

Original Research Article

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Comparative Studies on Leaf Yield, Quality and Economy of Three Cultivars of Betelvine (*Piper betle* L.) as Influenced by Integrated Nitrogen Management

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ABSTRACT

Keywords

Simurali Deshi, Simurali Bhabna, Halisahar Sanchi, Mustard oil cake, Cow dung manure, Poultry manure, Pond silt, Fresh and dry weight, Chlorophyll content, Essential oil content, Ascorbic acid content, β Carotene content

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Piper betle L., (family- Piperaceae) commonly known as the betel vine is an important medicinal and recreational plant in Southeast Asia. Betel vine is a dioecious, evergreen, perennial creeper with glossy heart shaped leaves. The present study was executed to identify the suitable integrated nitrogen management on leaf yield, quality and economy of betel vine (*Piper betle* L.) cultivars in new alluvial zone of West Bengal. The field experiment was conducted at Horticulture Research Station, Mondouri, Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal during the 2017-2018. The experiment was laid out in Randomized Block Design, replicated thrice with eight treatments of integrated nitrogen management. It was noted that treatments in combination with inorganic and organic sources of nitrogen produced better results than the treatments with sole application of organic source of nitrogen. The application of nitrogen from mustard oil cake and urea in 1:1 ratio (T₁) produced maximum leaf yield/ vine (86.45 leaves/ vine/ year), projected leaf yield (63.22 lakhs/ ha/ year), chlorophyll content of the leaves (52.30 SPAD value), Ascorbic acid content of leaves (3.07 mg/100g), essential oil content (65.50 mg/100g) and β Carotene content of leaves (7.28 mg/100g) in Simurali Deshi (V₁). Maximum fresh weight (261.25 g) and dry weight (42.01 g) of 100 leaves were found in Halisahar Sanchi (V₃). Among all the sources of nitrogen Mustard oil cake 50% + Urea 50% (T₁) showed highest benefit and cost ratio in all the three cultivars.

Introduction

Betel vine (*Piper betle* Linn) commonly known as Paan is a perennial dioecious evergreen creeper, grown in shady condition with high humidity (Das and Mallick, 2010)^[7]. It is a member of *Piperaceae* family.

It is originated from Malaysia but is distributed extensively in South and Southwest China. This crop is usually cultivated in India, Sri Lanka, Malaysia, Thailand, Taiwan and other Southeast Asian countries. This plant is economically, medicinally and traditionally important in the

whole world (Punuri *et al.*, 2012)^[26]. It is one of the important commercial crop grown mostly by small and marginal farmers in the states of Assam, West Bengal, Bihar, Andhra Pradesh, Karnataka, Tamil Nadu, Maharashtra, Madhya Pradesh, Kerala, Uttar Pradesh and Orissa with an estimated area of 53,539 ha (Ray, 2008)^[30]. The cultivation economy depends both in terms of benefit-to-cost ratio and net income. For the last 7 years an average productivity of 19.41 lakh leaves/ha has been observed (Kaleeswari and Sridhar, 2013)^[17]. India has exported 13195.43 MT of Betel Leaves to the world for the worth of Rs. 46.75 crores/ 6.74 USD Millions in 2018-19 (APEDA agriXchange)^[1]. It is a perennial source of employment (Prasad *et al.*, 2003)^[25]. The betelvine is called as 'green gold of india' as about 20 million people derive their livelihood directly or indirectly from production, processing, handling, transportation and marketing of betel leaves in India (Janeet *et al.*, 2014)^[15]. Betel vine (*P. betle*) is called by different names in India *i.e.* Pan in Hindi, Tambula in Sanskrit, Villayadela in Kannada, Vettillakkoti in Malayalam, Vettilai in Tamil, Tamalapaku in Telugu, Videch-pan in Marathi, Nagarbel in Gujrati, Pan in Bangala also called Tanbol in Arabic and Burg-e-Tanbol in Persian. (Thomas *et al.*, 2013)^[37]. The betel leaves are mainly used as mouth freshener and is also well known for curing many communicable and non-communicable diseases like cold, cough, bronchial asthma, rheumatism, stomachalgia and used to treat other diseases like bad breath, boils and abscesses, conjunctivitis, constipation, swelling of gums, cuts and injuries (Gundala *et al.*, 2014)^[12]. It is also found that betel has significant anti proliferative activity in vitro and in vivo prostate cancer models (Paranjpeet *et al.*, 2013)^[23]. Studies have evidenced that some potential phytochemicals of the betel vine leaf extract such as hydroxychavicol (Chang *et al.*, 2002; Jeng *et al.*, 2004)^[5, 16], ursolic acid

(Kassi *et al.*, 2007; Yamai *et al.*, 2009; Yu *et al.*, 2010; Shao *et al.*, 2011)^[18, 40, 41, 35], chlorogenic acid (Rakshit *et al.*, 2010)^[28], and eugenol (Ghosh *et al.*, 2005; Pisano *et al.*, 2007; Manikandan *et al.*, 2010; Jaganathan *et al.*, 2011)^[9, 24, 22, 14] can induce apoptosis in tumour cells confirming the chemopreventive effect. The crop is cultivated in conservatory structure called as 'boroj.' It provides shade and high humid environment to the crop needed for a good harvest (Khatua, 2013)^[19]. Lack of soil moisture (drought), insufficient water supply, occurrence of natural calamities, disease and pest attack, non-availability of skilled labour, high labour cost, lack of storage facilities, transportation facilities, large number of intermediaries, lack of export promotional activities etc. are some constraints of betel vine cultivation (Sahoo *et al.*, 2017)^[13]. The betel leaf can be segregated into various varieties based on the leaf size, colour, taste, and fragrance. Some of the commonly cultivated varieties of betel vine in India are the Mysore, Banarasi, Salem, Magadhi, Kauri, Calcutta, Bagerhati, and Ghanagete (Satyavati *et al.*, 1987; Warriar *et al.*, 1995; Rai *et al.*, 2011)^[33, 38, 27]. The potential growth and developmental rates for a particular genotype may be decreased by stress factors (Shukla *et al.*, 2013)^[36]. Light is one of the most limiting factors for growth and biomass of the plant (Yuan-long *et al.*, 2012)^[42]. Since the green leaves constitute the economically relevant part of the plant, the nitrogen requirement of the crop is quite high (Saikia *et al.*, 1995)^[32]. In India most of the betel vine growers apply large amounts of organic manures mainly in the form of mustard oil cake. Use of integrated nitrogen management with balanced organic and inorganic nitrogen sources can provide cost effective and environment friendly production tool. This present study assesses the effect of different integrated nitrogen management treatments in betel vine (*Piper betle* L.) cultivars in new alluvial zone of West Bengal.

Materials and Methods

The experiment was laid out in Randomized Block Design with three replications. Three cultivars viz., Simurali Deshi (V₁), Simurali Bhabna (V₂) and Halisahar Sanchi (V₃) were used. The eight treatments of integrated nitrogen management viz., T₁ = Mustard oil cake (50%) + Urea (50%), T₂ = Cow dung manure (50%) + Urea (50%), T₃ = Poultry manure (50%) + Urea (50%), T₄ = Pond silt (50%) + Urea (50%), T₅ = Mustard oil cake (100%), T₆ = Cow dung manure (100%), T₇ = Poultry manure (100%) and T₈ = Pond silt (100%). Experiment was conducted at Horticulture Research Station, Mondouri, Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal. The experiment site is located at 23°50' N latitude and 80°02' E longitude with an altitude of 9.75 meters above mean sea level (MSL). The soil of the experimental site is sandy loam in texture having good drainage and water holding capacity and slightly acidic in nature with moderate soil fertility status. Recommended dose of fertilizers for betel vine is 200:100:100 kg NPK/ha, N applied in the form of urea, mustard oil cake, cow dung manure, poultry manure and pond silt, P₂O₅ applied in the form of single super phosphate and K₂O applied in the form of MOP. In all the nitrogen sources P₂O₅@ 100 kg/ ha and K₂O @ 100 kg/ ha were applied from inorganic sources during April considering the amount present in the respective organic manures to be applied. Then different combinations of nitrogenous fertilizer were applied in different nitrogen sources in three split doses during April, July and September. Leaf production was recorded in total number of leaves/ vine/ year. Data was collected at monthly interval and then added to get total number of leaves produced by a vine in a year. Projected leaf yield was recorded with the help of leaf production by a vine in a year multiplied by total number of plants covering

one hectare of land (number of leaves/ vine/ year X total number of vines/ ha). It was expressed in lakh/ ha. Fresh weight of leaves was taken from freshly harvested 100 leaves without petiole. For taking dry weight of leaves, the same leaves were dried in a drier at 45°C for 48 h and weighed. For essential content, 100 g fresh betel leaves from each cultivar were taken for extraction and estimation of essential oil content. The essential oil was extracted using Clevenger's method (1928)^[6]. The volume of the essential oil was collected in 10 ml conical flask and calculated on weight basis. Chlorophyll content of the randomly selected nine leaves per plot was measured after harvesting of leaves at an interval of six months by using portable leaf chlorophyll meter (SPAD 502, Minolta) and following the method of Arnon (1949)^[2]. β-carotene in leaf was estimated by the method of Broadman & Anderson (1967)^[4]. Ascorbic acid was estimated by using 2, 6 dichlorophenol indophenol dye titration method (Ranganna, 2000)^[29]. The present experiment is designed in factorial RBD (Randomized Block Design) with three replications, where nitrogen sources and cultivars were considered as two factors. The data obtained in this experiment were subjected to statistical analysis by appropriate analysis of variance method (Gomez and Gomez, 1984)^[10] and significance of different sources of variations were tested by Fisher and Snedecor's 'F' test at 0.05 probability level.

Results and Discussion

Yield characters

Leaf yield/ vine/ year

The economic part of betel vine is leaf so importance is always given on more leaf production/ vine/ year. Data presented in Table 1 clearly reveals that nitrogen sources,

cultivars and their interaction had a significant influence on leaf yield/ vine/ year. It was noted from the experimental findings that among the sources of nitrogen Mustard oil cake 50% + Urea 50% (T₁) resulted highest leaf yield/ vine in all of the three cultivars with the number of leaves of 86.45 leaves/ vine/ year in Simurali Deshi (V₁), 81.01 leaves/ vine/ year in Simurali Bhabna (V₂) and 81.93 leaves/ vine/ year in Halisahar Sanchi (V₃) followed by Cowdung manure 50% + Urea 50% (T₂). The best performance was shown with the application of mustard oil cake (50%) and urea (50%) as the nitrogen source maximum number of leaves (83.13 leaves/ vine) were produced/ vine and when total nitrogen was only from the organic sources (100%) the vine showed lowest number of leaf (42.81 leaves/ vine). Data presented in Table 1 reveals that among the cultivars highest overall number of leaves/ vine/ year was obtained 59.75 leaves/ vine /year in Simurali Deshi (V₁) followed by 57.20 leaves/ vine /year in Halisahar Sanchi (V₃) and 55.37 leaves/ vine /year in Simurali Bhabna (V₂). Similar results were found by Maiti *et al.*, (1995)^[21], Saikia *et al.*, (1995)^[32], Dey *et al.*, (2003)^[8], Das *et al.*, (2010)^[7], and Imam *et al.*, (2012)^[13].

Projected leaf yield/ ha/ year

The data presented in Table-2 indicates that nitrogen sources and cultivars registered their significant effect on projected leaf yield/ hectare/ year. Among the sources of nitrogen Mustard oil cake 50% + Urea 50% (T₁) resulted highest leaf yield/ha/year resulting 63.22 lakhs leaves/ year/ ha in Simurali Deshi (V₁), 59.92 lakhs leaves/ year/ ha in Halisahar Sanchi (V₃) and 59.24 lakhs leaves/ year/ ha in Simurali Bhabna (V₂). The best performance was shown with the application of mustard oil cake (50%) and urea (50%). Among the cultivars, Simurali Deshi (V₁) performed the best (43.70 lakhs leaves/ year/

ha). Dey *et al.*, (2003)^[8], revealed that highest leaf yield (74.67 lakhs/ha) was obtained when the required nitrogen was applied from Mustard oil cake 50% + Urea 50%). Imam *et al.*, (2012)^[13] reported that the highest number of leaf (77.37 lakh /ha) was obtained from mustard oil cake and urea at 50:50 combination.

Maximum leaf yield was recorded when organic and inorganic nitrogen was applied in equal proportion. This might be due to maximum utilization of nitrogen from inorganic and organic sources. Urea is a water soluble fertilizer, and prone to high leach ability in the soil. Therefore, if nitrogen was applied fully through urea, then leaching loss was more and plants could not utilize nitrogen totally. On the other hand, the utilization of nitrogen was found better when it was applied with a combination from both the sources. Although on the basis of content and utilization of nitrogen, organic manures are less efficient than the inorganic fertilizers, combined use of those sources was considered to be superior to use of either organic or inorganic nitrogen alone.

The reason behind those observations may be that urea hastened decomposition of mustard oil cake by providing a part to the microorganism to mobilize nitrogen slowly and progressively from the organic sources. This promoted to attain faster growth rate at early period, which reflected on overall impact of vine and leaf yield. (Dey *et al.*, 2003)^[8]. The superiority of combination, but nitrogen through inorganic source might be added advantage of organic nutrients, which besides supplying all the essential nutrients, also improves physical conditions of soil in respect of granulation, friability, porosity and water holding capacity which enable the crop to utilize nutrients and water more efficiently especially under light textured loamy sand soils (Yadav, 2005)^[39].

Table.1 Effect of different nitrogen sources on leaf yield / vine/ year of three different cultivars of Betel vine

Nitrogen source	Cultivar			
	V ₁	V ₂	V ₃	Nitrogen source Mean
T ₁	86.45	81.01	81.93	83.13
T ₂	73.85	67.33	68.09	69.76
T ₃	60.96	56.20	60.59	59.25
T ₄	58.62	54.09	54.23	55.64
T ₅	57.30	54.15	57.17	56.21
T ₆	51.18	45.93	47.00	48.03
T ₇	46.29	42.21	45.56	44.69
T ₈	43.40	42.00	43.02	42.81
Cultivar Mean	59.75	55.37	57.90	
Factors		C.D. (p = 0.05)		SE(m) ±
Nitrogen source (Factor A)		1.52		0.53
Cultivar (Factor B)		0.93		0.33
Nitrogen source X Cultivar		2.64		0.92

Note: T₁ = Mustard oil cake (50%) + Urea (50%), T₂ = Cow dung manure (50%) + Urea (50%), T₃ = Poultry manure (50%) + Urea (50%), T₄ = Pond silt (50%) + Urea (50%), T₅ = Mustard oil cake (100%), T₆ = Cow dung manure (100%), T₇ = Poultry manure (100%), T₈ = Pond silt (100%), Simurali Deshi (V₁), Simurali Bhabna (V₂) and Halisahar Sanchi (V₃)

Table.2 Effect of different nitrogen sources on projected leaf yield/ ha/ year of three different cultivars of Betelvine (lakh /ha)

Nitrogen source	Cultivar			
	V ₁	V ₂	V ₃	Nitrogen source Mean
T ₁	63.22	59.24	59.92	60.79
T ₂	54.00	49.24	49.79	51.01
T ₃	44.58	41.10	44.31	43.33
T ₄	42.86	39.55	39.66	40.69
T ₅	41.90	39.60	41.81	41.10
T ₆	37.42	33.59	34.37	35.13
T ₇	33.85	30.87	33.32	32.68
T ₈	31.74	30.72	31.46	31.30
Cultivar Mean	43.70	40.49	41.83	
Factors		C.D. (p = 0.05)		SE(m) ±
Nitrogen source (Factor A)		1.11		0.39
Cultivar (Factor B)		0.68		0.24
Nitrogen source X Cultivar		1.93		0.68

Note: T₁ = Mustard oil cake (50%) + Urea (50%), T₂ = Cow dung manure (50%) + Urea (50%), T₃ = Poultry manure (50%) + Urea (50%), T₄ = Pond silt (50%) + Urea (50%), T₅ = Mustard oil cake (100%), T₆ = Cow dung manure (100%), T₇ = Poultry manure (100%), T₈ = Pond silt (100%), Simurali Deshi (V₁), Simurali Bhabna (V₂) and Halisahar Sanchi (V₃)

Table.3 Effect of different nitrogen sources on qualitative characters of three different cultivars of Betelvine

Treatments	Fresh wt of 100 leaves (g)	Dry wt of 100 leaves (g)	Chlorophyll Content (SPAD value)	Essential oil content (mg/100g)	β Carotene (mg /100g)	Ascorbic acid(mg /100g)
T ₁	253.84	41.03	50.19	59.394	7.11	2.75
T ₂	250.97	40.04	48.35	58.006	6.98	2.69
T ₃	244.37	38.69	47.65	56.948	6.77	2.62
T ₄	235.22	36.34	45.79	56.079	6.56	2.54
T ₅	239.92	37.68	45.00	55.249	6.46	2.50
T ₆	244.09	38.70	43.69	53.858	6.35	2.38
T ₇	231.93	36.36	42.83	52.914	6.12	2.31
T ₈	226.54	35.71	40.88	51.531	5.94	2.23
CD	2.76	0.49	0.39	0.57	0.07	0.01
S.Em(±)	0.97	0.17	0.14	0.20	0.02	0.01
V ₁	235.42	37.52	46.72	60.68	6.75	2.82
V ₂	238.96	37.78	45.62	54.18	6.49	2.54
V ₃	248.20	38.90	44.29	51.63	6.38	2.16
CD	1.69	0.23	0.24	0.35	0.04	0.01
S.Em(±)	0.59	0.11	0.08	0.12	0.01	0.01
T ₁ V ₁	247.91	40.04	52.30	65.5	7.28	3.07
T ₂ V ₁	244.40	39.07	49.38	63.737	7.19	3.00
T ₃ V ₁	238.15	38.00	48.85	62.577	7.06	2.93
T ₄ V ₁	230.43	36.00	46.96	61.433	6.71	2.87
T ₅ V ₁	240.22	38.00	46.15	61.217	6.63	2.83
T ₆ V ₁	234.79	38.02	44.66	58.633	6.57	2.70
T ₇ V ₁	226.86	36.01	43.69	57.493	6.39	2.63
T ₈ V ₁	220.60	35.01	41.76	54.857	6.15	2.54
T ₁ V ₂	252.36	41.05	50.45	57.493	7.10	2.76
T ₂ V ₂	250.63	40.00	48.56	56.537	6.92	2.71
T ₃ V ₂	241.75	39.01	47.90	55.157	6.69	2.64
T ₄ V ₂	231.99	35.02	45.83	54.837	6.54	2.55
T ₅ V ₂	245.57	36.02	45.08	53.697	6.43	2.51
T ₆ V ₂	236.43	39.05	43.43	52.757	6.30	2.43
T ₇ V ₂	229.44	36.04	43.02	51.883	6.03	2.37
T ₈ V ₂	223.52	36.06	40.72	51.09	5.90	2.31
T ₁ V ₃	261.25	42.01	47.84	55.19	6.95	2.42
T ₂ V ₃	257.89	41.04	47.10	53.743	6.83	2.36
T ₃ V ₃	253.22	39.05	46.19	53.11	6.58	2.29
T ₄ V ₃	243.23	38.00	44.57	51.967	6.44	2.21
T ₅ V ₃	248.54	39.01	43.78	50.833	6.32	2.16
T ₆ V ₃	246.46	39.02	42.98	50.183	6.19	2.02
T ₇ V ₃	239.49	37.02	41.77	49.367	5.93	1.93
T ₈ V ₃	235.49	36.05	40.16	48.647	5.78	1.84
CD	4.79	0.85	0.67	0.99	0.12	0.02
S.Em(±)	1.67	0.30	0.23	0.35	0.04	0.01

Note: T₁ = Mustard oil cake (50%) + Urea (50%), T₂ = Cow dung manure (50%) + Urea (50%), T₃ = Poultry manure (50%) + Urea (50%), T₄ = Pond silt (50%) + Urea (50%), T₅ = Mustard oil cake (100%), T₆ = Cow dung manure (100%), T₇ = Poultry manure (100%), T₈ = Pond silt (100%), Simurali Deshi (V₁), Simurali Bhabna (V₂) and Halisahar Sanchi (V₃)

Table.4 Effect of different nitrogen sources on economy of three cultivars of betelvine

Treatments	Cultivars	Gross Return/ ha/ year (Rs)	Total Cost/ha/ year	Net Return/ha/ year (Rs)	Benefit: Cost
T₁	V₁	210721	65847	144875	2.20
	V₂	197479	65847	131632	2.00
	V₃	199718	65847	133871	2.03
T₂	V₁	180009	64433	115576	1.79
	V₂	164126	64433	99692	1.55
	V₃	165973	64433	101539	1.58
T₃	V₁	148587	62813	85774	1.37
	V₂	136999	62813	74186	1.18
	V₃	147690	62813	84877	1.35
T₄	V₁	142879	63087	79792	1.26
	V₂	131845	63087	68758	1.09
	V₃	132183	63087	69096	1.10
T₅	V₁	139671	68920	70751	1.03
	V₂	131990	68920	63070	0.92
	V₃	139367	68920	70447	1.02
T₆	V₁	124744	66253	58490	0.88
	V₂	111965	66253	45712	0.69
	V₃	114556	66253	48302	0.73
T₇	V₁	112838	63347	49491	0.78
	V₂	102895	63347	39548	0.62
	V₃	111050	63347	47703	0.75
T₈	V₁	105785	63440	42345	0.67
	V₂	102390	63440	38950	0.61
	V₃	104859	63440	41419	0.65

Note: T₁ = Mustard oil cake (50%) + Urea (50%), T₂ = Cow dung manure (50%) + Urea (50%), T₃ = Poultry manure (50%) + Urea (50%), T₄ = Pond silt (50%) + Urea (50%), T₅ = Mustard oil cake (100%), T₆ = Cow dung manure (100%), T₇ = Poultry manure (100%), T₈ = Pond silt (100%), Simurali Deshi (V₁), Simurali Bhabna (V₂) and Halisahar Sanchi (V₃)

Qualitative characters

Fresh and dry weight of 100 leaves

Data presented in Table-3 clearly indicated significant variation with respect to fresh and dry weight of 100 leaves. Combination of mustard oil cake (50%) and urea (50%) produced maximum fresh weight in Halisahar Sanchi (V₃) (261.25 g) followed by Simurali Bhabna (V₂) (252.36 g) and Simurali Deshi (V₁) (247.91 g). Minimum fresh weight of 100 leaves was observed when nitrogen was

applied in the form of pond silt (100%) and the fresh weights were 220.60 g in Simurali Deshi (V₁), 223.52 g in Simurali Bhabna (V₂) and 235.49 g in Halisahar Sanchi (V₃). Among the three cultivars, maximum fresh weight was found in Halisahar Sanchi (V₃) (248.20 g).

Mustard oil cake (50%) + urea (50%) is one of the treatment combination which produced maximum dry weight of 100 leaves in Halisahar Sanchi (V₃) (42.01 g), Simurali Bhabna (V₂) (41.05 g) and Simurali Deshi

(V₁) (40.04 g) while minimum dry weight was produced where pond silt was used as 100% nitrogen source. Among the cultivars, Halisahar Sanchi (V₃) produced maximum dry weight of 100 leaves (38.90 g). Among all of the treatment combinations, maximum dry weight (41.03 g) was found from mustard oil cake (50%) and urea (50%).

Chlorophyll content of leaves (SPAD value)

Combination of mustard oil cake (50%) and urea (50%) produced maximum chlorophyll content of the leaves in Simurali Deshi (V₁) (52.30) followed by Simurali Bhabna (V₂) (50.45) and Halisahar Sanchi (V₃) (47.84). Minimum chlorophyll content of leaf was observed when nitrogen was applied in the form of pond silt (100%) and the results were as 41.76 in Simurali Deshi (V₁), 40.72 in Simurali Bhabna (V₂) and 40.16 in Halisahar Sanchi (V₃). Among the three cultivars, maximum chlorophyll content was found in Simurali Deshi (V₁) (46.72). Among all of the treatment combinations, mustard oil cake (50%) and urea (50%) showed the highest result (50.19).

The application of organic manures and inorganic fertilizers in combination lowered the C: N ratio thereby favouring microbial decomposition which in turn contributed to the higher uptake of nitrogen along with other nutrients, leading to higher level of photosynthetic pigments. (Arulmozahian *et al.*, 1998)^[31].

Ascorbic acid content of leaves (mg /100g)

Combination of mustard oil cake (50%) and urea (50%) produced highest Ascorbic acid content of leaves in Simurali Deshi (V₁) (3.07 mg/100g) followed by Simurali Bhabna (V₂) (2.76 mg/100g) and Halisahar Sanchi (V₃) (2.42 mg/100g). Lowest Ascorbic acid content was found in Halisahar Sanchi (V₃)

(1.84 mg /100g) from T₈*i.e.* pond silt (100%). All-over among the cultivars Simurali Deshi (V₁) produced highest (2.82 mg/100g) Ascorbic acid content followed by Simurali Bhabna (V₂) (2.54 mg/100g) and Halisahar Sanchi (V₃) (2.16 mg/100g). Overall performance was best (2.75 mg/100g) when nitrogen was supplied as a combination of mustard oil cake (50%) and urea (50%). Guha (2006)^[11] reported that ascorbic acid content in fresh betel leaves varied from 0.002%–0.01%.

Essential oil content of leaves (mg/100g)

Mustard oil cake 50% + Urea 50% (T₁) was found to be the best in case of essential oil production and results were as 65.50 mg/100g in Simurali Deshi (V₁) followed by 57.49 mg/100g in Simurali Bhabna (V₂) and 55.74 mg/100g in Halisahar Sanchi (V₃). The lowest oil content was obtained with application of pond silt as 100% nitrogen source (T₈). The overall result showed that the highest essential oil content (59.39 mg/100g) was obtained with application of mustard oil cake (50%) and urea (50%). Among the cultivars, Simurali Deshi (V₁) produced highest essential oil content (60.68 mg/100g). Essential oil is a secondary plant metabolite synthesized from the products of photosynthesis. Restricted availability of photosynthates adversely affects crop growth and essential oil synthesis and accumulation (Kumar *et al.*, 2014)^[20].

β Carotene content of leaves (mg/100g)

Mustard oil cake 50% + Urea 50% (T₁) was found to be the best, resulting 7.28 mg/100g in Simurali Deshi (V₁), 7.10 mg/100g in Simurali Bhabna (V₂) and 6.95 mg/100g in Halisahar Sanchi (V₃) in production of β Carotene content of leaves. The lowest result was obtained with application of pond silt as 100% nitrogen source (T₈). The overall result

showed that the maximum β Carotene content (7.11 mg/100g) was obtained with application of mustard oil cake (50%) and urea (50%) and minimum β Carotene content (5.94 mg/100g) was obtained when 100% nitrogen was applied from pond silt (T_8). Among the cultivars, Simurali Deshi (V_1) produced maximum β Carotene content (6.75 mg/100g).

Economy of the crop

Data presented in Table-4 clearly indicated that the benefit and cost ratio varied with the nitrogen sources (treatments) and cultivars in betel vine. Among the sources of nitrogen Mustard oil cake 50% + Urea 50% (T_1) showed highest benefit and cost ratio in all the three cultivars with the values of 2.20 in Simurali Deshi (V_1), 2.00 in Simurali Bhabna (V_2) and 2.03 in Halisahar Sanchi (V_3) followed by cowdung manure 50% + Urea 50% (T_2) resulting 1.79, 1.55 and 1.58 in Simurali Deshi (V_1), Simurali Bhabna (V_2) and Halisahar Sanchi (V_3) respectively. The lowest benefit and cost ratio in all the three cultivars where 0.61 in Simurali Bhabna (V_2), 0.65 in Halisahar Sanchi (V_3) and 0.67 in Simurali Deshi (V_1), when 100% nitrogen was applied from Pond silt. In benefit and cost ratio Simurali Deshi (V_1) performed the best followed by Halisahar Sanchi (V_3) and Simurali Bhabna (V_2). When 100% nitrogen was applied from mustard oil cake showed a benefit and cost ratio of 2.20 in Simurali Deshi (V_1), 0.92 in Simurali Bhabna (V_2) and 1.02 in Halisahar Sanchi (V_3).

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