	14 (13.59)	103
Primary	81 (61.83)	19 (14.50)	6 (4.58)	25 (19.08)	131
Secondary	28 (17.39)	17 (10.56)	26 (16.15)	90 (55.90)	161
Degree	18 (29.03)	4 (6.45)	6 (9.68)	34 (54.84)	62
Total	**200 (43.76)**	**49 (10.72)**	**45 (9.85)**	**163 (35.67)**	**457**

Chi-square value = 199*

df = 9

* = Significant at 1 percent level= 21.66

Table 7 presents data on the education level and respondents' views on advantages of applying bio fertilizers and chemical fertilizers. It is noted that the majority of the illiterate respondents prefer the bio fertilizers for advantages of high-quality food for humans and animals. According to primary educated respondents group, the bio-fertilized food and crops are more nutritious.

The majority of the (16.15 %) secondary level educated farmers prefer bio-fertilizer due to its eco friendly nature.

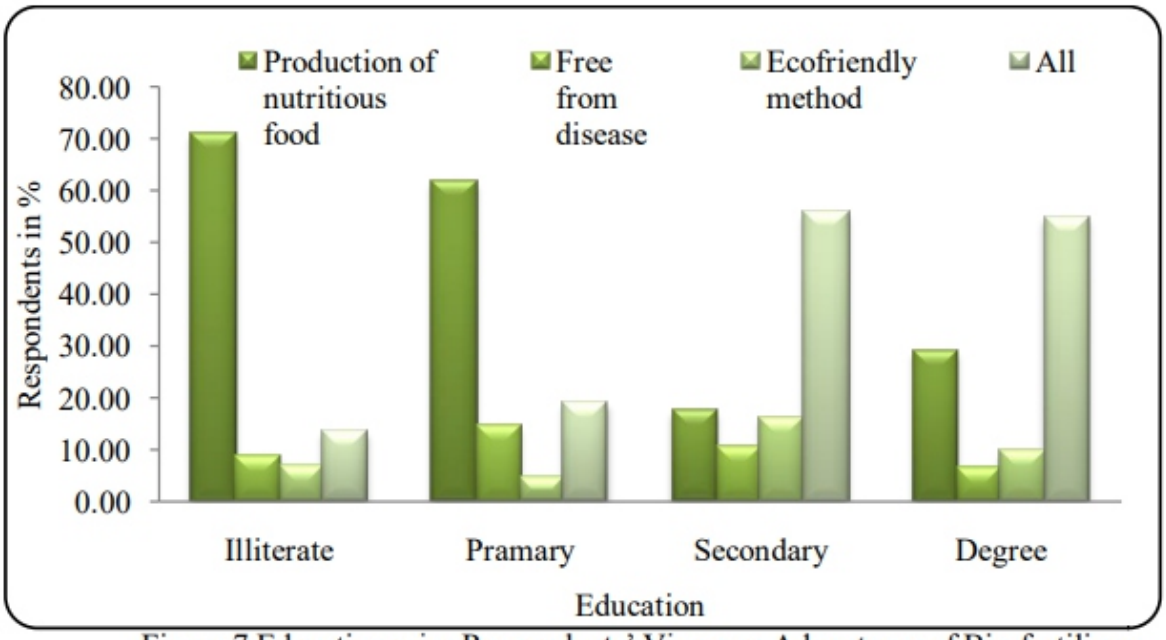

Figure 7 Education-wise Respondents' Views on Advantages of Bio-fertilizers

More than a half of the degree (54.84 %) and secondary (55.90 %) level educated farmers to feel that the multiple advantages of applying bio-fertilizers, such as the production of nutritious food, disease-free food production, food that gives more strength and stamina and as an eco-friendly method.

The computed chi-square value for table 7 is 199 which is greater than its tabulated value at 1 percent level (21.66) of significance. Hence, the difference in educational status is found to be statistically identified as significant with respect to respondents' views on advantages of applying bio-fertilizers to raise their crops. A similar result has been observed with respect to the application of chemical fertilizers.

The above analysis reveals that degree level educated farmers to realize more on multiple advantages of applying bio-fertilizers rather than an individual advantage. It is pointed out that the majority of the illiterate and primary level educated farmers to perceive mainly on the individual advantage of either applying bio-fertilizers or chemical fertilizers to raise the crops.

3.3 Discussion

Many researchers have highlighted the importance of the application of bio-fertilizers in cultivation. They have realized the problems associated with the application of chemical fertilizers particularly it affects the health of the soil and human beings. Hence, there is a need to review works in this regard [7]. have pointed out the implications of integrated nutrient management in terms of organic manures, green

manures, crop inoculates. They have reported that this type of nutrient management in agriculture reduces pollution and maintains soil productivity and agricultural output [1]. have analyzed the components of the agricultural system and identified the conflict between organic and chemical agriculture. Further, they came to a conclusion that application of composting as the best strategy to increase the agricultural production. Food and fertilizer technology center (1995) has identified the evils of application of weedicides to destroy the weeds in the cropped area. Application of bio-fertilizers good for soil health and better way for deduction of input cost of cultivation. Government and NGO's should be promoted and motivate framers for use of biofertilizers.

4. Conclusion

From the complete analysis, it can be concluded that there are different attitudes regarding the use of organic fertilizers and benefits of its application according to farm size and education level of farmers. Large farm size farmers and educated farmers used more organic fertilizers compared to small size farmers and illiterate farmers. Some educated large and medium land size holding farmers adopted both fertilizers but small land size holding farmers mostly used chemical fertilizers because they trying for maximum production from a small piece of land. Bio-fertilizers and chemical fertilizers both are highly used by educated medium farm size farmers. The degree level educated farmers are more conscious about multiple advantages of applying bio-fertilizers rather than a single advantage. Small farm size farmers focus on maximum production from available small agricultural land and hence they do not pay any attention to the benefits of bio-fertilizers. The education wise result reveals that the degree level educated farmers are more aware of the multiple advantages of applying bio-fertilizers and the negative impacts of chemical fertilizers. The majority of the illiterate and primary level educated farmers to concentrate mainly on the individual advantage of either bio-fertilizers or chemical fertilizers application.

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Non-Amine Catalyzed Baylis-Hillman Reaction

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I. 1NTRODUCTION

n:The synthetic chemistry demands expansion of different carbon-carbon bond forming reactions and has been working in this direction for the last several years. The Baylis Hillman reaction1,2 is a carbon carbon bond forming reaction which is essentially a three-component (electrophile, activated alkene and catalyst) reaction has been developing in recent years. This is an atom economic reaction, coupling at -position of activated alkene with carbon electrophile under catalytic influence of a tertiary amine. The most commonly used catalyst is 1,4-diazabicyclo(2.2.2)octane [DABCO] to produce the Baylis-Hillman (B-H) adducts (Fig. 1). The Baylis-Hillman reaction originates from a German patent3filed in the year 1972 by two American chemists A. B. Baylis and M. E. D. Hillman. They had also U.S patent4 in the year 1973 on this reaction

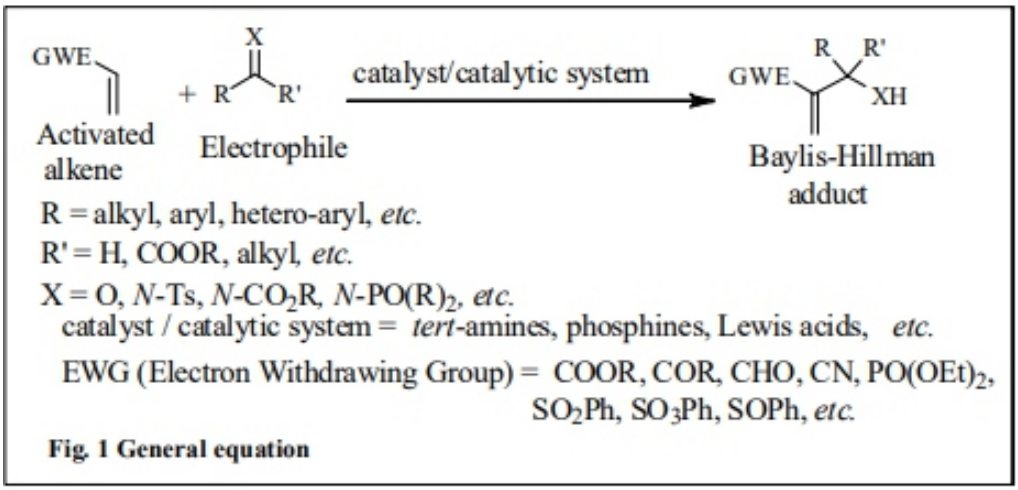

Fig. 1 General equation

Non-Amine Catalyzed Baylis-Hillman Reaction:In addition to the tertiaryamine catalysts, several non-amine catalysts such as trialkylphosphines, triarylphosphinesand metal complexes like RhH(PPh3)4, RuH2(PPh3)4,R2S−TiCl4,TiCl4-NR4X (X = halide), TiCl4NR3, TiCl4, and R2X−BF3 (X = O, S) weresuccessfully employed to the coupling of activated alkenes with aldehydes to provide the Baylis-Hillman adducts. Cheng and coworkers5 applied, for the first time, methoxide ion as useful catalyst for Bayils-Hillman reaction with cyclic activated alkenes and various aldehydes under mild conditions to provide the desired Baylis-Hillman adducts (Scheme 1).

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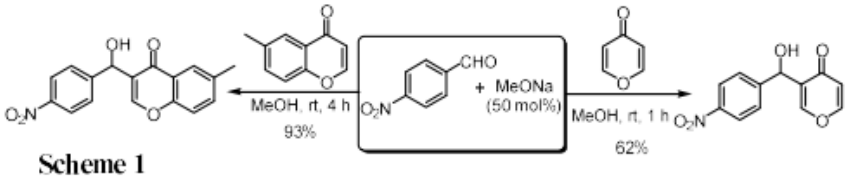
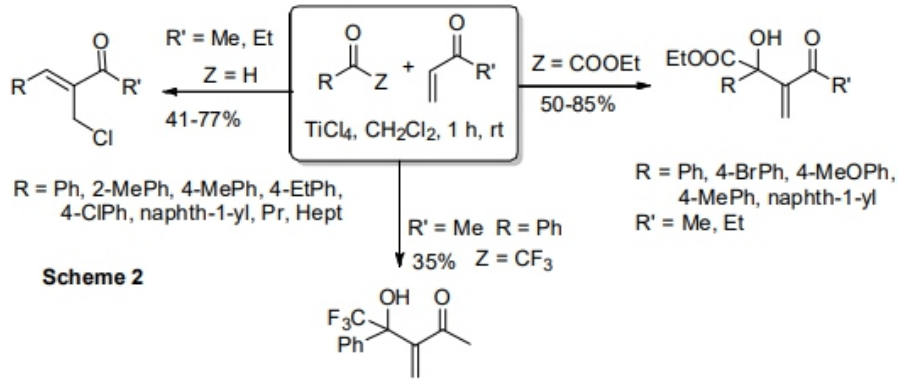


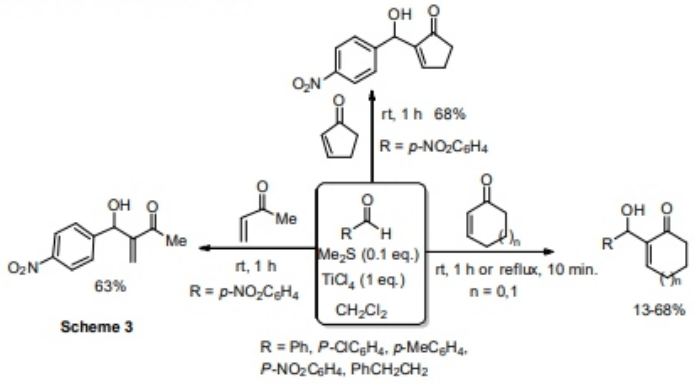
Scheme 1

TiCl4 catalyzed Baylis-Hillman reaction of -keto esters and trifluoromethyl phenyl ketone with alkyl vinyl ketones to obtain the desired Baylis-Hillman adducts has been reported by Basavaiah research group.6 Similar reaction with aldehydes provided the (Z)-allyl chlorides (Scheme 2).



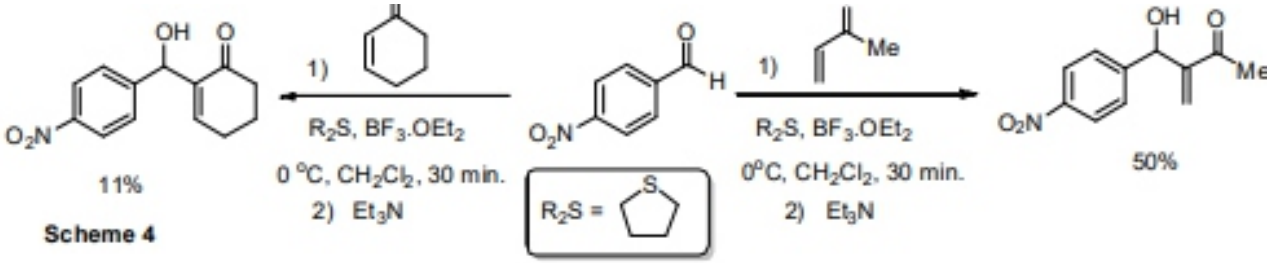
Scheme 2

Kataoka and co-workers[7-9]reported an interesting class of chalcogenide catalyzed Baylis–Hillman reaction of various aldehydes with alkyl vinyl ketones in the presence of titanium tetrachloride (Scheme 3).



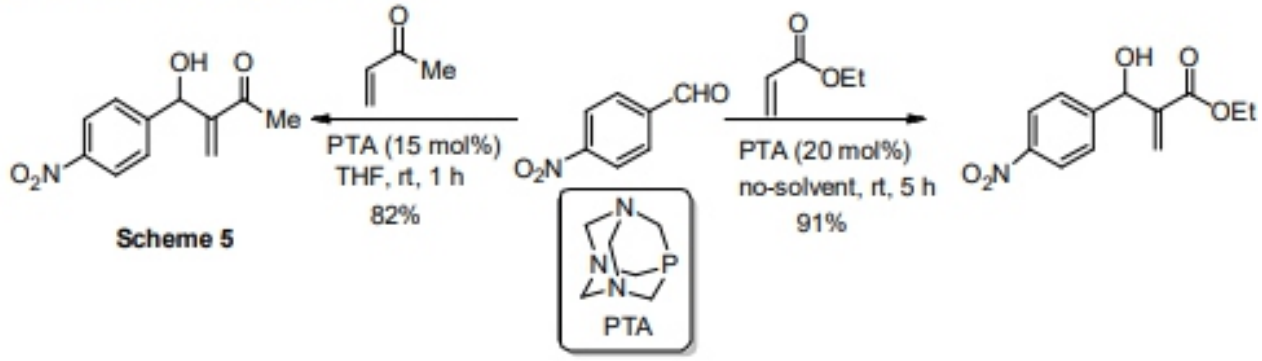
Scheme 3

Goodman and co-workers[10] have applied tetrahydrothiophene $BF_3 \bullet OEt_2$ as a catalytic system for the Baylis–Hillman coupling between aldehydes (electrophiles) and activated ketones (MVK and cyclohex-2-enone) (Scheme 4).



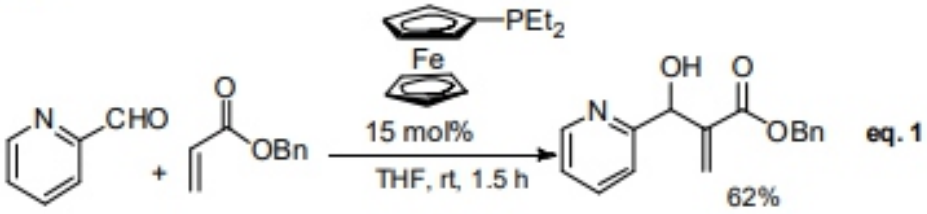
Scheme 4

1, 3, 5-Triaza-7-phosphaadamantine (PTA) has been successfully employed as a catalys for the Baylis-Hillman reaction of various aldehydes with various activated olefins by H and co-workers[11] (Scheme 5).



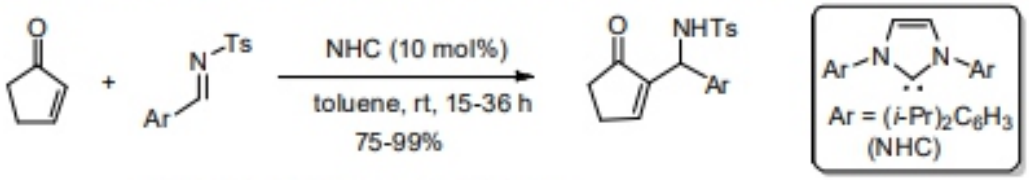
Scheme 5

Ferrocene diethylphosphine as an air stable catalyst reported by Carretero and co-workers[12]for the Baylis-Hillman coupling reaction of various aldehydes and acrylates to obtain the corresponding B-H adducts in high yields (eq. 1).



eq. 1

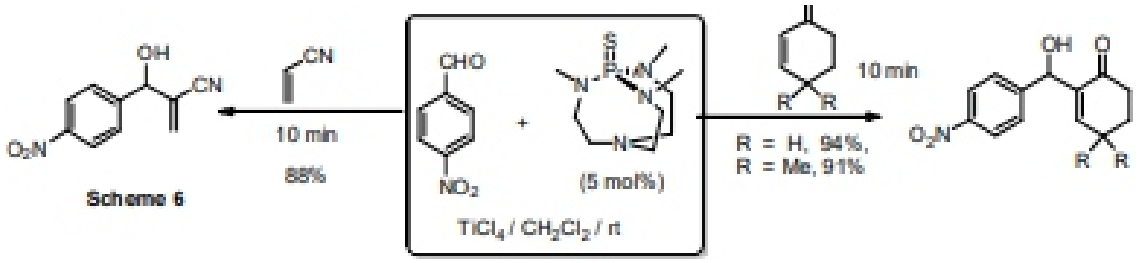
N-heterocyclic carbene (NHC) catalyzed Baylis-Hillman reaction of cyclic enones with a *N*-tosylimines has been reported by He and co-workers[13] to obtain the corresponding B-H adducts in high yields (eq.2).



eq. 2

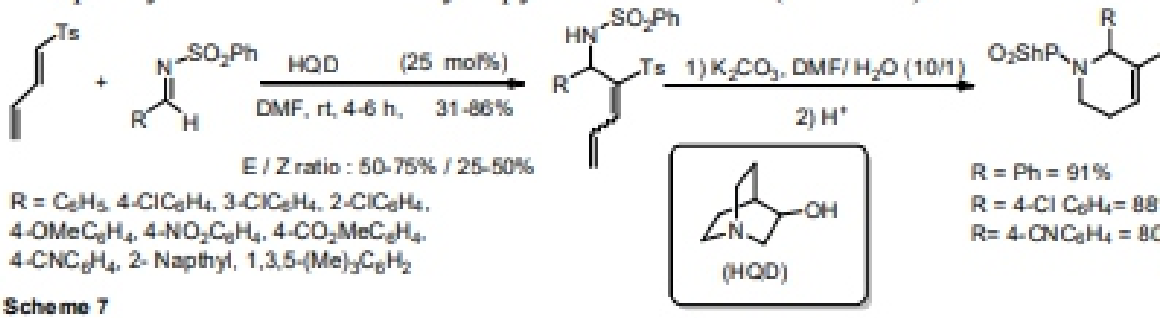
Ar = C_6H_5, 4-MeC_6H_4, 4-$MeOC_6H_4$, 4-ClC_6H_4, 4-FC_6H_4, 4-$NO_2C_6H_4$, 2-Furyl, 3-$MeOC_6H_4$, 3-ClC_6H_4, 2-$MeOC_6H_4$

The aza-phosphine has been used as a catalyst for the Baylis-Hillman coupling between various acyclic/cyclic activated alkenes and different types of aldehydes by Verkade and co-workers[14]in high yields (Scheme 6).



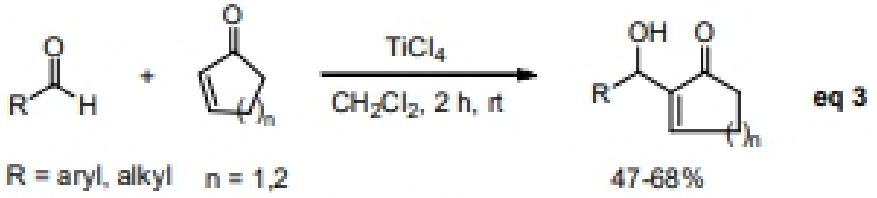
Scheme 6

Back and co-workers[15] have successfully emplayed (*p*-toluenesulfonyl)-1,3-butadiene activated alkene for coupling with aldimine derivatives. 3-Hydroxyquinuclidine (HQ appliedas catalyst to provide the corresponding Baylis-Hillman adducts which w subsequently converted into tetrahydropyridine derivatives (Scheme 7).

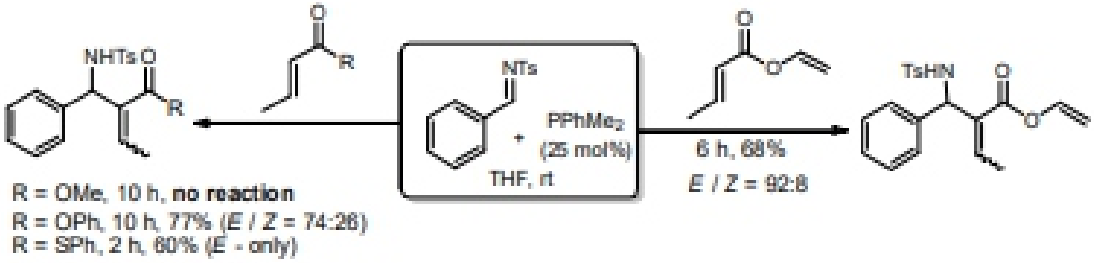


Scheme 7

$TiCl_4$-mediated Baylis-Hillman reaction of cyclic enones with various aldehydes reported by Li and co-workers[16](eq3).

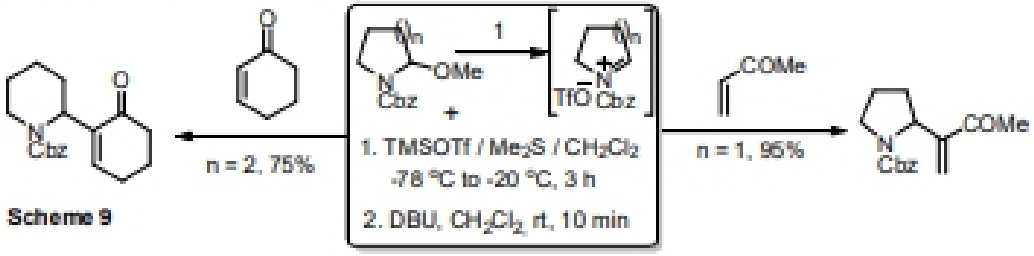


Shi *et.al.*, reported phosphine ($PPhMe_2$) catalysedaza-Baylis-Hillman reaction of β-substituted α, β-unsaturated esters with *N*-tosylated imines to provide the corresponding Baylis-Hillman adducts (Scheme 8).[17]



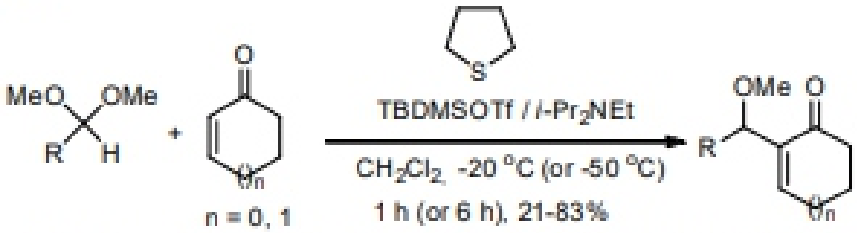
Scheme 8

In situ generated iminium ions as electrophiles to produce the Baylis-Hillman adduct with activated alkenesreported by Aggarwal and coworkers[18](Scheme 9).



Scheme 9

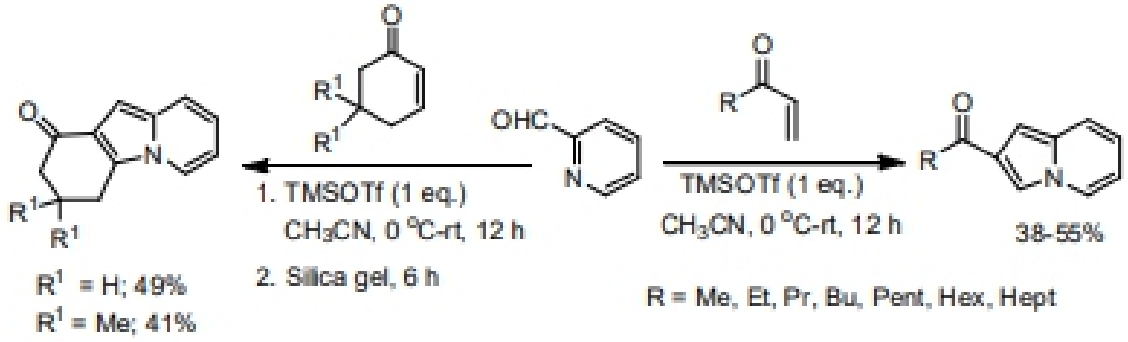
Metzner and coworkers[19]haveused dimethyl acetals as electrophiles with cyclic enonesin the Baylis-Hillman coupling under the influence of tetrahydrothiophene and TBDMSOTf in the presence of *i*-Pr_2NEt (Hunig's base) (eq. 4).



eq. 4

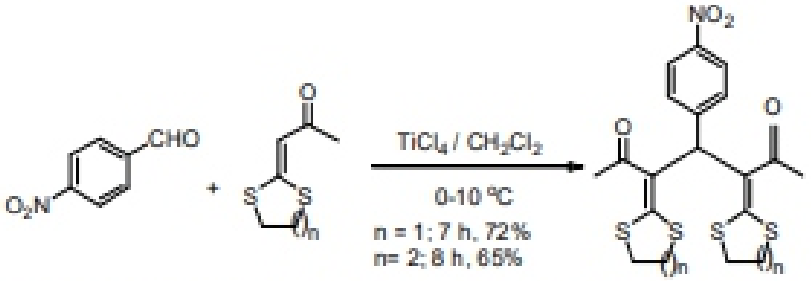
R = C_6H_5, 4-MeC_6H_4, 4-ClC_6H_4, 4-FC_6H_4, 4-$CF_3C_6H_4$, 2-$MeOC_6H_4$, 4-$MeOC_6H_4$, C_6H_5CH=CH, $C_6H_5CH_2CH_2$

Basavaiah research group published an electrophile induced intramolecular Baylis–Hillman reaction between activated alkenes and pyridine-2-carboxldehyde under the influence of trimethylsilyl trifluoromethanesulfonate (TMSOTf), for the synthesis of indolizine (Scheme 10).[20]



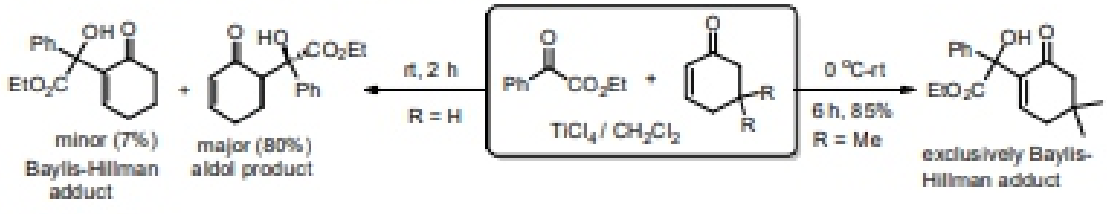
Scheme 10

Yin and coworkers[21] published, $TiCl_4$-mediated Baylis-Hillman type reaction of α–oxoketene dithioacetals with aldehydes for the synthesis of polyfunctionalized 1,4-pentadienes *via* C-C bond formation at the α-position of α–oxoketene dithioacetals has been described (eq. 5).



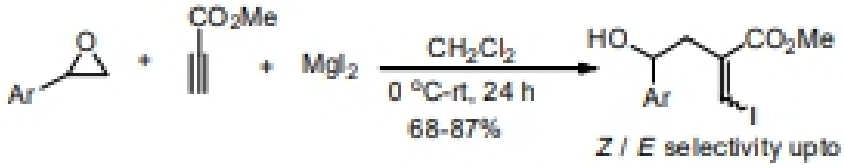
eq. 5

Basavaiah research group[22] has developed steric factors directed Baylis-Hillman and aldol reactions in $TiCl_4$ mediated coupling between α-keto esters with cyclohex-2-enone derivatives. Thus, 5,5-dimethylcyclohex-2-enone provides the corresponding Baylis-Hillman adducts exclusively in reaction with α-keto esters under the influence of $TiCl_4$, whereas a similar reaction of α-keto esters with cyclohex-2-enone furnishes the corresponding aldol adducts with high *syn*-diastereoselectivity as the major product along with the Baylis-Hillman adduct as the minor product (Scheme 11).



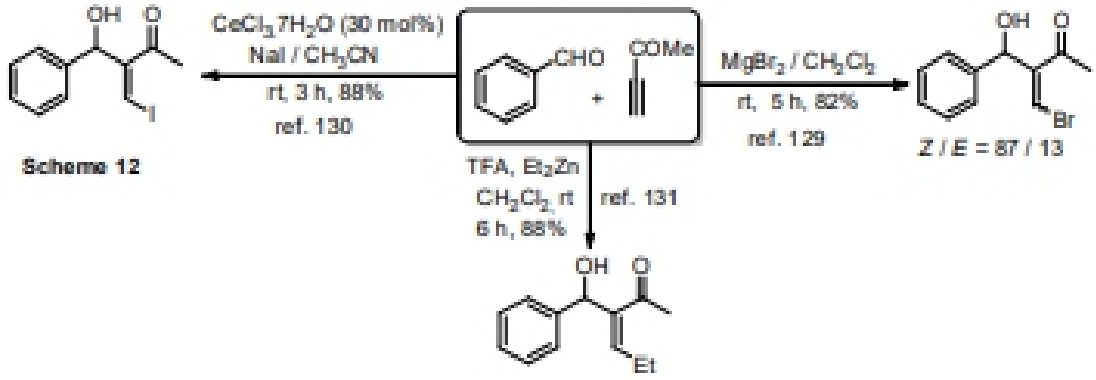
Scheme 11

For the first time, Li and coworkers[23]demonstrated the application of oxirane as an electrophile for coupling with methyl propiolate in the presence of MgI_2 to provide densely functionalized homoallylic alcohols (eq. 6).



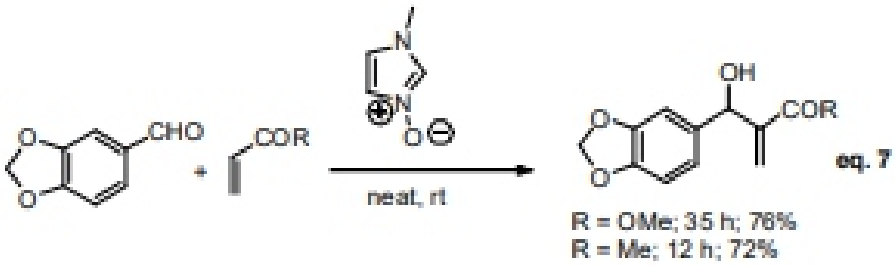
Ar = C_6H_5, 2-MeC_6H_4, 4-MeC_6H_4, 2-MeOC_6H_4, 3-MeOC_6H_4, 4-MeOC_6H_4, 2-ClC_6H_4, 4-ClC_6H_4, 4-FC_6H_4, thiophen-2-yl

Various research groups[24-26] developed independently simple methods for synthesis of β-substituted Baylis-Hillman adducts *via* one-pot three-component reaction protocol involving the treatment of α, β-acetylenic ketones (*in situ* generation of allenoates) with various aldehydes in the presence of various catalysts / reagents to provide allyl alcohols (Scheme 12).

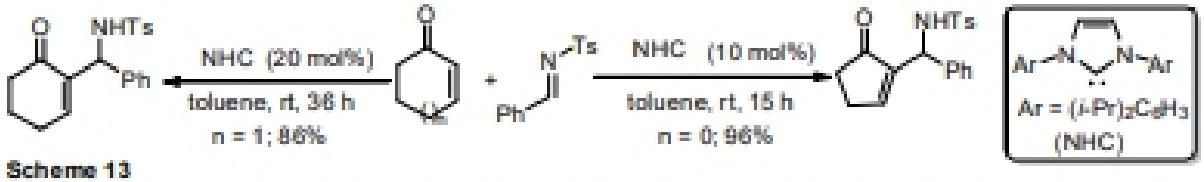


Scheme 12

1-Methylimidazole 3-*N*-oxide catalyzed Baylis-Hillman coupling of various aldehydes with methyl acrylate / methyl vinyl ketone to provide corresponding adducts in good yields was reported by Tsai and coworkers (eq. 7).[27]



Ye and coworkers[28]described an interesting, *N*-heterocyclic carbene (NHC) catalyzed aza-Baylis-Hillman coupling of cyclic enones with a variety of *N*-tosylimines to provide the corresponding adducts in high yields (Scheme 13).



Scheme 13

Shi and Xu[29] have successfully used methyl diphenylphosphine as a catalyst for Baylis-Hillman reaction between *N*-tosylated imines and different activated olefins (Scheme 14).

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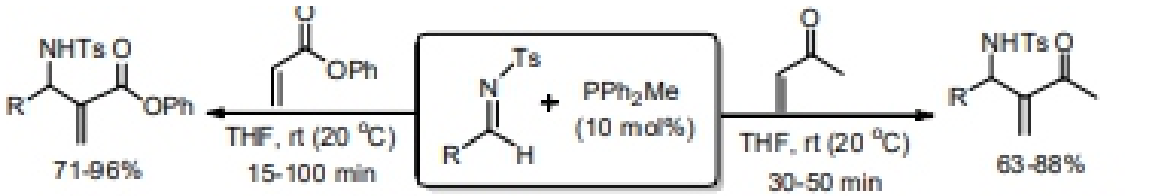
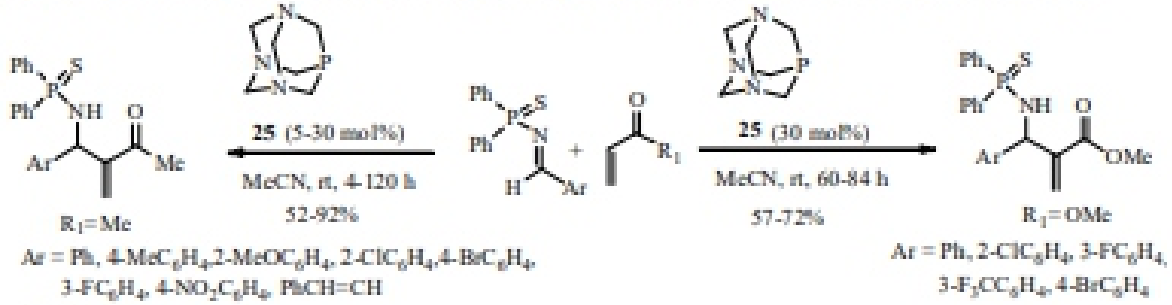


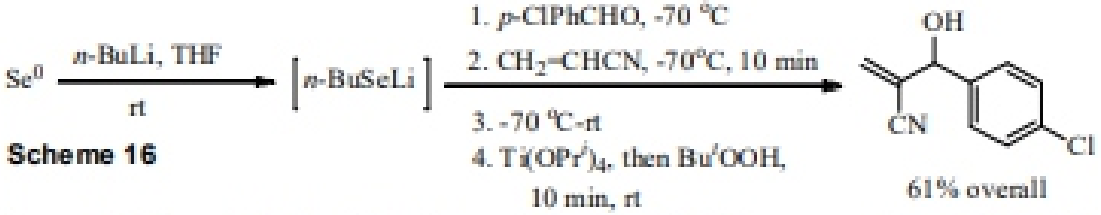
Scheme 14

Zhou and coworkers[30] have described an interesting 1,3,5-triaza-7-phosphaadamantane (PTA) catalyzed Baylis-Hillman coupling of *N*-thiophosphoryl imines with MVK and methyl acrylate to provide the corresponding Baylis-Hillman adducts (Scheme15).



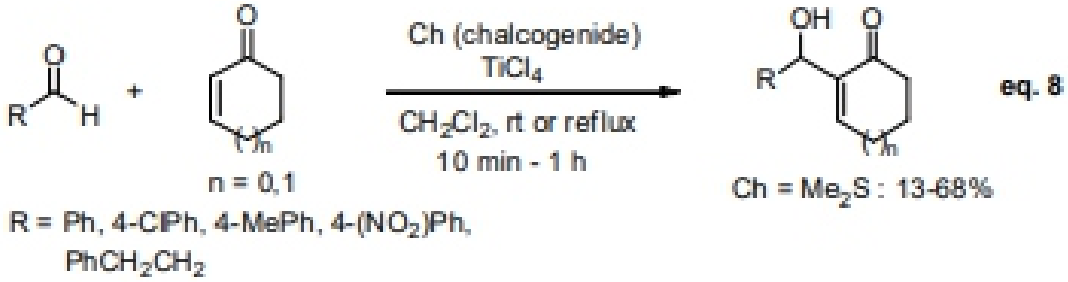
Scheme 15

Comasseto and coworkers[31] have established a simple and efficient one-pot access to Baylis-Hillman adducts (Scheme 16).



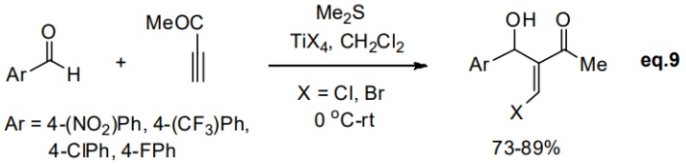
Scheme 16

Kataoka *et al.*[32] have developed an interesting Baylis-Hillman coupling of vinyl ketones with various aldehydes catalyzed by sulfides or selinides (Me_2S, PhSMe) in the presence of $TiCl_4$as a Lewis acid. Selinide and Me_2S were proved to be the best catalysts for this reaction (eq. 8).



eq. 8

Kataoka[33]successfully reportedchalcogeno-Baylis-Hillman reaction to activated alkynes. Thus, the reaction between activated alkynes with aldehydes under the influence of $Me_2S.TiX_4$ provided an interesting α-halomethylene aldols *i.e.*,β-halo Baylis-Hillman adducts (eq. 9).



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TO STUDY THE EFFECT OF CUTTING FLUID CONCENTRATION AND CUTTING PARAMETERS ON SURFACE ROUGHNESS OF STEEL AFTER TURNING

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ABSTRACT

In present industrial era, strict tolerance limits are used in manufacturing parts that require higher surface finish and the given work laid emphasis on optimizing the surface roughness of AISI 1030 steel during wet CNC turning operation. The main purpose of this experimental investigationis to analyse the effect of cutting parameters such as cutting speed, feed rate, depth of cut, cutting fluid concentration and two cutting fluids with different base oils on surface roughness (Ra) on AISI 1030 steel during turning operation. The design of experiments, custom design method, and Taughci method are used to achieve this objective. The analysis reveals that feed rate has the most significant effect on surface roughness (Ra) and value of surface roughness does not significantly differ for two different cutting fluids used.

Keywords: *CNC Machine, AISI 1030,Cutting Fluid,Surface Roughness Tester*

Introduction

Turning is the primary operation in most of the production process in the industry. It is a material removal process in which major motion of the single point cutting tool is parallel to the axis of rotation of the rotating workpiece . The workpiece is usually held in a work holding device known as chuck and the tool is mounted in the tool post.

Parameters affecting characteristics of turned parts

The dimensional accuracy, surface roughness of the turned parts are affected by tool or insert geometry, tool material, cutting speed, feed rate, depth of cut, dry cutting conditions, wet cutting conditions etc., a brief explanation of which has been given below

Cutting speed: It is defined as the relative velocity between the cutting tool and the surface of the workpiece. It is expressed in metres per minute. It is important to know cutting speed or peripheral speed to calculate spindle speed as if the spindle speed is not proper it could lead to chatter and tool breakage.

Feed rate :It is the relative velocity at which the cutter is advanced along the work piece. Its vector is perpendicular to the vector of cutting speed, feed rate units depend on the motion of tool and the workpiece; when the workpiece rotates as in case of turning and boring its units are distance per spindle revolution in/rev or mm/rev.

Depth of cut It is thickness of the material that is removed by one pass of the cutting tool over the workpiece. Its units are mm or inch.

Surface finish

Surface finish or surface texture consists of repetitive and/or random deviations from the nominal surface of the object; it has four components lay, waviness, surface roughness and flaws as shown in fig. 1.1. Lay is the direction of predominant surface pattern determined by production method used. Within limitations resulting from components manufacture, a designer must select a functional surface condition that will satisfy operational constraints which might be a requirement for a smooth or a rough surface [4].

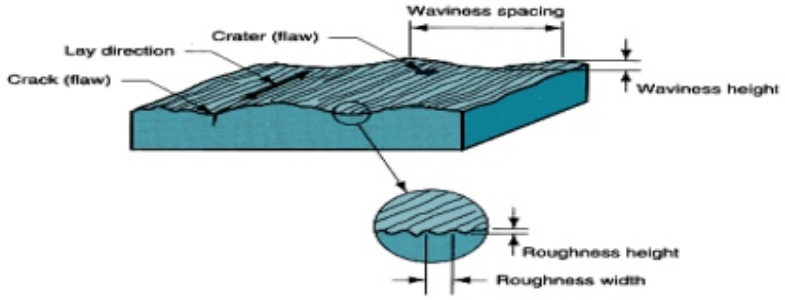

Fig. 1.1 Surface texture features [4]

Cutting fluids

Cutting fluids or cutting oils are engineering materials that optimize the machining operation. They are used for lubrication, heat dissipation, corrosion prevention, chip disposal etc. The advantages of using cutting fluids are mentioned below [9].

1) The use of cutting fluid reduces friction and heat. The removal of heat prevents the workpiece from expanding during the machining operation, which would cause size variation as well as damage to the microstructure of material.

2) Proper use of cutting fluids increase the tool life, which reduces the tooling costs. Increased tool life also reduces tool changes and downtime which decreases labour costs.

3) The use of cutting fluids reduces friction and heating in a cutting operation. This allows high speeds and feeds to be used so as to achieve optimal cutting conditions.

4) Effective use of cutting fluids help in chip removal, which if caught in between tool and workpiece could cause scratches and it also helps in preventing formation of built up edges thus improving surface

finish.

5) Cutting fluid leaves a residual film behind after evaporation of water from the surface of tool and workpiece thus preventing it from corrosion.

Types of cutting fluids

The cutting fluids are divided into four broad categories according to their constituents which are as given below [10].

1) Straight oils These are also called mineral oils and are not diluted with water. These contain mineral or petroleum oil as base oil and often contain polar lubricants such as fats, vegetable oils and esters as well extreme pressure additives such as chlorine, sulphur, phosphorus etc., they provide best lubrication and the poorest cooling characteristics amongst cutting fluids.

2) Soluble oils They are a mixture of water with mineral oil. Emulsifier is added to help produce stable mixture.

3) Synthetic fluids They contain no petroleum or mineral oil base and instead are formulated from alkaline inorganic and organic compounds along with additives for corrosion inhibition. They provide best cooling performance among all cutting fluids.

4) Semi synthetic fluids These are a combination of synthetic and soluble oils having characteristics common to both types of fluids these are very popular these days. Their cost and heat transfer properties lie between synthetic and soluble oils.

2 LITERATURE SURVEY

Kuram et al. (2010) conducted a study using three different types of vegetable based cutting fluids developed from raw and refined sunflower oil, two commercial types (vegetable and mineral based cutting oils) to determine their effects on thrust force and surface roughness while drilling AISI 304 austenic stainless steel using HSSE tool.

Krishna et al. (2011) performed an experimental investigation on the performance of nanoboric acid suspension in SAE- 40 and coconut oil during turning AISI 1040 steel, flow rate of 10 ml/min which is nearly dry was maintained for different concentration of boric acid in coconut oil and SAE oil.

Singh H. et al (2012) presented an experimental study to investigate the effects of cutting parameters like spindle speed, feed rate and depth of cut on surface finish of EN-8 material while dry turning, employing taguchi method and using L-16 orthogonal array.

Sharma et al. (2013) performed an experiment to optimize the cutting parameters for surface roughness during turning of AISI 410 carbon steel, Cutting speed, feed rate, depth of cut and insert radius were chosen as control parameters, the signal to noise ratio and ANOVA were used to analyse the effect of different control parameters on surface roughness.

Davis and Alazhari (2014) analysed the effects of major cutting parameters of speed, feed rate and depth of cut during dry turning of mild steel for obtaining optimum surface roughness, MINITAB 15 software.

Das et al. (2014) conducted a study to optimize cutting parameters on tool wear and workpiece surface temperature during dry turning of AISI D2 steel employing Taguchi's orthogonal array design, ANOVA, main effect plots using MINITAB 15 software

Singh D. et al (2015) performed an experimental investigation on surface roughness and MRR during dry turning of EN-8 on CNC lathe using Response surface methodology [RSM] to optimize the cutting parameters of speed, feed and depth of cut.

3.OBJECTIVES AND METHODOLOGY

1) To optimize the surface roughness of AISI 1030 steel during wet CNC turning on cylindrical workpiece

2) To analyse the effects of various cutting parameters i.e. spindle speed, feed rate, depth of cut and cutting fluid concentration on surface roughness using Taguchi method and plot various interactions.

3) To compare the effect of two base oils used in water soluble cutting fluids namely heavy duty diesel and spindle oil.

4.EXPERIMENTATION AND OBSERVATIONS

Workpiece :The AISI 1030 steel is a high carbon steel, and has moderate strength and hardness in the as-rolled condition. It can be hardened and strengthened by cold work. It also has fair machinability, ductility and good weldability.

Table 1.1 Chemical composition of AISI 1030

Fe %	Mn %	C %	P %	S %
98.67-99.13	0.60-0.90	0.270-0.340	≤ 0.040	≤ 0.050

Cutting tool : The cutting tool used was Sandvik Coromant made carbide turning insert CNMG 431 PF- 4225, which was considered taking care of workpiece material and cutting conditions. The specifications of the cutting tool insert are shown below in the table 3.

Table 1.2 Specifications of the cutting tool insert

Insert thickness	0.1875 inches.
Nose radius	0.0157 inches
ISO number	CNMG 12 04 04-PF 4225
No. of edges	4
Coating	MTCVD

Cutting fluids: The environmental conditions for the turning were wet flood cooling conditions, the flow rate of 8litre/min. There were two types of cutting fluids used which were specially prepared by Nirmal Industries, Phase1, Chandigarh for the purpose of experiments which are as given below

1. Cool-cut-Nirma 40 A – Water soluble cutting fluid with spindle oil as base oil.
2. Cool-cut-Nirma 30 A – Water soluble cutting oil with heavy duty diesel oil as base oil.

Equipment

CNC Machine:The advantages of using CNC over conventional lathe are that CNC turning machines are said to deliver components at a faster production rate with optimum manufacturing accuracy. It allows reaching tight tolerances in every piece; other advantages are parts consistency and uniformity. The lathe that was used in experiment for turning was a Lokesh made CNC with specifications given in the table 1.3.

Table 1.3 CNC lathe specifications

Model	LOKESH TL 30 XL
Power	11 hp/8.2 KW
controller	FANUC Series 0 i TC
Max. Spindle speed	3000 RPM
Chuck size	249.6 mm
Spindle size	$A_2$6
Tool holder	Standard Lokesh made with 25*25 mm shank

Surface Roughness Analyser:A contact type profilometer was used for measuring the surface roughness; these are the devices which use diamond stylus, which is moved across the surface for a specified distance. A profilometer can measure small surface variations in vertical stylus displacement as a function of position.

Fig. 1.2 Surface roughness tester

Design of Experiment

The objective functions to be optimized are also identified with control factors and their levels.

Table 1.4 The machining parameters and their levels

S. No.	Machining Parameters	Symbols	Unit	Level		
				Level 1	Level 2	Level 3
1.	Fluid	A40, A30		A40	A30	
2.	Velocity	V	rpm	800	1200	1500
3.	Feed	F	mm/rev.	0.10	0.15	0.20
4.	Depth	D	mm	0.50	1.00	1.50

L 18 orthogonal mixed array was selected for this study, because one parameter has two levels and rest parameters have three levels. After selection the orthogonal array matrix, the design of experiment procedure (flow chart of experiment procedure) adopted for the experimentation. The experimental matrix based on L18 mixed orthogonal array of Taguchi method is shown in Table 1.5

Table 1.5 Design of experiment of L18 orthogonal array

S. No.	Fluid	V (rpm)	F (mm/rev.)	D (mm)
1.	A40	800	0.10	0.50
2.	A40	800	0.15	1.00
3.	A40	800	0.20	1.50
4.	A40	1200	0.10	0.50
5.	A40	1200	0.15	1.00
6.	A40	1200	0.20	1.50
7.	A40	1500	0.10	1.00
8.	A40	1500	0.15	1.50
9.	A40	1500	0.20	0.50
10.	A30	800	0.10	1.50
11.	A30	800	0.15	0.50
12.	A30	800	0.20	1.00
13.	A30	1200	0.10	1.00
14.	A30	1200	0.15	1.50
15.	A30	1200	0.20	0.50
16.	A30	1500	0.10	1.50
17.	A30	1500	0.15	0.50
18.	A30	1500	0.20	1.00

5.RESULTS AND DISCUSSIONS

Analysis of Surface Roughness

Surface roughness was measured using surface roughness tester Mututoyo SJ .201. Two replications were made for each sample. These results of surface roughness are compiled into average of the two replications in the Table 1.6. The surface roughness is measured in μm.The mean effects plot of the S/N ratio for SR using "smaller is better" is shown in Fig. 5.1 which reveals that the SR is minimum at 1st level of fluid (A40), 1st level of velocity (800rpm), 1st level of feed rate (0.10 mm/rev.) and 2nd level of depth (0.10mm). Thus the S/N ratio shows that F1, V1, f1, and D1 parameter set gives the minimum SR. Main effects of plot for S/N ratio of SR also reveals that feed rate gives higher surface roughness as compared to the other input parameters.

Table 1.6 Response Table for the SR

S. No.	Fluid	V (rpm)	F (mm/rev.)	d (mm)	R_{a1}	R_{a2}	Avg. Ra
1	A40	800	0.10	0.50	1.65	1.89	1.77
2	A40	800	0.15	1.00	1.91	1.87	1.89
3	A40	800	0.20	1.50	2.31	2.35	2.33
4	A40	1200	0.10	0.50	1.85	1.89	1.87
5	A40	1200	0.15	1.00	1.93	2.02	1.98
6	A40	1200	0.20	1.50	2.44	2.58	2.51
7	A40	1500	0.10	1.00	2.27	2.14	2.21
8	A40	1500	0.15	1.50	2.46	2.60	2.53
9	A40	1500	0.20	0.50	2.73	2.88	2.81
10	A30	800	0.10	1.50	1.78	1.84	1.81
11	A30	800	0.15	0.50	1.88	1.93	1.91
12	A30	800	0.20	1.00	2.29	2.38	2.34
13	A30	1200	0.10	1.00	1.99	1.85	1.92
14	A30	1200	0.15	1.50	2.12	1.90	2.01
15	A30	1200	0.20	0.50	2.47	2.70	2.59
16	A30	1500	0.10	1.50	2.23	2.29	2.26
17	A30	1500	0.15	0.50	2.61	2.69	2.65
18	A30	1500	0.20	1.00	3.04	2.69	2.87

Fluid and depth also affect the SR, but doesn't give significant results. The main effect plots of the S/N ratios for SR are found with the help of Minitab-18 software. This plot revealed that the steeper slope with longer lines gives significant effect on the surface roughness.

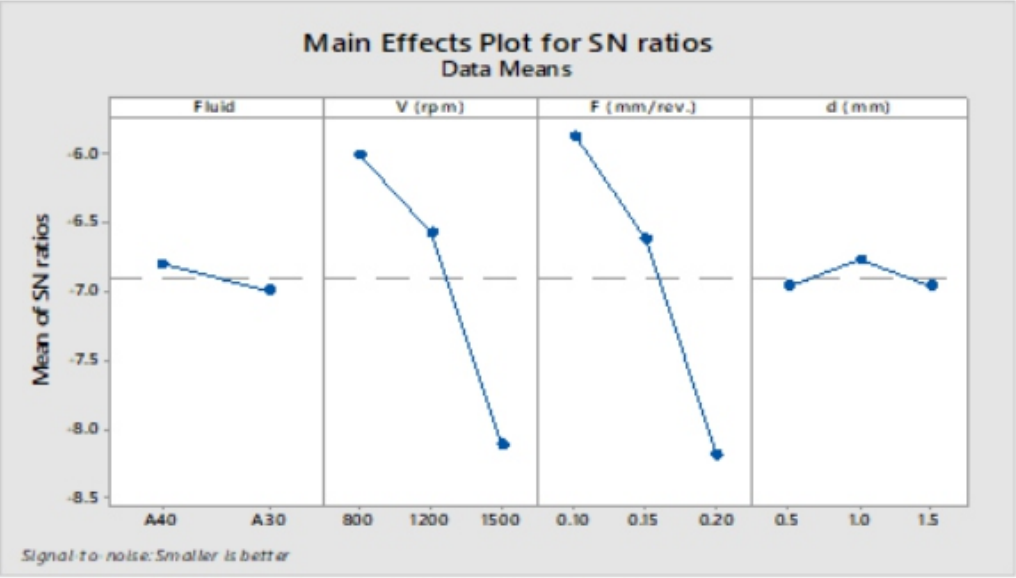

Fig. 1.3 Mean effect plot for S/N ratios for surface roughness

Response table of the ANOVA (Analysis of Variance) also shows that the feed rate is the most significant parameters and second one is the velocity which is significant parameter. Fluid and

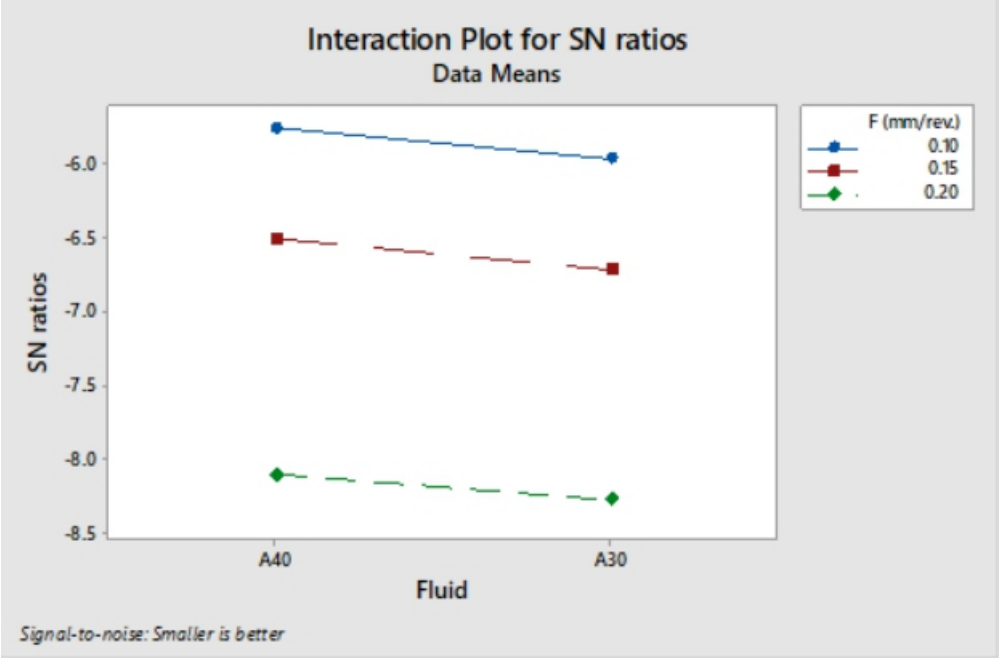

Fig. 1.4 Interactions plot of S/N ratio for SR (feed rate)

The different types of interaction curves are shows in the following figure, which shows that the interactions between the feed rate, velocity and fluid are shown in the fig. 5.2 and fig. 5.3. These figures show that the surface roughness is increase with the sharply increase in feed rate and velocity and there is no significant affect with the fluid type. i.e feed rate and velocity are the significant parameters.

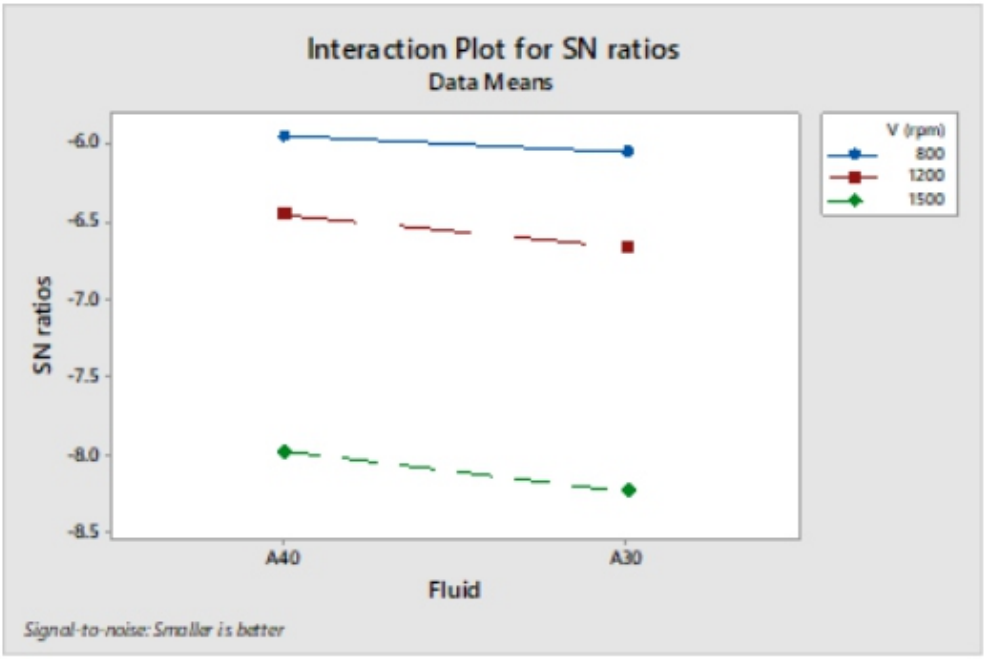

Fig. 1.5Interactions plot of S/N ratio for SR (Velocity)

Conclusions

In this study we used design of experiments and various statistical methods such as Taguchi, ANOVA are used for optimizing surface roughness during wet turning of AISI 1030 steel on CNC lathe machine. Feed rate and cutting velocity have significant and most dominant effect on the surface roughness of AISI 1030 steel during wet CNC turning operation.

1) Surface roughness increases with increase in feed rate as well as cutting velocity

2) It was found that surface roughness tends to increase with increase in depth of cut but after certain value of depth of cut, it shows downward trend.

3) No significant difference was found between the cutting fluids when compared on the basis of their effect on surface roughness and workpiece tool interface temperature

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