Summary & Conclusions

A variation exists in the betelvine germplasm available in India and most of the collections are poorly organised. Evaluation of germplasm is usually incomplete and sketchy due to lack of reliable testing methods for some characteristics. Constant efforts in systematic collections as well as evaluation of the collected germplasm lead to play an important role in varietal improvement of both in qualitative and quantitative traits.

Over use of agro-chemicals have raised alarming situation in terms of soil health, soil resilience and overall the quality of the produce. Thus, to combat the declining quality of the soil and produce, an emphasis has been given on integrated use of organic, inorganic and biological sources of nutrients. The INM approach is economically cheap, technically sound, practically feasible and capable of maintaining soil health as well as sustainability of production.

The present investigation entitled “Varietal Evaluation and Studies on Integrated Nutrient and Disease Management of Betelvine (Piper betle L.) under Terai Region of West Bengal” were carried out during the year 2008 and 2009 at the instructional farm and the lab experiments were conducted at the research laboratory of the Department of Plantation Crops & Processing of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar.

An attempt was made to identify suitable betelvine cultivar for terai region of West Bengal. Attempt was also made to standardize the nutrient supply system including in-organic, organic and bio-logical sources of nutrient and their effect on disease development.
**Experiment – 1**

**Studies on performance of 12 different betelvine cultivars under Terai zone of West Bengal.**

The twelve cultivars under study (Bagnan Sanchi, Simurali Chamurdali, Kotki, Simurali Deshi, Simurali Sanchi, Simurali Gole Bhabna, Halisahar Sanchi, Bagerhat, Simurali Bhabna, Utkal Sudam, Gayasur, Kali Bangla) were collected from All India Co-ordinated Research Project on Betelvine, BCKV, OUAT and major betelvine growing areas of West Bengal. The experiment was laid in Randomised Block Design with three replications to evaluate for their growth, yield and quality performance in Terai region of West Bengal.

The pooled data revealed that Halisahar Sanchi recorded the maximum vine elongation per month (61.65 cm). However, among the Bangla cultivars Simurali Gole Bhabna recorded the highest mean monthly vine increment (51.11 cm) and Utkal Sudam was the slowest growing of (32.15 cm) of all the varieties having shortest internodes (3.98 cm), longest petiole length (10.17 cm) with high mean monthly leaf production (8.10). Simurali Sanchi recorded the largest leaf area (184.44 sq. cm.) having highest fresh weight of hundred leaves (599.33 g). Leaf thickness varied significantly among the cultivars ranging from 0.35 mm to 0.43 mm. Bagnan sanchi and Simurali chamurdali produced the thickest leaves (0.42 mm) followed by Halisahar Sanchi (0.40 mm) with highest dry weight of hundred leaves (73.56 g).

The cv. Utkal Sudan produced highest LAI (7.598) with lowest RGR (0.015 g g\(^{-1}\) d\(^{-1}\)). Lowest LAI was produced by Simurali Deshi (2.953) having minimum CGR (1.718 g m\(^{-2}\) d\(^{-1}\)). All the sanchi cultivars recorded maximum relative growth rate (0.025 g g\(^{-1}\) d\(^{-1}\)).

Wider variations in anatomical features were exhibited by the different betelvine cultivars under study due to their variation in chromosome number and sexual dimorphism. A significant variation was recorded in the stomatal frequency and the number of vascular bundles per sq. cm. cross section of the vine when observed under microscope (200X). The cultivar Simurali Gole Bhabna recorded highest number of vascular bundles (1789.77) and stomatal frequency (2477.40).

In Terai region of West Bengal generally betelvine suffers from three major diseases like Bacterial leaf spot, Phytophthora leaf blight and Sclerotium Foot rot. In this context twelve betelvine cultivars were screened against the mentioned diseases with an objective to locate tolerance.
Among the three diseases, bacterial leaf spot caused by *Xanthomonas campestris pv. betlicola* appeared throughout the year except for the month of extreme cold during January and February. Where as Phytophthora leaf blight was appeared with the onset of winter in the month of November and remained till the month of March or early April may be marked as onset of summer. The third important disease, foot rot caused by *Sclerotium rolfsii* was observed during the month of monsoon from April to August.

Considering all the diseases and their respective incidences Simurali Bhabna was found to be the tolerant to all the three diseases. Kali Bangla was found to be tolerant to bacterial leaf spot and phytopthora leaf blight, where as Gayasur local was found to be tolerant to phytopthora leaf blight and Sclerotium foot rot. The cultivars containing higher proportion of OD-phenol of the total phenol content showed fairly higher tolerance to bacterial leaf blight and sclerotium foot rot diseases.

Wide variation in chemical composition of leaf of different cultivars in the present study suggested genotypic control of the chemical content at the inter-varietal level. Sanchi cultivars were recorded significantly higher chlorophyll content of the leaves over all the Bangla cultivars. Simurali Gole Bhabna recorded the highest chlorophyll content (47.28) among the Bangla cultivars. A significant variation in vitamin C content was observed in the present investigation. Halisahar Sanchi was the highest vitamin C containing cultivar (4.55 mg/100 g) and was statistically superior over all the variety followed by Simurali Gole Bhabna (3.98 mg/100 g) and Kali Bangla recorded the lowest (1.58 mg/100 g) vitamin C content. However, the Simurali Deshi exhibited as the highest vitamin A containing cultivar (12144.01 IU) and the lowest vitamin A content was observed in Kotki leaves (6490.21 IU). A significant variation was observed with respect to reducing, non-reducing and total sugar content of the leaves of different cultivars. The total sugar content in leaves was ranging from 5.76 % to 10.18 %. Highest total sugar content was observed in case of Simurali Deshi (10.18 %), which was statistically at par with Simurali Sanchi (10.14 %). Maximum starch content and protein content of the leaves were recorded in Simurali Gole Bhabna recorded (2.84%) and Simurali Sanchi (1.99 %) respectively. Due to significant variation in tannin content, leaves of different cultivars exhibited varied level of bitterness. Sanchi cultivars recorded low to moderate tannin content compared to the Bangla cultivars.
From the above findings, it may be concluded as:

- Kali Bangla and Simurali Bhabna and Utkal Sudam may be recommended for the Terai region for commercial cultivation owing to their higher economic yield potential and disease tolerance.

### Experiment – II

**Validation of integrated nutrient management and effect of different organic amendments and bio-fertilizers on quality leaf production and disease management.**

The experiment was conducted integrating organic and inorganic sources of nutrients as main intervention along with conjunct application of bio-fertilizers and bio-control agents as subsidiary intervention. Strategy for disease management in betelvine with particular reference to leaf and vines diseases were based on the principle of avoidance of disease through nutrient management through reduction in inorganic nitrogenous fertilizer which predisposes the plant to leaf and vine diseases. The experiment was laid out in split plot design comprising of two main plot and twelve sub-plot treatments with an objective to validate the integrated nutrient and disease management system for production of quality betelvine leaves using Kali Bangla Cultivar.

The pooled result indicated that the application of 50% inorganic nitrogen (M₂) through straight fertilizer in the main plot resulted slightly higher monthly vine increment, monthly leaf production, inter-nodal length, petiole length having higher leaf size with increased fresh weight of 100 leaves compared to organic main plot (M₁). The magnitude of vegetative growth and yield were found better under the sub-plot treatments comprising of only organic manures (S₁), full dose of in-organic fertilizers (S₂), Azotobacter with 75% N and full P₂O₅ & K₂O (S₄), and 75% and without P₂O₅ with full N & K₂O with PSB and VAM (S₇ & S₈).

The data recorded on the different physiological parameters were found statistically at par under both the main plot treatments. However, the sub-plot treatments comprising of phosphate solubilizing bacteria and mycorrhizal inoculation and only mustard cake recorded higher leaf bio-mass yield, LAI and CGR indicating higher dry matter accumulation resulted from increased crop growth.
The results obtained in anatomical aspect did not show any variation might be due to genetical constitution of the cultivar used under the study.

The organic and inorganic main plot treatments have no significant influence on the uptake of nitrogen and phosphorus, though, the organic main plot recorded higher N uptake (42.68 kg/ha) compared to the inorganic main plot treatment (40.90 kg/ha). However, different sub-plot treatments varied significantly with respect to N uptake ranging from 28.36 kg/ha (S₅) to 49.62 kg/ha (S₇). The treatments S₁₀ and S₁₂ also gave statistically at par results, but it was not reflected in the leaf biomass yield (Tab-4.2.10), due to low internal use efficiency of nitrogen by the crop resulting from poor uptake of phosphorus. It is also evident, that application of phosphate solubilizer and mobilizer alone when applied with partial dose of chemical fertilizer showed better response under organic main plot helps in better N uptake. The organic main plot showed higher P uptake (5.81) compared to the inorganic (5.65). The sub-plot treatment comprising of phosphate solubilizer, mobilizer along with 75% chemical phosphatic fertilizer and recommended dose of nitrogen and potash recorded highest phosphorus uptake (7.16) and the similar trend was also observed in the interaction effect under both the main plots, which was manifested in higher leaf biomass yield (3171.28 kg/ha).

Irrespective of the subplot treatments disease progress in organic plot was found lower during June to September and September to December. In organic plots, the disease progress was lower in the later three months, where as in inorganic plots, it was higher. In the organic plots, the disease progress were found lower in the treatment comprising of Azobacter, PSB, VAM, Trichoderma and Pf (S₄, S₆, S₇ and S₁₂). However, in the inorganic plots, initial lower disease progress were recorded in the treatment comprising of Azobacter, PSB, VAM, Trichoderma and Pf with full dose of N and full P₂O₅ & K₂O (S₁₂, S₃ & S₆) but in the later stage, disease were found lower in S₆ and S₁₂ only. Irrespective of any main plot effect, the disease progress was found lower in S₆, S₁₂ and S₄ at the early stage as well as in the later stage. The above results indicate that the combination of proper bio-agents and organic management of crop may lead to lower disease incidence of bacterial leaf spot in betelvine. The organic main plot recorded significantly lower foot rot incidence. Irrespective of main plot effects, among the sub-plots treatments, lowest disease was recorded in the treatment containing Azobacter, PSB and VAM (S₀). Unlike foot rot, there was no significant difference in Phytophthora leaf blight incidence between organic and inorganic main plots. Irrespective of the main plots effect, significant variation in disease reaction was observed among the sub-plots with
lowest disease incidence in plots without inorganic fertilizers and highest in plots with full inorganic fertilizers. The magnitude of disease was also found lower in treatments including Trichoderma, Fluorescence Pseudomonas and phosphate solubilizer. Treatments with Azotobacter inoculation recorded higher disease incidence indicating increase of disease under higher nitrogen continuum.

Different quality parameters that betelvine responded well on the application of organic, inorganic, bio-fertilizer and bio-agents in different combinations. Application of 50 % nitrogen as organic in the main plot has a favourable effect on chlorophyll, Vitamin-C, protein, starch and total sugar content of the leaves. However, vitamin-A, tannin content of leaves and production of stress related metabolites as phenol and ortho-dihydroxy phenol were found higher in inorganic main plot.

Only organic nutrition (M1S1) without application of phosphatic and potassic fertilizers recorded lowest Vitamin-A content (4360 IU) might be due to nutritional imbalance in potash deficient and phosphate fixing Terai soils. The effect of different treatments was found statistically significant in respect of vitamin-C content of betel leaves in all the three cases where the organic main plot performed better (12.53 mg/100 g) than inorganic main plot (7.80 mg/100 g). Among the sub-plots the application of PSB + VAM + 75% P2O5 and full N, K2O (S7) treated plants recorded the minimum vitamin-C content (8.05 mg/100 g), whereas, all the bio-fertilizer and bio-control agents when applied with 75% inorganic N, P2O5 and 100% K2O (S11) produced maximum vitamin-C (12.30 mg/100 g) in betel leaves. Protein content of the leaves also showed significant variation with respect to sub-plot, mainplot and their interaction. The data revealed that the organic main plot recorded higher protein content (0.70 %) compared to the inorganic main plot (0.65 %) reflecting higher nitrogen use efficiency of the under organic plot (Tab.- 4.2.19). The treatment receiving Azotobacter with 75% N and full P2O5, K2O (S4) and PSB + VAM with full N and K2O (S8) recorded highest protein content of the leaves (0.74%). The organic main plot also recorded higher starch content (2.89%) compared to the inorganic main plot (2.07%) (Tab.- 4.2.19). Different sub-plot treatments showed significant variation in starch content of the leaves and application of PSB + VAM + full N, P and K (S8) recorded highest starch content (2.89%). The effect of main plot, sub-plot and their interaction showed significant variation in all the three cases with respect to sugar content of the leaves. Organic main plot recorded much higher sugar content (6.14%) compared to the inorganic main plot (4.52%).
The economic analysis showed that the treatment receiving phosphate solubilizer and mobilizer along with 100% N and K under organic main plot (M1S8) recorded highest B:C ratio (3.3) due to higher net leaf yield (38.77 lakh per ha.) with larger size having highest market price (Rs. 34 per 100 leaves) in terai zone of West Bengal.

From the above findings, the following conclusion may be drawn as:

- Integration of different sources of nutrient and managing them judiciously may enhance the quantity of the produce maintaining the quality at higher level.
- Among the bio-fertilizers phosphate solubilizers and phosphate mobilizers played a significant role in productivity enhancement under acidic phosphate fixing soil and tropical humid climate with heavy soil.
- Three important diseases were observed in different season as Bacterial leaf spot, Phytophthora leaf blight and Sclerotium foot rot. However, among the diseases, Bacterial leaf spot seems to be most important in said climatic condition.
- The magnitude of the diseases were lower organic nutrient supply system, may be due to higher internal nutrient use efficiency of plants under organic plots resulting in less succulence of the leaves which avoid pathogen growth.
- From the economic point of view the treatment receiving phosphate solubilizer and mobilizer along with 100% N and K under organic main plot recorded highest B:C ratio 3.3.