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Orignal Article

Assessment of Integrated Nutrient Management in French bean (Phaseolus vulgaris L.) under Sub tropical Conditions of Uttarakhand

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Abstract

Present experiment was carried out at Horticulture Research Block, School of Agricultural Sciences, Shri Guru Ram Rai University, Dehradun, Uttarakhand to study the effect of integrated nutrient management on growth and yield of French bean cultivar Pant Anupma under subtropical conditions of Dehradun. Treatments included twelve combinations viz. T_1 (Without any organic, inorganic or biofertilizer application), T_2 (50% RDF i,e 15:25:15 Kg NPK/ha, respectively), T_3 (75% RDF i,e 22.5:37.5:22.5 Kg NPK/ha, respectively), T_4 (100% RDF i,e 30:50:30 Kg NPK/ha, respectively), T_5 (FYM @ 5 ton/ha), T_6 (VC @ 2.4 ton/ha)), T_7 (Biofertilizer viz., Rhizobium + PSB @ 20g/kg seed),T_8 (50% FYM + 50% VC + Biofertilizer), T_9 (50% RDF + 50% FYM), T_{10} (50% RDF + 50% VC), T_{11} (50% RDF+ Biofertilizer) and T_{12} (50% RDF + 50% FYM + 50% VC + Bio-fertilizer). The experiment was laid out in Randomized Block Design with three replications. Results revealed that the yield attributes and yield increased significantly over control and highest pods/plant (13.40), seeds/pod (5.00), pod length (11.01 cm), 100-seed weight (g) and seed yield (1386.67 kg/ha) were recorded with application of 100% RDF but showed no significant difference with treatment T_{12} (50% RDF + 50% FYM + 50% VC + Biofertilizer). Among growth and quality parameters, highest plant height (33.50 cm), primary branches (4.80, secondary branches (4.40), LAI (5.77), total dry weight (22.00), protein content (21.20%) and protein yield (294.01 kg/ha) were also recorded with application of 100% RDF and lowest in control.

Keywords: French bean, Organic, Inorganic, Biofertilizers, Yield attributes, Protein content

Introduction

French bean (Phaseolus vulgaris L.) is commonly known by various names viz. common bean, kidney bean, haricot bean, snap bean etc. in English and in Hindi it is called as Farash bean or Rajma. It is an important leguminous vegetable crop which is consumed as vegetable when pods are immature, delicate, tender, soft and green; and also as it is one of the most precious and highly relished pulse crop of North India with a high yield potential of 18-20 q/ha (Zahida et al. 2016). Pods are valuable source of protein, vitamins as well as minerals. It is a short duration crop and can be grown in all types of soils ranging from light sandy loam to clay soils but it cannot withstand water-logging. French bean being a fertilizer responsive crop it responds well to nutrition. With population explosion, the demand for the crop has increased significantly leading to the extensive use of chemical fertilizers without any consideration for people health as well as soil health and quality, which is a critical factor for realizing sustainability in yield. The use of chemical fertilizers boosted the agricultural products and

the farming communities are using the same indiscriminately in such areas where irrigation facility exists with an eye on two to three crops in a year. This has drained the soil and resulted in the loss of soil productivity. Besides this the residual effects of chemical fertilizers on our environment, underground water, soil microbes and the crop products etc. are matter of great concern. Greater use of chemical fertilizers not only puts a heavy financial burden to the farmers but also gradually decreases the production and thereby, jeopardizes the sustenance of the basic ecological system. Lesser use of the organic manures has also rendered soils deficient in macro and micro nutrients (Acharya and Mandal, 2002). Organic manures are eco-friendly, cheap source of nutrients and are potentially sound for supplying nutrients which can reduce dependence on chemical fertilizers (Datt et al., 2013). Organic resources are largely biological in origin and they have several nutrients in their composition, which on decomposition are released into soil (Kumar et al., 2014). Organic sources of the plant nutrients have been reported to improve nutritional quality, protein content and mineral content in crops as compared to those with inorganic sources (Bhadoria et al., 2002). Thus, for increasing the yield and quality of French bean, besides other factors, an adequate quantity of nutrients from organic and inorganic sources is pre-requisite. Keeping the views of the above aspects the present research work was planned to study the effect of integrated nutrient management on growth, yield and quality of French bean under sub tropical conditions of Uttarakhand.

Materials and Methods

The experiment was conducted during kharif season 2018 at Horticulture Research Block, School of Agricultural Sciences, Shri Guru Ram Rai University, Dehradun, Uttarakhand, India located at 29o58′ N and 77o34′ E and at an altitude of 610 m above msl, to study the effect of integrated nutrient management on growth, yield and quality of French bean cv. Pant Anupma. The experiment was laid out in a Randomized Block Design having 12 treatments (Table-1), comprising different combinations of inorganic fertilizers, organic manure and biofertilizers viz., T_1 (Without any organic, inorganic or biofertilizer application), T_2 (50% RDF i,e 15:25:15 Kg NPK/ha, respectively), T_3 (75% RDF i,e 22.5:37.5:22.5 Kg NPK/ha, respectively), T_4 (100% RDF i,e 30:50:30 Kg NPK/ha, respectively), T_5 (FYM @ 5 ton/ha), T_6 (VC @ 2.4 ton/ha)), T_7 (Biofertilizer viz., Rhizobium + PSB @ 20g/kg seed), T_8 (50% FYM + 50% VC + Biofertilizer), T_9 (50% RDF + 50% FYM), T_{10} (50% RDF + 50% VC), T_{11} (50% RDF+ Biofertilizer) and T_{12} (50% RDF + 50% FYM + 50% VC + Bio-fertilizer) and was replicated thrice. The climate of the experimental site is sub-tropical characterized by moderately hot summers and cold winters. Rainfall received during the growing season (April to July) was 118.6 mm. The mean weekly maximum and minimum temperatures during the growing seasons varied from 7.2 to 19.52oC and 19.68 to 33.48oC respectively, whereas mean minimum relative humidity 42.78 to 66.78% and mean maximum relative humidity was 71.44 to 88.78 per cent. Recommended doses of NPK fertilizers (100% as per soil test) applied to French bean were N: P_2O_5: K_2O @ 30:50:30 kg/ha. The 100% NPK was applied as basal at the time of sowing. The recommended dose of Rhizobium (20 g/kg seed) or PSB as per treatment was first mixed in clean water to make thick slurry and seed was then inoculated as per treatments with the biofertilizer. Organic manures (farm yard manure and vermicompost) were incorporated according to the treatments at the time of field preparation and mixed thoroughly. French bean cv. Pant Anupma was sown @ 80 kg/ha at 30cm × 15cm spacing. All other intercultural operations were followed as per standard recommendations. The grain and straw yield of French bean were recorded and observation on growth and yield attributers were recorded from five randomly selected tagged plants from each plot at 60 days after sowing (DAS). Protein estimation was done in laboratory and protein yield was calculated as per following standard formula.

$$\text{Protein yield (kg/ha} = \frac{\text{Seed yield (kg/ha)} \times \text{Protein content (\%)}}{100}$$

The experimental data were analyzed as per the standard procedure for Analysis of Variance (ANOVA) as described by Gomez and Gomez (1984). The significance of treatments were tested by 'F' test (Variance ratio) and Standard error of mean (SEm±) was computed in all treatments. The difference in the treatment mean was tested by using critical difference (CD) at 5% level of probability.

Table 1: Organic and Inorganic Treatment Combinations

Abbreviation Used	Treatment Details	Treatment Combinations
T_1	Control	Without any organic, inorganic or biofertilizer application
T_2	50% RDF	15 N: 25 P_2O_5:15 K_2O kg/ha
T_3	75% RDF	22.5 N: 37.5 P_2O_5:22.5 K_2O kg/ha
T_4	100% RDF	30 N: 50 P_2O_5: 30 K_2O kg/ha
T_5	FYM	5 ton/ha
T_6	Vermicompost	2.4 ton/ha
T_7	Biofertilizers (Rhizobium+PSB)	20 g/kg seed
T_8	50% FYM+ 50%VC + Biofertilizers	2.5 ton/ha + 1.2 ton/ha + 20 g/kg seed
T_9	50% RDF + 50% FYM	15 N: 25 P_2O_5: 15 K_2O kg/ha + 2.5 ton/ha
T_{10}	50% RDF + 50% VC	15 N: 25 P_2O_5 :15 K_2O kg/ha + 1.2 kg/ha
T_{11}	50% RDF + Biofertilizers	15 N: 25 P_2O_5:15 K_2O kg/ha + 20 g/kg seed
T_{12}	50%RDF + 50% FYM + 50%VC + Biofertilizers	15 N: 25 P_2O_5: 15 K_2O kg/ha +2.5 ton/ha + 1.2 ton ton/ha + 20 g/kg seed

Results and Discussion

Growth Attributes

Results shows that the various growth parameters (Table-2) increased significantly with the application of various organic and inorganic fertilizers over control except germination percentage. It was observed that the increase in the inorganic fertilization dose (RDF) increases the all growth attributes as compared to control. Among all treatments the application of 100% RDF (T_4) recorded highest plant height (35.50 cm), primary branches (5.20), secondary branches (4.80), leaf area index (5.86) and total dry weight (22.20 g) and remained statistically at par with the treatment T_{12} (50%RDF + 50% FYM + 50%VC + Biofertilizer) and were significantly superior over control (T_1) at 60 DAS whereas as the minimum plant height (23.00 cm), primary branches (2.80), secondary branches (3.20), leaf area index (1.21) and total dry weight (11.83 g) was recorded in control (T_1). Similar observations were also recorded by Jagdale et al., (2015). The increase in growth attributes in treatment T_4 might have been due to more and quick supply of NPK with heavy application

Table 2: Influence of organic and inorganic fertilizers on growth parameters of French Bean cv. Pant Anupma

Treatments	Germination percentage	Plant Height (cm)	No. of Primary Branches	No. of Secondary Branches	LAI	Total dry Weight
T1	81.00	23.00	2.80	3.20	1.21	11.83
T2	84.00	27.50	3.40	3.60	2.12	18.50
T3	82.67	32.00	4.40	4.00	5.06	22.00
T4	85.82	35.50	5.20	4.80	5.86	22.20
T5	85.55	30.00	3.80	3.80	3.37	20.27
T6	85.00	30.90	3.80	3.80	3.99	20.40
T7	88.44	29.30	3.67	3.60	2.77	20.01
T8	87.50	28.37	3.60	3.60	2.70	19.13
T9	86.00	31.60	4.00	4.00	4.32	20.60
T10	86.44	31.60	4.40	4.20	4.66	20.70
T11	88.50	31.39	4.20	3.80	4.14	20.60
T12	88.00	32.50	4.80	4.53	5.42	22.00
SEm±	1.88	1.00	0.11	0.11	0.17	0.55
CD (p≤0.05)	NS	3.28	0.31	0.33	0.50	1.63

of inorganic fertilization which increases the photosynthetic activity, cell division, cell elongation and differentiation etc. resulting in higher growth attributes as compared to other treatments. The increase in growth attributes at higher fertility levels is similar with the observations of Shubashree et al., (2011) and El-Bassiony et al., (2010). Further, the increased growth with substitution of 50% RDF by organic manures along with biofertilizers (T_{12}) might be due to the fact that the organic manures releases nutrients slowly, increases nutrient use efficiency, biological fixation and also increases availability of micro-nutrients as reported by Nawalgatti et al., (2009) and Shubasshree et al., (2011).

Yield and Yield Attributes

The data presented in Table-3 indicates significantly higher yield attributes viz. pods/ plant at 60 DAS (13.64), pods/plant at harvest (14.26), seeds/pod (5.40), pod length (12.14cm) and 100-seed weight (40.36 g) were recorded with the application of T_4 (100% RDF i.e. 30:50:30 Kg NPK/ ha, respectively) without showing any significant difference with the treatment involving application of 50% RDF along with 50% FYM + 50% VC + 20 g biofertilizers/Kg seed (T_{12}). The minimum yield attributes viz. pods/plant at 60 DAS (5.18), pods/ plant at harvest (6.60), seeds/pod (1.96), pod length (5.80 cm) and 100-seed weight (26.67 g) were recorded in control (T_1). The maximum seed yield of (1434.26 Kg/ha) was recorded with treatment T_4 (100% RDF i.e. 30:50:30 Kg NPK/ha, respectively) whereas minimum seed yield (586.20 Kg/ha) was recorded with treatment control (T_1) where no any organic, inorganic fertilizer or biofertilizer was applied. However, no any statistical difference was recorded between seed yield (1434.26 Kg/ha) with the treatment T_4 i.e. 100% RDF and seed yield (1320.16 kg/ha) with the treatment T_{12} (50% RDF + 50% FYM + 50% VC + biofertilizer). The seed yield of treatments T_3 (75% RDF), T_9 (50% RDF + 50% FYM, T_{10} (50% RDF +50% VC) and T_{11} (50% RDF + biofertilizers) were at par with each other. In case of stover yield, maximum stover yield (1298.00 kg/ ha) was recorded with 75% RDF (T_3) which was remained statistically at par with the stover yield (1267.00 kg/ha) of treatments T_{12} (50% RDF + 50% FYM + 50% VC + biofertilizer) and stover yield (1274.00 kg/ha) of treatments T_4 (100% RDF). These results show similarity with Abd El-Mawgoud et al., (2015) and Dhanjal et al., (2011).

The increase in yield attributes might have been due to increased availability of NPK, higher total dry matter production and more vegetative growth resulting in better growth and development of yield attributes and also the higher seed yield with application of heavy inorganic fertilization. Similar observation was also recorded by Veeresh (2013). Further, higher seed yield and stover yield by application of inorganic fertilizers in combination with organic manures might has been due to its greater availability and uptake of more macro and micro nutrients resulting in higher rate of photosynthesis, cell and tissue differentiation and also due to translocation of assimilates and photosynthates etc. leading to higher seed and

Table 3: Influence of Organic and Inorganic Fertilizers on Yield Attributes, Yield and Quality of French Bean cv. Pant Anupma

Treatments	Pods/ plant at 60 DAS	Pods/ Plant at Harvest	Seeds/ pod	Pod Length (cm)	100-Seed Weight	Seed Yield (Kg/ha)	Stover Yield (Kg/ha)	Harvest Index (%)	Seed Protein (%)	Protein Yield (kg/ha)
T1	5.18	6.60	1.96	5.80	26.67	586.20	680.33	44.16	17.70	95.22
T2	8.20	9.60	2.60	7.07	32.00	890.00	841.3	51.64	18.20	161.98
T3	11.33	12.60	4.40	9.80	37.00	1180.00	1298.00	48.76	20.80	245.1
T4	13.64	14.26	5.40	12.14	40.36	1434.26	1274.00	53.06	21.28	296.02
T5	10.20	10.80	3.20	7.53	34.80	977.00	928.00	51.23	18.46	180.34
T6	10.13	11.20	3.40	7.80	35.00	1002.00	949.00	51.37	18.48	185.34
T7	10.13	10.73	3.00	7.33	34.60	952.00	883.6	51.95	18.36	174.79
T8	8.93	10.40	2.80	7.20	34.30	912.00	920.00	50.01	18.30	166.89
T9	10.47	11.60	4.00	8.77	36.20	1152.00	985.00	51.72	18.60	195.65
T10	10.80	11.60	3.73	9.20	36.33	1173.00	1053.33	51.41	18.90	210.41
T11	10.27	11.40	3.60	8.13	35.50	1145.00	973.00	50.90	18.50	193.33
T12	11.67	12.80	4.53	9.93	37.60	1320.16	1267.00	50.74	19.70	250.60
SEm±	0.42	0.55	0.28	0.57	1.28	51.49	32.23	1.61	0.076	10.17
CD (p≤0.05)	1.25	1.62	0.82	1.69	3.79	152.00	95.15	NS	0.223	29.71

stover yield. Similar finding was also reported by Sen et al., (2012). The result on harvest index indicated that there were no significant differences among the treatments. These observations are in agreement with the results of Thirumalia and Abdul Khalak (1998).

The data on seed protein percentage indicated significantly higher protein percentage (21.28 %) with application of 100% RDF (T_4), showings 19.14% increase over control while the minimum protein percentage (17.70%) was recorded with control (T_1). Similar observations were also reported in terms of protein yield, with significantly higher protein yield (296.02 kg ha-1) with application of 100% RDF than all the treatments, showing 19.14 percent increase over control. This might have been due to the increased nitrogen availability and uptake in case of heavy fertilization and nitrogen being an essential component of seed protein. These results are in agreement with Gupta et al., 1998 and Abdel-Mawgoud et al., (2015).

Conclusion

From the present investigation it was concluded that in context of sustainable agriculture, the growth, yield and quality may be improved and enhanced by integrated use of organic and inorganic fertilizers under sub-tropical conditions of Uttarakhand and the nutrient management of French bean may involve substitution of 50% RDF through 50% FYM (2.5 ton FYM/ha) + 50%VC (1.5 ton VC/ha) + Biofertilizer (20 g biofertilizer/kg seed).

Hence, the integrated nutrient management practice is required for sustaining the desired crop productivity by optimizing the benefits from all the sources of plant nutrients in an integrated approach.

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Orignal Article

Estimation of general and combining ability effects by Line X Tester Analysis

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Abstract

Using a broad-based genotype as a tester the general combining ability of lines is tested in the top cross method. Line X Tester analysis is an extension of this method in which several testers are used. This design thus provides information about general and specific combining ability of parents and at some time it is helpful in estimating various types of gene effects. This paper constructs and computes Line X Tester methodologies with and without parents. It also constructs and determine the analysis of variance for parents and crosses. The computation of the analysis of variance for RBD design have been done. It also determines the genetic components, standard errors for combining ability effects and proportional contribution of lines, testers with interactions to various genetic components. Rigorous experimentation with multiple data sets have been done and it gives promising results. Economic benefits have been observed to such a large extent by implementation of the methods and analysis discussed.

Keywords: Line, Tester, GCA, Treatments, Parents, Crosses, Combining Ability, Effects, Interactions.

Introduction

In the top cross method, genotype as a tester. the general combining ability of lines is tested. Line X Tester analysis is an extension of this method in which several testers are used. The latter design thus provides information about general and specific combining ability of parents and at some time it is helpful in estimating various types of gene effects. The crossing plan of this design is as follows.

Let us consider '*l*' lines and '*t*' testers. All of these '*l*' lines are crossed to each of '*t*' testers and thus l x t full sib progenies are produced. These progenies along with or without parents i.e., testers and lines, are then tested in a replicated trial using suitable design, say randomized block design[4].

Methodology

Line X Tester Analysis include the following sections

ANOVA for Line X Tester Analysis

The analysis of variance with number of testers (T), number of lines (L) and number of replication (R) are partitioned as shown in Table 1.

Table 1 Analysis of Variance for Line X Tester

Source	df	SS	MS	F
Lines	L-1	LSS	MSSL	MSSL / MSSLT
Testers	T-1	TsSS	MSSTs	TsMS / MSSLT
Line X tester	(L-1)(T-1)	LTSS	MSSLT	LTMS / MSSE
Error	(R-1)(N-1)	ESS	MSSE	

Computation of ANOVA for Line X Tester Analysis Including Parents

This computation of the ANOVA for Line X Tester analysis including parents with number of testers (T), number of lines (L) and number of replications(R) are shown in Table 2.

Table 2 ANOVA for Line X Tester including parents

Source	Df	SS	MS	F	Prob>F
Replications	R-1	RSS	MSSR	MSSR/ MSSE	Prob (R,E)
Treatments	N-1	TrSS	MSSTr	MSSTr/ MSSE	Prob (Tr,E)
Parents	(T+L)-1	PSS	MSSP	MSSP/ MSSE	Prob (P,E)
Parents vs Crosses	PC	PCSS	MSSPC	MSSPC/ MSSE	Prob (PC,E)
Crosses	(T*L)-1	CSS	MSSC	MSSC/ MSSE	Prob (C,E)
Lines	L-1	LSS	MSSL	MSSL/ MSSE	Prob (L,LT)
Testers	T-1	TsSS	MSSTs	MSSTs/ MSSE	Prob (Ts,LT)
Line X Tester	(L-1) (T-1)	LTSS	MSSLT	MSSLT/ MSSE	Prob (LT,E)
Error	(R-1) (N-1)	ESS	MSSE		
Total	(NR-1)	TSS			

Computation of ANOVA for Line X Tester Analysis Including Parents by Using Following Formulae

Correction Factor $(C.F.)_{Total} = (Grand\_Total)^2 / N^* r$

where

$N = (LxT) + (L+T)$

Correction Factor Parent $(C.F.)_{Parent}$ = (Grand Total for Parents)^2/ R(T + L)

Correction Factor Crosses $(\mathbf{C.F.})_{Crosses}$ = (Grand_ Total for Crosses)^2/ R (T * L)

Replication Sum of Square (**RSS**) = 1 / N ($\Sigma\, y_{.j}^2$) - $(C.F.)_{Total}$

where

$\Sigma\, Y_{.j}^2 = 1 / N\ (Y_{.1}^2 + Y_{.2}^2 + Y_{.3}^2 + \ldots\ldots Y_{.n}^2)$

Treatment Sum of Square **(TrSS)** = 1 / R ($\Sigma y_{i.}^2$) – $\mathbf{(C.F.)}_{Total}$

where

$\Sigma\, Y_i^2 = 1 / R\ (Y_{1.}^2 + Y2.^2 + Y3.^2 + \ldots\ldots Yn.^2)$

Total Sum of Square **(TSS)** = $\Sigma\, \Sigma\, y_{i\,j}^2$ - $\mathbf{(C.F.)}_{Total}$

Error Sum of Square **(ESS)** = TSS - TrSS - RSS

Parents Sum of Square **(PSS)** = 1 / R ($\Sigma\, y_{.j}^2$) parent - $\mathbf{(C.F.)}_{parent}$

where

$\Sigma\, Y_{.j}^2 = 1 / R\ (Y_{.1}^2 + Y_{.2}^2 + Y_{.3}^2 + \ldots\ldots Y_{.n}^2)_{parent}$

Parents .vs. Crosses Sum of Square **(PCSS)** = $(C.F.)_{Crosses} + (C.F.)_{Parent} - (C.F.)_{Total}$

Crosses Sum of Square (CSS) = 1 / R ($\Sigma\, y_{i.}^2$) crosses – $(C.F.)_{crosses}$

where

$\Sigma\, Y_{i.}^2 = 1/R\ (Y_{1.}^2 + Y_{2.}^2 + Y_{3.}^2 + \ldots\ldots Y_{n.}^2)_{crosses}$

Lines Sum of Square (LSS) = 1 / (R * T) ($\Sigma\, y_{i.}^2$) $_{crosses}$ – $(C.F.)_{crosses}$

where

$\Sigma\, Y_{i.}^2 = 1 / R\ (Y_{1.}^2 + Y_{2.}^2 + Y_{3.}^2 + \ldots\ldots Y_{n.}^2)_{crosses}$

Tester Sum of Square (**TsSS**) =1 / (R * T)($\Sigma\, Y_{.j}^2$) Crosses - $\mathbf{(C.F.)}_{Crosses}$

where

$\Sigma\, Y_{.j}^2 = 1 / R\ (Y_{.1}^2 + Y_{.2}^2 + Y_{.3}^2 + \ldots\ldots Y_{.n}^2)_{Crosses}$

Lines X Tester Sum of Square (**LTSS**) = CSS – LSS - TsSS

Mean Sum of Square due to Replication (**MSSR**) = RSS / R - 1

Mean Sum of Square due to Treatment (**MSSTr**) = TrSS / N - 1

Mean Sum of Square due to Parents (**MSSP**) = PSS / ((T + L) – 1)

Mean Sum of Square due to Parents and Crosses (**MSSPC**) = PCSS / [N – 1] - [(T + L) - 1] - [(T * L) – 1]

Mean Sum of Square due to Crosses (**MSSC**) = CSS / ((T X L) – 1)

Mean Sum of Square due to Lines (**MSSL**) = LSS / L - 1

Mean Sum of Square due to testers (**MSTs**) = TsSS / T - 1

Mean Sum of Square due to Line X Tester (**MSSLT**) = LTSS / (T – 1) (L – 1)

Mean Sum of Square due to Error (**MSSE**) = ESS / (R – 1) (N – 1)

ANOVA for Line X Tester Including Parents

where

PC = [N – 1] - [(T + L) - 1] - [(T * L)– 1]

Prob (R,E) = Probability due to replications and error for degree of freedom (R - 1)

Prob (Tr,E) = Probability due to treatment and error for degree of freedom (N - 1)

Prob (P,E) = Probability due to parents and error for degree of freedom (T + L) - 1

Table 3 Analysis of Variance for Line X Tester

Source	df	SS	MS	F	Prob>F
Replications	R-1	RSS	MSSR	MSSR/ MSSE	Prob (R,E)
Treatments	N-1	TrSS	MSSTr	MSSTr/ MSSE	Prob (Tr,E)
Parents	(T+L)-1	PSS	MSSP	MSSP/ MSSE	Prob (P,E)
Parents vs Crosses	PC	PCSS	MSSPC	MSSPC/ MSSE	Prob (PC,E)
Crosses	(T*L)-1	CSS	MSSC	MSSC/ MSSE	Prob (C,E)
Lines	L-1	LSS	MSSL	MSSL/ MSSE	Prob (L,LT)
Testers	T-1	TsSS	MSSTs	MSSTs/ MSSE	Prob (Ts,LT)
Line X Tester	(L-1) (T-1)	LTSS	MSSLT	MSSLT/ MSSE	Prob (LT,E)
Error	(R-1) (N-1)	ESS	MSSE		
Total	(NR-1)	TSS			

Prob (PC,E) = Probability due to parents, crosses and error for degree of freedom PC

Prob (C,E) = Probability due to crosses and error for degree of freedom (T * l) - 1

Prob (L,LT) = Probability due to lines and Line X Tester for degree of freedom (L - 1)

Prob (Ts,LT) = Probability due to testers and Line X Tester for degree of freedom (T - 1)

Prob (LT,E) = Probability due to Line X Tester and error for degree of freedom (L-1) (T-1)

Computation of ANOVA for Parents and Crosses

The computation of Anova with parents and crosses with number of testers(T), number of lines(L) and number of replications(R) are shown in Table 4.

Correction Factor (C.F.) Total = $(Grand\_Total)^2 / N * R$

where

$N = (L X T) + (L + T)$

Correction Factor Parent $(C.F.)_{Parent}$ = $(Grand\_Total\ for\ Parents)^2 / R (T + L)$

Correction Factor Crosses $(C.F.)_{Crosses}$ = $(Grand\_Total\ for\ Crosses)^2 / R (T * L)$

Treatment Sum of Square (TrSS) = $1 / R (\Sigma\ y_i.^2) - (C.F.)_{Total}$

where

$\Sigma Y_i.^2 = 1 / R (Y_1.^2 + Y_2.^2 + Y_3.^2 + \ldots\ldots Y_n.^2)$

Replication Sum of Square **(RSS)** = $1 / N (\Sigma y._j^2) - (C.F.)_{Total}$

where

$\Sigma Y._j^2 = 1 / N (Y._1^2 + Y._2^2 + Y._3^2 + \ldots\ldots Y._n^2)$

Total Sum of Square **(TSS)** = $\Sigma\Sigma Y_{ij}^2 - (C.F.)_{Total}$

Error Sum of Square **(ESS)** = TSS - TrSS - RSS

Crosses Sum of Square **(CrSS)** = $1 / R (\Sigma Y_i.^2_{Crosses} - \mathbf{(C.F.)}_{Crosses}$

where

$\Sigma Y_i.^2 = 1 / R (Y_1.^2 + Y_2.^2 + Y_3.^2 + \ldots\ldots Y_n.^2)_{Crosses}$

Parents Sum of Square **(PSS)** = $1 / R (\Sigma Y._j^2)_{Parent} - (C.F.)_{Parent}$

where

$\Sigma Y._j^2 = 1 / R (Y._1^2 + Y._2^2 + Y._3^2 + \ldots\ldots Y._n^2)_{arent}$ Error Sum of Square **(ESS)** = $\mathbf{(C.F.)}_{Crosses} + (C.F.)_{Parent} - \mathbf{(C.F.)}_{Total}$

Mean Sum of Square due to Replications **(MSSR)** = RSS / R - 1

Mean Sum of Square due to Treatment **(MSSTr)** = TrSS / N - 1

Mean Sum of Square due to Parents **(MSSP)** = PSS / ((T + L) – 1)

Mean Sum of Square due to Crosses **(MSSC)** = CSS / ((T X L) – 1)

Mean Sum of Square due to Parents and Crosses **(MSSPC)** = PCSS / [N-1] - [(T + L) - 1] - [(T * L) –1]

Mean Sum of Square due to Error **(MSSE)** = ESS / (R – 1) (N – 1)

Anova with Parents and Crosses

Table 4 Analysis of Variance for Line X Tester for Parents and Crosses

Source	df	SS	MS	F	Prob>F
Replications	R-1	RSS	MSSR	MSSR / MSSE	Prob (R,E)
Treatments	N-1	TrSS	MSSTr	MSSTr / MSSE	Prob (Tr,E)
Parents	(T+L)-1	PSS	MSSP	MSSP/ MSSE	Prob (P,E)
Crosses	(T*L)-1	CSS	MSSC	MSSC/ MSSE	Prob (C,E)
Parents vs Crosses	PC	PCSS	MSSPC	MSSPC/ MSSE	Prob (PC,E)
Error	(N-1) x (R-1)	ESS	MSSE		

where

PC = [N – 1] - [(T + L) – 1] - [(T * L) – 1]

Prob (R,E) = Probability due to replications and

error for degree of freedom (R - 1)

Prob (Tr,E) = Probability due to treatments and

error for degree of freedom (N - 1)

Prob (P,E) = Probability due to parents and error for degree of freedom (T + 1) - 1

Prob (C, E) = Probability due to crosses and error for degree of freedom (T * L) - 1

Prob (PC,E) = Probability due to parents and crosses for degree of freedom PC

Computation of Analysis of Variance for Simple R.B.D.

It is computation of analysis of variance for simple RBD in Line X Tester analysis shown in Table 5 with number of testers(T), number of lines(L) and number of replications(R).

Correction Factor **(C.F.)** = $(Grand\_Total)^2 / N * R$

where

$N = (L X T) + (L + T)$

Treatment Sum of Square **(TrSS)** = $1 / R (\Sigma Y_i^2)$ - C.F.

where

$\Sigma Y_i.^2 = 1 / R (Y_1.^2 + Y_2.^2 + Y_3.^2 + ... Y_n.^2)$

Replication Sum of Square **(RSS)** = $1 / N (\Sigma Y_{.j}^2)$ - C.F.

where

$\Sigma Y_{.j}^2 = 1 / N (Y_{.1}^2 + Y_{.2}^2 + Y_{.3}^2 + ... Y_{.n}^2)$parent

Total Sum of Square **(TSS)** = $\Sigma \Sigma Y_{ij}^2$ - C.F.

Error Sum of Square **(ESS)** = TSS - TrSS - RSS

Mean Sum of Square due to Replications **(MSSR)** = RSS / R - 1

Mean Sum of Square due to Treatment **(MSSTr)** = TrSS / N - 1

Mean Sum of Square due to error **(MSSE)** = ESS / (R - 1) (N – 1)

Table 5 Analysis of Variance for Line X Tester RBD

Source	df	SS	MS	F	Prob>F
Replications	R-1	RSS	MSSR	MSSR/ MSSE	Prob (R,E)
Treatments	N-1	TrSS	MSSTr	MSSTr/ MSSE	Prob (Tr,E)
Error	(R-1)/ (N-1)	ESS	MSSE		
Total	NR-1	TSS			

Prob (R,E) = Probability due to replications and error for degree of freedom (R – 1)

Prob (Tr,E) = Probability due to treatments and error for degree of freedom (N - 1)

Computation of Estimation of GCA Effects

(a) Lines

$g_i = x_i$ ./ tr - x.../ ltr

where,

l = number of lines

t = number of testers

r = number of replications

Check $\Sigma g_i = 0$

(b) Testers

$g_i = x_{.j}$. / lr - x... / ltr

where,

l = number of lines

t = number of testers

r = number of replications

Check $\Sigma g_i = 0$

Computation of Standard Errors for Combining Ability Effects

S.E.(gca for line) = $(M_e / r \times t)^{1/2}$

S.E.(gca for tester) = $(M_e / r \times l)^{1/2}$

S.E.(gca for effects) = $(M_e / r)^{1/2}$

S.E.$(g_i - g_j)$line = $(2M_e / r \times t)^{1/2}$

S.E.$(g_i - g_j)$tester = $(2M_e / l \times r)^{1/2}$

S.E.$(s_{ij} – s_{tl})$ = $(2M_e / r)^{1/2}$

Computation of Genetic Components

Cov H.S.(line) = $(M_l – M_{l \times t}) / rt$

Cov H.S.(tester) = $(M_t – M_{l \times t}) / rl$

Cov H.S.(average) = $1/r (2lt - l - t) [(l-1) (M_l) + (t-1) (M_t) / 1+t-2 - M_{l \times t}]$

Cov F.S. = $(M_l-M_e) + (M_t-M_e) + (M_l x_t - M_e) / 3xr$

σ^2 gca = Cov H.S. = $[1+F/4]^2 \sigma^2 A$

Calculate $\sigma^2 A$ with F=0 and F=1

σ^2 sca = $M_{lxt} - M_e / r$

$\sigma^2 sca = [1+F / 2]^2 \sigma^2 D$

Calculate with F=0 and F=1

Computation of proportional contribution of Lines, Testers and their Interactions to Total Variance

Contribution of Lines = SS(l) x 100 / SS(Crosses)

Contribution of Testers = SS(t) x 100 / SS(Crosses)

Contribution of (l x t) = SS (l x t) x 100 / SS(Crosses)

Experimental Analysis

Rigorous experimentation has been done with real data sets leads to very efficient and promising results. Generalized multithreaded [1-3] object-oriented computer programs have been developed. The result of a real data set with 3 lines and 5 tester is mentioned below

Analysis of Variance of Simple RBD

Source	df	SS	MS	F	Prob>F
Replications	3	83.000117	666706	0.303826	0.822519
Treatments	22	32553.202391	1479.691018	16.249429	0.000010
Error	6	6010.032983	91.061106		
Total	91	38646.235491			

ANOVA with Parents and Crosses

Source	df	SS	MS	F	Prob>F
Replications	3	83.000117			
Treatments	22	32553.202391			
Parents	7	6299.885187	899.983598	9.883293	0.000010
Crosses	14	26199.654333	1871.403881	20.551078	0.000010
P.vs.C.	1	53.662870	53.662870	0.589306	0.445425
Error	6	6010.032983	91.061106		

ANOVA for Line X Tester Analysis

Source	df	SS	MS	F	Prob>F
Lines	2	10114.343613	5057.171807	3.538881	0.079252
Testers	4	4653.059400	1163.264850	0.814023	0.550400
LineXTesters	8	11432.251320	1429.031415	15.693104	0.000010
Error	66	6010.032983	91.061106		

ANOVA for Line X Tester Analysis Including Parents

Source	df	SS	MS	F	Prob>F
Replications	3	83.000117	27.666706	0.303826	0.822519
Treatments	22	32553.202391	1479.691018	16.249429	0.000010
Parents	7	6299.885187	899.983598	9.883293	0.000010
P. vs. C.	1	53.662870	53.662870	0.589306	0.000000
Crosses	14	26199.654333	1871.403881	20.551078	0.000010
Lines	2	10114.343613	5057.171807	3.538881	0.079252
Testers	4	4653.059400	1163.264850	0.814023	0.550400
LineXTesters	8	11432.251320	1429.031415	15.693104	0.000010
Error	66	6010.032983	91.061106		

Summation of GCA Effects due to lines

GCA Effects	Value
g1	-6.2897
g2	18.0843
g3	-11.7947
Summation of All g's	-0.0000

Summation of SCA Effects due to testers

SCA Effects	Value
S14	1.9563
S15	28.8030
S16	-23.8470
S17	-11.4237
S18	4.5113
S24	-5.3177
S25	-2.3260
S26	10.6790
S27	8.6723
S28	-11.7077
S34	3.3613
S35	-26.4770
S36	13.1680
S37	2.7513
S38	7.1963
Summation of All Sij's	0.0000

Summation of GCA Effects due to Testers

GCA Effects	Value
g4	-13.3533
g5	-1.1100
g6	-3.4600
g7	4.7417
g8	13.1817
Summation of All g's	0.0000

Standard Errors for Combining Ability Effects

STANDARD ERROR	Value
SE (gca For Line)	2.1338
SE (gca For Tester)	2.7547
SE (sca Effects)	4.7713
SE (gi -gj) Line	3.0176
SE (gi -gj) Tester	3.8957
SE (Sij -Skl)	6.7476

Calculation of Genetic Component

GENETIC COMPONENTS	Value
Cov. H.S. (Line)	181.4070
Cov. H.S. (Tester)	-22.1472
Cov. H.S. (Average)	11.7296
Cov. F.S	606.8707

Proportional Contribution of Lines Testers And Their Interactions To Total Variance

PROPORTIONAL CONTRIBUTION	Value
Contribution Lines	38.6049
Contribution Testers	17.7600
Contribution LinesXTesters	43.6351

Conclusion

Line X Tester analysis is an extension of this method in which several testers are used. This paper constructs and computes Line X Tester methodologies with and without parents. It also constructs and determine the analysis of variance for parents and crosses. The computation of the analysis of variance for RBD design have been done. It also determines the genetic components, standard errors for combining ability effects and proportional contribution of lines, testers with interactions to various genetic components. Rigorous experimentation with multiple data sets have been done and it gives promising results. Implementation of these methods leads to economic benefits.

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Orignal Article

Determination of estimates of Variance Analysis

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Abstract

Variance analysis is quantitative investigation of the difference between actual and planned behavior. ANOVA is a statistical tool which can be used to test for difference between treatments in an experiment. It can be used to aid in estimates of heritability by partitioning variances. Knowledge of the broad heritability of a trait in a population is not very useful in itself but a finer subdivision of phenotypic variance can provide important information for plant and animal breeders. The genetic and environmental variation can themselves each be subdivided into possibility of shaping genetic composition of a population..

This paper determines all the estimates of variance analysis. Rigorous experimentation has been done with multiple real data sets. The computation of Analysis of variance have been done. The evaluation of treatment critical difference at 1% and 5% level of significance have been computed. The pairwise treatment differences have also been computed. The estimates of genotypic, environmental and phenotypic coefficient of variation and their coefficients have been determined. The heritability indices values have also been computed. The results are very challenging and promising. Implementation of this method is beneficial for both government and industrial sectors.

Keywords: ANOVA, Heterosis, genotypic, Environmental, Phenotypic, Critical Difference, Heritability, Coefficient of Variation.

Introduction

The variance estimation and stratification due to different sources is estimated by Variance Analysis. For providing the test of significance at various level of significance variance analysis has to be computed.

The partitioning of the variation into different sources of variation depends on the arrangement of the various treatments with regard to one another. Accordingly, there are two systems of classification viz., cross classification and hierarchical classification.

If we consider two sets of treatments, say A and B, and if all the levels of factor of B are common to each level of factor A, the system is known as cross-classification.

Testing of (v) varieties each in (r) replications is an example of this type. Considering again factor A and B, if all the levels of factor B are not common to each of the levels of factor A, the classification becomes hierarchical.

The advantage of having variation in the population is that some individuals will be better adapted to their environment than others. Those who are not well adapted to their environment are less likely to survive or reproduce.

The genotypic variance usually combines with

the environmental variance. A genotype refers to the genetic characteristics of an organism and a phenotypic refers to the physical characteristics. The degree of genotypic and phenotypic variation is measured through the heritability index.

The formulations and methodologies for computation and analysis are further proceeding in the preceding sections.

Methodology

Analysis of Variance

The partitioning of the variation into different sources of variation (as in Table 1) depends on the arrangement of the various treatments with regard to one another [4,5].

Table 1: Different Sources of Variation

Source	D.F.	S.S.	M.S.	F
VARIETIES	V-1	VSS	VMS	VMS/EMS
ENVIRONMENT	R-1	RSS	RMS	RMS/EMS
ERROR	(V-1*(R-1)	ESS	EMS	
TOTAL	VR-1	TSS		

where

$$Y_{i.} = (1/n) \sum_{v=1}^{n} Y_{iv}$$

$$Y.. = (1/np) \sum_{i=1}^{p} \sum_{v=1}^{n} Y_{iv}$$

N=np.

E(EMS) = E(ESS/N-p) = (1/N-p)E(ESS).

E(VMS) = E(VSS/p-1) = (1/p -1)E(VSS).

Where E for Expectations.

Correction Factor (CF) = $(Grand\_Total)^2$ / V*R

Varieties Sum of Square (VSS) = $1/R\ Y_{i.}^2$ – C.F.

where

$Y_{i.}^2 = 1/R\ (Y_{1.}^2 + Y_{2.}^2 + Y_{3.}^2 + ... + Y_{n.}^2)$

Environment Sum of Square (RSS) = $1/V\ Y_{.j}^2$ –C.F.

where

$Y_{j.}^2 = 1/V\ (Y_{.1}^2 + Y_{.2}^2 + Y_{.3}^2 + \ldots\ldots\ldots Y_{.n}^2)$

Total Sum of Square (TSS) = Y_{ij}^2 – C.F.

Error Sum of Square (ESS) = TSS - VSS - RSS

Varieties Mean Sum of Square (VMS) = VSS / V1

Environment Mean Sum of Square (RMS)= RSS/R-1

Error Mean Sum of Square (EMS) = ESS / (V-1(R-1)

Total Mean Sum of Square (TMS) = TSS / (VR-1)

Components of Variance

The mean sum of squares between varieties will consist of the variances

- (i) Attributable to varietal differences (i.e., genotypic differences)
- (ii) Due to environmental variation among individuals of each genotype.

Expected Mean Sum of Squares for Environment

$E(MS_e) = MS_e$

Expected Mean Sum of Squares for Varieties

$$E(MS_v) = MS_e + R * GV$$

where,

GV = (MSv –MSe) / R

GV = Genotypic Variance

Phenotypic Variance (P.V.) = GV + $E(MS_e)$

Phenotypic coefficient of Variation (P.C.V.) = $(PV)^{1/2}$ / Grand mean * 100

Genotypic coefficient of variation (GCV) = $(GV)^{1/2}$ / Grand mean * 100

Heritability It is the ratio of genotypic variance to the phenotypic variance:

Heritability (xi) = GV / PV

Treatment Critical Difference

In order to compare the means of various entries, we require to calculate the critical difference (C.D.) by the following formula:

Critical Difference (C.D.) = S.E.* 't'

where,

S.E. is standard error of the difference of the treatment means to be compared, and

$$S.E. = (2\ MS_e / r)^{1/2}$$

With EMS an error mean sum of squares and R as the number of replications, and 't' is the tabulated value at 5% or 1% level of significance for the degree of freedom of error mean square. Thus,

C.D.= [(2 * EMS / R)1/2 * 't']

If the mean difference between any two varieties is greater than calculated C.D. value than the difference is taken to be significant. In this case,

S.E.* = [((n –1) / n * EMSe / r)]$^{1/2}$

Thus,

C.D. * = S.E. * 't'

C.D. = [((n – 1) / n * EMS / r)]$^{1/2}$ * 't'

The mean of individual parents may be compared with the grand mean and if the difference is more than the calculated value of C.D.* the difference is taken to be significant.

Coefficient of Variation

The coefficient of variation (C.V.) is a good basis for comparing the extent of variation between different characters with different scales.

C.V. = ((MSe)$^{1/2}$ / Grand mean) * 100)

Experimental Analysis

Rigorous experimentation has been done with multiple real data sets. All the results are very promising and improves efficiency and performance. The result of a data set consists of 8 parents, 4 characters and 4 replications are as follows. Complete generalized multithreaded object-oriented dynamic computer programs have been developed [1-3].

The computation of analysis of variance have been done. The evaluation of treatment critical difference at 1% and 5% level of significance have been computed. The pairwise treatment differences have also been computed. The estimates of genotypic, environmental and phenotypic coefficient of variation and their coefficients have been determined. The heritability have also been computed.

Analysis of Variance

ANOVA for the Character # 1

Source	df	SS	MS	F	Prob>F
Replications	3	109.223750	36.407917	2.6387	0.076156
Treatments	7	1023.988750	146.284107	10.6023	0.000011
Error	21	289.746250	13.797440		
Total		31	1422.958750		

ANOVA for the Character # 2

Source	df	SS	MS	F	Prob>F
Replications	3	0.602500	0.200833	1.0684	0.383715
Treatments	7	7.985000	1.140714	6.0684	0.000580
Error	21	3.947500	0.187976		
Total		31	12.535000		

ANOVA for the Character # 3

Source	df	SS	MS	F	Prob>F
Replications	3	00.013750	0.004583	0.4783	0.700826
Treatments	7	2.413750	0.344821	35.9814	0.000010
Error	21	0.201250	0.009583		
Total		31	2.628750		

ANOVA for the Character # 4

Source	df	SS	MS	F	Prob>F
Replications	3	369.840938	123.280313	1.7083	0.195897
Treatments	7	6248.367187	892.623884	12.3689	0.000010
Error	21	1515.501562	72.166741		
Total		31	8133.709688		

Treatment Critical Difference

C.D. for Treatments At (1%) Level of Significance

Character #	Value
1	7.435739
2	0.867913
3	0.195967
4	17.005657

C.D. for Treatments At (5%) Level of Significance

Character #	Value
1	5.463206
2	0.637676
3	0.143981
4	12.494443

SEm for Treatments

Character #	Value
1	1.857245
2	0.216781
3	0.048947
4	4.247551

SEd for Pairwise Treatment Differences

Character #	Value
1	2.626541
2	0.306575
3	0.069222
4	6.006944

Coefficient of Variation

Character #	Value
1	8.738693
2	2.177337
3	2.348294
4	10.029265

Components of Variances

Genotypic Covariance

Character #	Value
1	33.1217
2	0.2382
3	0.0838
4	205.1143

Environmental Covariance

Character #	Value
1	13.7974
2	0.1880
3	0.0096
4	72.1667

Phenotypic Covariance

Character #	Value
1	46.9191
2	0.4262
3	0.0934
4	277.2810

Phenotypic Coefficient of Variation

Character #	Value
1	16.114695
2	3.278392
3	7.330793
4	19.658965

Genotypic Coefficient of Variation

Character #	Value
1	13.539521
2	2.450930
3	6.944498
4	16.908245

Heritability (Broad Sense)

Character #	Value
1	0.705931
2	0.558908
3	0.897387
4	0.739734

Conclusion

This paper determines all the estimates of variance analysis. Rigorous experimentation has been done with multiple real data sets. The computation of Analysis of variance have been done. The evaluation of treatment critical difference at 1% and 5% level of significance have been computed. The pairwise treatment differences have also been computed. The estimates of genotypic, environmental and phenotypic coefficient of variation and their coefficients have been determined. The heritability indices values have also been computed. The results are very challenging and promising. Utilization of this method is beneficial for both government and industrial sectors.

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Review Article

"SEAT", "PLACE" & "VENUE":- A CATCH-22 WEB

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Abstract

The seat of the arbitration is one of the most significant features of any arbitration. Once the seat is determined the other facets related to arbitration proceedings are settled i.e., the court exercising jurisdiction over arbitration proceedings, law which will govern that arbitration and procedure related to the enforceability of the award passed in any arbitration proceedings. The UNCITRAL model law is one of the most important texts which guide the parties while deciding the seat of the arbitration proceedings. The Indian Arbitration & Conciliation Act 1996 was based on the scheme of the UNCITRAL model law and thus apart from the seat of the arbitration, the place where award was declared and signed also becomes important. It is needless to mention that under both the schemes, it is enshrined that the place where award is signed will determine whether the award is a domestic award or it is a foreign award. The seat of arbitration brings itself the character of permanency and it is not changed like the venue can be and this work is an effort to encapsulate the development of law and the interpretation resorted by the Hon'ble courts to settle the debate of seat vs. venue. This piece of work is an attempt to holistically examine the law related to "seat" and "venue" and highlighting a way forward in lieu of the principles of UNCITRAL model law. This work is expected to enhance the knowledge of the readers of laws related to Arbitration, and author is hopeful that it will contribute towards further research.

Keyword: Arbitration, Contract, Seat, Venue, Section & India.

Introduction

The conundrum of "seat", "venue" & "place" of arbitration especially in International Commercial Arbitration is widely debated around the world amongst the lawyers and the judges and legal scholars. The puzzle emanates from the basic questions like what law shall govern the arbitration proceedings, will the same law be applicable if the interim measure which is asked by one of the parties related to another country i.e., restraining the party from alienating the assets lying in another country from where the arbitration is taking place, what will happen in a case if the venue of arbitration proceedings are different and finally, what is a juridical seat or lex arbitri? It is a common accepted principle that the arbitration clause which is part and parcel of the main agreement is a separate agreement between the parties and that's how the "Competence Competence" principle has been evolved in the arena of arbitration. Thus, the law which governs the main agreement can be different than the law which governs the arbitration clause. The party autonomy principle which is bedrock of the sanctity of arbitration proceedings prescribes that the parties are empowered enough to agree on a different law which governs the arbitration between them[1]. Though, this principle is in line

with the principles of UNCITRAL model law but this issue brings with itself endless litigation.

The three terms used in the title of this article "seat", "place" & "venue" can be used interchangeably with each other but these words have entirely different connotation when it comes to law related to arbitration. To grasp a laymen understanding, the Hon'ble Apex Court in Bharat Aluminium v. Kaiser Technical Services[2], propounded an interpretation and said that the character of permanency is attached to the seat of arbitration and it has the supervisory jurisdiction over arbitration while venue is merely for the convenience of the parties and it is provisional or temporary in nature. During the course of this article, we will be dealing the law related to seat and venue of arbitration as mentioned under Arbitration Act, certain important judgements which has shaped the law in India, what is an actual difference between seat and venue and in the end we will try to conclude by defining this complex law in the easiest manner.

GOVERNING LAWS

One of the oldest English cases i.e., Naviera Amazonica Peruana SA v. Compania International de Seguros del Peru[3], has laid down the laws which govern the arbitration in the most beautiful manner. This judgement lays down three types of laws which are applicable to any arbitration proceedings and they are mentioned below:-

- Law which governs the entire (main) contract,
- Law which governs the arbitration clause and the performance of such clause which is commonly known as lex arbitri,
- Law which governs the procedural aspect of the arbitration which is commonly known as curial law.

One of the most significant aspects of drafting an arbitration clause is to stipulate these three things clearly because it can save the parties an extravagant cost of litigation. It is not necessary that every dispute which arises between the parties as per the contract is arbitrable. It is important to understand that only such disputes can be referred to arbitration which the parties intended to arbitrate and that is governed by the clause which is incorporated in the main agreement. Normally, in the arbitration agreement, the disputes which are arbitrable are mentioned and thus the arbitral tribunal is only empowered to adjudicate such issues only. Thus, a clear demarcation can easily be seen in the fact that the courts having jurisdiction over the disputes referred to arbitration can be different from the courts having jurisdiction on the disputes not referred to arbitration[4]. However, keeping this in mind, it becomes easy for parties by expressly mentioning the curial law and lex arbitri to determine which court will finally have supervisory jurisdiction.

In many cases decided by the Hon'ble Supreme Court of India, it was clearly held that parties while entering into an agreement if sign upon the terms ousting the jurisdiction of the courts completely is against the public policy of India and are null and void[5]. Without prejudice to whatever has been held in this judgement, many voices are raised that similarly ousting the jurisdiction of the courts at a primary level and referring the dispute to arbitration should also be considered as against the public policy but such argument lost sight of the fact that referring such dispute to arbitration does not obviate the jurisdiction of courts in its entirety, it only creates a different mechanism of dispute resolution between the parties and the supervisory jurisdiction still vest within the courts[6]. Such determination of rights and liabilities of the parties by arbitration is finally subjected to the jurisdiction of courts. It goes without saying that if the parties to an agreement are entering into a contract stating that they are eliminating the jurisdiction of the courts and giving that to a private person or an arbitral tribunal without recourse to the courts in case of gross error of law committed by the tribunal then the contract itself violates the public policy at large and is null and void[7].

Section 20 Of Arbitration Act Followed By Bhatia International & Balco

Section 20 of the Arbitration and Conciliation Act 1996 talks about the place of arbitration and it says that 20. Place of arbitration.—(1) The parties are free to agree on the place of arbitration.

(2) Failing any agreement referred to in sub-section (1), the place of arbitration shall be determined by the Arbitral Tribunal having regard to the circumstances of the case, including the convenience of the parties.

(3) Notwithstanding sub-section (1) or sub-section (2), the Arbitral Tribunal may, unless otherwise agreed by the parties, meet at any place it considers appropriate for consultation among its members, for hearing witnesses, experts or the

parties, or for inspection of documents, goods or other property.

It has been observed by the judges as well as the law commission reports that there are certain inherent ambiguities attached with the Arbitration & Conciliation Act 1996. One such glaring example is the unsolved puzzle of seat and venue. Nevertheless, judicial intervention in any arbitration proceedings is uncalled for and it is considered as repugnant to the growth of arbitration regime but in the case of India it has rather proved to be beneficial and has helped our country in giving this ambiguous law a good character. Before moving further, it is important to understand the basic fallacy which exists in arbitration act. The Indian arbitration act has four parts and part I of the act governs the arbitration proceedings which are conducted in India. Moreover, it also mentions under Section 5, when a judicial intervention is sought for in an arbitration proceedings[8].

Now, the scope of the part I of the arbitration act is defined under Section 2(2) which says that this Part shall apply where place of arbitration is in India. While reading this section, a plain interpretation is that it is applicable to arbitrations which are conducted in India[9]. Whether the words "place" is similar to "seat" or whether these two terms are different and if they are what is the difference between these two terms and it lacks appropriate judicial interpretation. The similar obstacle is visible in Section 20 as well where the parties are given the powers to agree on the place of arbitration as mentioned under Section 20(1) but the vagueness and obscurity is maintained because the legislature failed to describe the difference between what amounts to seat and venue of arbitration.

Bhatia International v. Bulk Trading SA[10]. , (2002) 4 SCC 105

In simple terms, the facts of the case are that two parties entered into an agreement and the arbitration clause provided that the arbitration was to be as per rules of International Chamber of Commerce (ICC). The dispute arose when one party filed an application under Section 9 of the Arbitration Act praying for an injunction against another party to restrain them alienating their assets. The Learned District Court and the Hon'ble High Court upheld the contention that nevertheless the fact that the arbitration is conducted outside India, the courts in India will have the jurisdiction. The matter came to the Hon'ble Apex Court and the argument was raised on behalf of the Appellant that on a bare perusal of Section 2(2), it becomes clear that unless the International Commercial Arbitration is conducted in India, the remedies available under Section 9 cannot be availed. The Hon'ble Supreme Court, however, resorted to such an interpretation which made the difference between seat and venue more clouded and held that whenever any Indian party is involved in any International Commercial Arbitration, it becomes immaterial in which part of the world that arbitration is conducted and Indian courts are empowered o exercise jurisdiction under Part I of the Act.

Bharat Aluminium Company v. Kaiser Aluminium Technical Services Inc[11].

This case is one of the cases where certain defects were cured of the poorly drafted Arbitration & Conciliation Act. The Hon'ble Apex Court expressly overruled the law laid down in Bhatia International and held in clear terms that the word "place" as used in the act means "seat" and "venue" depending on the context and the section where that term has been used. The Hon'ble Court tried to maintain the distinction between seat and venue and held that Part I is only applicable in the cases when the seat or place of the arbitration is in India. Substantiating such interpretation, a very meaningful idea of law has been laid down by the Hon'ble judges on this case and it was held that the words "place" which has been used in Section 20 of the Act amounts to seat in Section 20(1) and 20(2) and it amounts to venue in Section 20(3).

Agreeing to the position of law as stated in this case, the Hon'ble Apex Court in the case of Enercon (India) Ltd. v. Enercon GmbH[12] and in Bharat Aluminium Co. v. Kaiser Aluminium Technical Services Inc[13]. further reiterated the position of law and also followed the English judgement of Naviera Amazonica Peruana SA v. Compania International de Seguros del Peru[14] and relied on "closest and intimate connection test" and held that when parties failed to mention the seat and venue in an arbitration proceedings then the intention of parties is of paramount importance to determine the seat of the arbitration.

Two Recent Landmark Cases After Balco (Paving a Positive Way Forward)

After analysing the judgement of BALCO and the test laid down in this judgement, one thing which becomes clear is that the arbitration agreement should be read in its entirety i.e., it should be read holistically to ascertain the intention of the parties in cases where no explicit mentioning of "seat" and "venue" is done by the parties. Sometimes, the

parties failed to mention seat but while entering into the contract they mention the venue then the Courts take a cautious approach and look at various factors to determine the seat of the arbitration.

One such case is Union of India v Hardy Exploration and Production (India) Inc[15]. , wherein the seat of an arbitration agreement was not mentioned. Two parties entered in an arbitration agreement and the Hardy (HEPI) initiated arbitration proceedings against Union of India. The Learned Arbitral Tribunal announced the award in favour of Hardy and the ward was signed and declared in Kuala Lumpur. The arbitration clause which is the centre of controversy in this case read as

"This Contract shall be governed and interpreted in accordance with the laws of India.

Nothing in this Contract shall entitle the Contractor to exercise the rights, privileges and powers conferred upon it by this Contract in a manner which will contravene the laws of India.

Arbitration proceedings shall be conducted in accordance with the UNCITRAL Model Law on International Commercial Arbitration of 1985 except that in the event of any conflict between the rules and the provisions of this Article 33, the provisions of this Article 33 shall govern.

The venue of conciliation or arbitration proceedings pursuant to this Article unless the parties otherwise agree shall be Kuala Lumpur and shall be conducted in English language. Insofar as practicable the parties shall continue to implement the terms of this contract notwithstanding the initiation of arbitration proceedings and any pending claim or dispute."

The Union of India filed an application under Section 34 of the Act in the Hon'ble Delhi High Court and HEPI opposed the application. The Hon'ble High Court agreed to the contention raised by the respondents i.e., the award was signed in Kuala Lumpur and hence Section 34 is not applicable and thus the matter went to the Hon'ble Supreme Court.

As laid down in the BALCO judgement i.e., when the seat of arbitration is not defined what becomes important is the intention of the parties to ascertain what is the seat of the arbitration. However, in this case the Court also mentioned in its judgement that when only "venue" is explicitly mentiuoned by the partiesin an agreement and there is no reference to "seat", then it can be considered as seat only if other factors are collateral to it. Thus, inevitable it can be concluded easily that by adjudicating the intention of the parties if it found that the venue and annexed factors to it make it seat also and that place is outside India then Part I of the Arbitration act is not applicable to such proceedings.

Now, the Hon'ble Court referred to the provisions of Section 20 and Section 31 wherein the word "place" has been used and held that according to the law laid down in BALCO's case the word place and seat are interchangeably used in the Act and thus according to Section 20 if the parties does not decide the seat of arbitration then the arbitral tribunal can decide the seat and while doing so any positive assertion or act is necessary while determining the seat of such arbitration. In this case, the venue is Kuala Lumpur and there is not such express determination being done by the Arbitral tribunal and thus it cannot be said that Kuala Lumpur is the seat of the arbitration and hence the Court held that Indian courts have jurisdiction ro entertain an application under Section 34 of the Act.

In another important case i.e., BGS SGS Soma JV v. NHPC Ltd[16]. , the Hon'ble Apex Court was again faced with conundrum of solving seat v. venue. The factual description of this case is that the parties have entered into the contract for a hydroelectric project located in Arunachal Pradesh. Certain disputes arose between the parties and the arbitration clause provided that "Arbitration Proceedings shall be held at New Delhi/Faridabad, India." Adhering to the clause, an arbitral tribunal was constituted and the proceedings were conducted in New Delhi and an award was passed in New Delhi. The parties exhausted various remedies under Arbitration Act and Commercial Courts Act to set aside the award. The Hon'ble Punjab and Haryana High Court while deciding an appeal under Section 37 of the Arbitration Act held that New Delhi is not a seat for arbitration and for the sake of administrative convenience the proceedings were conducted in New Delhi and thus the matter went to the Hon'ble Supreme Court.

While adjudicating this case, the Hon'ble Apex Court observed that

"It will thus be seen that wherever there is an express designation of a "venue" and no designation of any alternative place as the "seat", combines with a supranational body of Rules governing the arbitration, and no other significant contrary indicia, the inexorable conclusion is that the stated venue is actually the juridical seat of the arbitral proceeding."

One of the most significant issues which the

judgement dealt with the correctness of the law laid down in Hardy's case. The Hon'ble Court explicitly mentioned that the "venue" in such case was Kuala Lumpur and it was also mentioned in the agreement that UNCITRAL model rules will apply, and there is nothing contrary in the agreement, thus inevitably Kuala Lumpur is the seat of arbitration and thus the judgement held that Hardy's case did not follow the law laid down in BALCO[17]. In this case, the Court held that the venue of the arbitration proceedings was New Delhi/Faridabad and the arbitration was conducted in New Delhi and thus the "venue" is really the "seat" as mentioned under Section 20(1) of the Arbitration Act and hence, the courts of New Delhi alone had the jurisdiction to entertain a petition related to Section 34 of the Act.

Difference Between Seat and Venue Of Arbitration

One of the most vital aspects of the arbitration proceedings is the seat of arbitration because the courts of the seat have supervisory jurisdiction of the arbitration proceedings. The seat of the Arbitration is clearly independent of the venue or where the hearings of the arbitration are conducted[18]. The BALCO judgement is a path breaking event in the arbitration regime because it expressly lays down the importance of the seat in arbitration. Moreover, the importance of the seat in arbitration also lies in the fact that the award will be enforced (rights and liabilities related to the award) according to the law governing the arbitration procedure.

Considering the convenience of the parties taking part in the arbitration, the hearing of the arbitration can be conducted in many places but that change in the geographical locations of conducting the hearing does not affect the seat of the arbitration in any manner and it remains unaltered[19].

While adjudicating cases like BALCO, Enercon and BGS SGS Soma certain things are very clear regarding seat and venue of the arbitration proceedings. Even in any case where there is an express mention of the "venue" of the arbitration clause, that in no manner imply the fact that the place where the "venue" is prescribed is the "seat" for arbitration. The law which governs the main contract, the law governing the arbitration agreement and the law governing the arbitration procedure determines the seat of the arbitration or else when a seat is not explicitly mentioned the closest connection test is resorted and then the seat is determined and the courts of such place has supervisory jurisdiction.

For example, in the case of Enercon, the parties mentioned about the venue and London was venue in that case. The judgement held that just because London is venue of that arbitration does not mean the courts of London have supervisory jurisdiction over the arbitration because the law which governs the main contract, the law governing the arbitration agreement and the law governing the arbitration procedure has close affinity with India and thus the Hon'ble Court held that courts in London cannot have concurrent jurisdiction[20].

Assuming the jurisdiction of the Indian courts in every case by adopting a parameter that if the party/ parties are Indian or Indian law is being followed as per the terms of the agreement might hurt the arbitration and its development in the longer run because unnecessary judicial intervention is anathema to the arbitration proceedings. The Hon'ble Supreme Court in the case of BALCO explicitly held that the moment the choice of "seat" is transferred to any other place than India then the law of that country will play the role of supervisory jurisdiction on that arbitration proceedings. In addition to this, the Hon'ble Court also clarified the fact that when the agreement entered between the parties clearly mentions the fact that the "seat" of the arbitration is outside India but the Indian Arbitration Act is applicable on the arbitration proceedings, even in that case the Indian Courts are bereft of exercising jurisdiction on that arbitration proceeding or the award passed in that arbitration.

Conclusion

Taking into consideration the abovementioned legal principles, a conclusion of the law related to seat and venue in arbitration proceedings can easily be reached. It goes without saying that the seat of arbitration proceeding is very relevant as it constitutes the heart of the arbitration proceedings because it is the courts of the seat which exercises supervisory jurisdiction over the arbitration proceedings. The caveat regarding the applicability of Arbitration & Conciliation Act 1996 is mentioned in the BALCO judgment at length by the Hon'ble Apex Court of the country however, we must not forget the fact that Section 9 of the Arbitration Act (Interim measures, etc., by court) can be made applicable by the parties even if the arbitration is not held in India if they consent to it in the agreement.

The Supremacy of the Parties and the Competence Competence principle are the substratum of the arbitration and these principles make it clear that the law governing the main contract can be different from the law governing the arbitration agreement. The parties are free to choose the law governing the

arbitration agreement and that law can be different from the law which governs the main contract of which the arbitration agreement is one part.

Pursuant to the judgement in BALCO and in Enercon, it becomes unequivocally clear that when the parties failed to prescribe seat to the arbitration and only venue is mentioned, then the Courts have to act cautiously and have to rely on "closest and intimate connection test" where the intention of the parties are ascertained to determine the seat of arbitration. Later, in BGS Soma case, further extension of this test was seen wherein the Hon'ble Court held that when a "venue" has been clearly mentioned and no "seat" has laid down in the agreement and the agreement mentions the rules or law which will govern the arbitration and there is nothing contrary mentioned in the agreement, then the only conclusion which can be arrived at is that the "venue" is actually the "seat" of the arbitration proceedings.

This attempt to explain the law in a clear manner would not be complete if the words of appreciation are not marked for the Hon'ble Apex court to provide the urgently needed clarity on this aspect and give vaguely worded legislation i.e., Arbitration & Conciliation Act 1996 a meaningful interpretation which can further develop the law in this arena. Moreover, the Indian courts have always mentioned the importance any seat carries in any arbitration and how relevant it becomes to draft an arbitration agreement with utmost care to save endless litigation in future.

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Standard journal article

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