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Growth and water-use-efficiency of betelvine [*Piper betle* cv. Mitha] under coastal agro-ecosystem of Sundarbans

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ABSTRACT

The result of the field experiment carried out consecutively for three years in a conservatory of Bidhan Chandra Krishi Viswavidyalaya situated at Kakdwip, South 24-Parganas, West Bengal to study the effect of different mulches on growth, water-use efficiency and monetary return of betelvine cv. Mitha, revealed that maximum vine elongation (26.55 cm), number of leaves per vine (27.06), leaf weight and leaf area index were recorded under poly-mulch treatment. The increment of leaf yield was maximum (42.34%) over control due to poly-mulch with reduction of water utilization by 557.4 mm. The maximum water-use efficiency (52.94 kg ha^{-1} mm^{-1}) was recorded under poly-mulch treatment followed by straw and weed mulch. The per hectare per annum monetary return was maximum (₹19,56,492) under poly-mulch treatment which was 1.4 times higher over control.

Key word: Mulching, net return, water use efficiency

Sundarban, the Indo-Gangetic delta is mono-cropped with rice. As a consequence, a vast number of people live below poverty line. Occasional flooding with tidal water, scarce winter rain and non-availability of good quality of water (both surface and sub-surface) are the primary reasons for keeping the lands fallow following kharif rice. In some pockets, however, vegetables are grown. The areas where surface run-off can be stored and re-used, chilli is grown as cash crop. In high lands, especially the locations which are not being flooded with tidal saline water, betelvine is grown as a cash crop. But its cultivation is mostly restricted to large farmers. Moreover, the size and number of conservatory is decided by the land availability of farm family. In coastal saline zone the mitha variety of betelvine is prevalent, which fetches a good sum of money from both national and international markets. The livelihoods of large number of families depend directly or indirectly on the cultivation of this cash crop. For improving the production both in quantity and quality, the cultivation need to be performed most scientifically. The study was, therefore, undertaken to study the growth, yield and water use efficiency of the crop by adopting water conservation practices.

MATERIALS AND METHODS

The study was carried out consecutively for three years (1998-2002) in a conservatory (locally known as boroj) constructed within the experimental site of the Regional Research Station (Coastal Saline Zone) of Bidhan Chandra Krishi Viswavidyalaya situated at Kakdwip (21°90′ N latitude and 80° 10′ E) in the district of South 24-Parganas, West Bengal. Mitha variety of betelvine (*Piper betle* cv. Mitha) was planted following normal plantation practices. Climate of the region is humid tropic. The average annual rainfall varies between 1450 and 1925 mm. The winter rain is scarce and undependable. Mean air temperature and relative humidity vary from 32.5 to 15.5 °C and 52 to 91% respectively. The soil is very deep, poorly drained and fine textured. pH and electrical conductivity (EC) of the soil varied between 7.25 – 8.40 and 0.89 – 1.20 dSm^{-1} respectively. Available N, P_2O_5 and K_2O varied from 220 – 191, 40 – 37 and 400 – 425 kg ha^{-1} respectively, while organic carbon content varied from 0.68 – 0.65 per cent. The experiment was conducted with organic and the consisting of paddy straw (T_2) and dry weed (T_3) (*Saccharum* sp.) was applied after chopping between the rows of the vines @ 4 mt ha^{-1}. The strips of the polythene were also placed similarly. Mulches were placed following establishment of the slits in the plot size 3 x 1.5 m^2.

Soil samples from 0-15, 15-30, 30-45 and 45-60 cm depths were collected periodically and moisture content of the soil was determined with gravimetric method (Gardner, 1965). Information on vine elongation, number of nodes and branches per plant as well as number of leaves per plant were collected at regular interval. However, leaf weight and leaf area were measured treatment-wise with randomly selected samples after each harvest. Leaf area was measured with the leaf-area-meter. Summation of all the harvests round the year was converted to yield per annum. Water-use-efficiency was calculated as the ratio of yield per unit depth of water used. The net return was calculated using the prices which prevailed in the local whole-sale market at different seasons. The water use index was then calculated by dividing the net return by the amount of water used.

RESULTS AND DISCUSSION

Growth of vine

Parameters like elongation, number of nodes and branches per vine have been considered for

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analyzing the growth. It was revealed that mulch influenced vine elongation significantly (Table 1). The maximum (26.55 cm) vine elongation was noted under poly-mulch (T_4) followed by T_3 and T_2, which, however did not show any significant difference in between. The per cent increase in elongation due to organic and poly-mulch was 20.46 and 32.16, respectively over control. It was further observed that the rise in air temperature, increased soil temperature and decreased humidity within the conservatory result a change in micro-climate both below and above the soil surface. Such change in climate had direct bearing on the rate of growth of the vine, which was maximum with poly-mulch. This may be attributed to the fact that polythene sheet could maintain a congenial temperature in the root-zone throughout its growing period. As a consequence, the growth was maximum. The significant inverse correlation (r = -0.673*) further confirms the statement (Table 5). However, the relationship was positive and highly significant (r=0.868*) with light intensity inside the conservatory. The result conforms to the findings of Chakraborty (2000) in chilli and Sandhu and Hodges (1971) in *Cicer arietinum*.

Similar trend was noted in case of number of nodes and branches per plant. It was further noted, as obvious, that number of nodes had highly significant linear correlation (r = 0.787**) with vine elongation. However, irrespective of treatments mulch induced more growth by 22.88 per cent over control. Organic mulch, in general, proved better than the poly mulch.

Growth of leaf

The number of leaves per vine differed significantly with the treatments (Table 1). The maximum number of leaves (27.06) was noted under poly-mulch (T4) and minimum under no-mulch (control) treatment (T_1). The organic mulches did not show any significant difference between them and, in general, produced 14.58 per cent higher leaves over control. The poly-mulch, on the other hand, produced 42.57 per cent higher leaves over control.

The number of leaves also differed with the seasons. It was minimum during winter followed by summer and rainy seasons. Such seasonal difference was associated with the micro-climate of the conservatory and addition of mulch enhanced the production of leaves per vine. The sequence of leaf production, in general, was poly-mulch > straw > weed > control (Table 2). This variation was due to the sum total of leaves produced in main stem (*Khar pan*) and in branches (*Pala pan*). Further investigation revealed that both the types of the leaves also differed with seasonal difference (Table 3). Although the difference between khar and pala pan was marginal during winter, the pala pan superseded khar pan by 1.7 and 1.9 times during summer and rainy seasons respectively. However, khar pan was higher than pala in number during winter. The trend was similar even when mulch was applied.

Similar trend was noted in case of leaf weight. Leaf area, on the other hand, did not show any difference among the treatments. However, it was maximum (116.07 cm^2) due to poly-mulch (T_4). Neither of the treatments T_2 and T_3 had any difference with control. Further, the influence of season was least during rainy season. On the contrary, although the leaf area did not differ among the treatments during summer, the difference due to treatment was significant during winter (Table 2).

Yield and water-use-efficiency

The yield of the crop varied significantly (Table 4) among the treatments. The sequence of yield was poly-mulch > straw > weed > control. It was observed that the yield, in general, was increased by 29.40% over control. But, the increment was maximum (42.34%) over control due to poly-mulch. The difference in yield was associated with number of leaves per vine, weight and area of the leaves.

A significant difference in total water use by the plant was noted (Table 4). The plants, in general, used 58.68 per cent less water due to mulch. But it was minimum with poly-mulch and maximum (970.8 mm) under the control where no mulch was used. With respect to control the water utilization was reduced by 577.4, 221.9 and 329.80 mm due to polythene, straw and weed mulch, respectively. This finding was also in parity with the report of Chakraborty *et al.* (2001) and Parr (1990).

As a result of maximum yield and minimum water use, the water use efficiency of the crop under poly-mulch condition was maximum (52.94 kg ha^{-1} mm^{-1}) followed by organic mulch. However, the WUE of the crop did not show any significant difference between straw and weed mulch. This is in conformity with the results of Yule *et al.* (1990).

Table 1: Different growth parameters as influenced by mulch (mean of three years)

Treatments	Vine elongation (cm)	Branches vine^{-1}	Nodes vine^{-1}	Leaves vine^{-1}	Leaf weight vine^{-1} (g)	Leaf area (cm^2)
Control (T_1)	20.09	2.04	4.32	18.98	38.52	119.15
Paddy straw (T_2)	24.10	2.42	4.95	23.30	46.79	118.57
Weed mulch (T_3)	24.30	2.44	4.95	22.50	46.07	119.78
Poly-Mulch (T_4)	26.55	2.66	5.46	27.06	54.87	116.07
Mean	**23.81**	**2.39**	**4.92**	**22.96**	**46.56**	**118.39**
LSD (0.05)	**1.06**	**0.33**	**0.45**	**2.89**	**3.41**	**NS**

Table 2: Influence of mulch on leaves, leaf weight and leaf area (mean of three years)

Mulch	No. of leaves per vine			Mean leaf weight per vine (g)			Mean leaf area (cm^2)		
	Winter	Summer	Rainy	Winter	Summer	Rainy	Winter	Summer	Rainy
Control (T_1)	15.30	21.15	22.06	62.52	85.64	88.90	120.83	118.70	103.79
Paddy straw (T_2)	19.55	25.65	26.44	79.88	103.21	101.42	120.73	120.09	113.88
Weed mulch (T_3)	18.60	25.85	25.64	76.71	100.77	105.71	121.89	119.71	115.79
Poly-Mulch (T_4)	23.15	29.40	30.21	96.96	119.12	122.63	114.08	118.93	114.37
Mean	**19.15**	**25.26**	**26.09**	**79.02**	**102.19**	**104.67**	**119.38**	**119.36**	**111.96**
LSD (0.05)	**1.67**	**1.01**	**1.54**	**2.50**	**3.42**	**3.27**	**0.88**	**NS**	**1.09**

Table 3: Seasonal variations of leaves and leaf weight as influenced by mulch (mean of 3 years)

Treatments	Winter		Summer		Rainy	
	Khar	Pala	Khar	Pala	Khar	Pala
No. of leaves per vine						
Control: (T_1)	8.25	7.05	7.25	13.90	6.92	15.14
Straw mulch: (T_2)	10.40	9.15	9.40	16.25	9.11	17.33
Weed mulch: (T_3)	9.75	8.85	9.05	15.80	8.63	17.01
Poly-mulch: (T_4)	12.25	10.90	11.25	18.15	10.80	19.41
Mean	**9.47**	**8.99**	**9.24**	**16.03**	**8.71**	**17.22**
Weight per leaf (g)						
Control (T_1)	4.05	4.13	4.07	4.04	4.10	4.00
Straw mulch: (T_2)	4.00	4.18	4.07	4.00	3.49	4.02
Weed mulch: (T_3)	4.08	4.17	4.05	4.06	4.14	4.12
Poly-mulch: (T_4)	4.09	4.03	4.07	4.04	4.16	4.00
Mean	**4.05**	**4.13**	**4.06**	**4.04**	**3.97**	**4.00**

Table 4: Effect of mulch on leaf yield, water use efficiency (WUE) and water use index (WUI)

Treatments	Yield q ha^{-1}	Total water use (mm)	WUE kg ha^{-1} mm^{-1}	Net Return, (₹)	WUI ₹ ha^{-1} mm^{-1}
Control (T_1)	25.60	970.8	26.37	13,74,027	1415.36
Straw mulch (T_2)	32.30	748.9	43.18	17,34,602	2139.30
Weed mulch (T_3)	30.64	641.0	47.80	16,44,992	2566.29
Poly-mulch (T_4)	36.44	393.4	52.94	19,56,495	4973.30
Mean	**31.24**	**688.3**	**45.39**	**16,77,529**	**2773.56**
LSD (0.05)	**3.33**	**50.95**	**2.22**	**22,403**	**211.51**

Table 5: Correlation coefficients between growth parameters and environmental factors

Climatic factors	Vine elongation	No. of nodes vine^{-1}	No. of branch vine^{-1}	No. of leaves vine^{-1}	Total leaf weight	Leaf area
Air Temp.	-0.056	-0.039	-0.012	0.925**	0.941**	0.924**
Soil Temp.	-0.673*	-0.498	-0.341	0.345	0.557	0.586
Humidity	-0.175	-0.182	-0.168	-0.614*	-0.767**	-0.770**
Luminosity	0.868**	0.862**	0.851**	0.623*	0.801**	0.823**
Wind Vel.	0.475	0.236	-0.739**	0.643	0.534	0.543

Net return and water use index

The monetary return was maximum of ₹19,56,492 ha^{-1} annum^{-1} when poly-mulch (T_4) was used for cultivation of betelvine, which was 1.4 times higher over control. The monetary return was increased 1.2 times over control in organic mulch. The net return due to the treatment was in the sequence of $T_4>T_2>T_3>T_1$. Similar result was also reported in oil seeds and pulse crops by Chakraborty (2003). Water-use-index showed trend similar to that of the return.

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