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Crop response of swamp taro to organic sources of nitrogen in lower gangetic plains

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Abstract. Swamp taro (*Colocasia esculenta* L. Schott) is a wet land minor edible aroid grown in flooded or swampy situation. The crop is grown on a small scale particularly in irrigated lowlands or low-lying ditches of eastern India. The crop being a long duration (8 to 10 months) depletes major plant nutrients particularly nitrogen from the soil. Therefore, the field experiments were under taken to study the nitrogen requirement through organic and inorganic sources in alluvial soil of Lower Gangetic Plains (23.5^{o} N latitude and 89^{o} E longitude and 9.75m above mean sea level) of West Bengal, India during 2001 and 2002. The treatments comprised of different organic and inorganic combinations of 25, 50, 75 % of normal dose of nitrogen (200 kg ha^{-1}) taking mustard cake, neem cake, poultry manure as organic sources and urea as an inorganic source. The stolons (edible part) that initiated from basal sucker corms were harvested periodically at 15-day intervals after attaining suitable marketable length (80 to 100 cm) throughout the stolon bearing period (April to October). Observations on stolon production and yield attributes revealed that inorganic nitrogen source significantly increased stolon production (27.3 tha^{-1}) by 38 to 67 % whereas organic nitrogen sources like mustard cake, neem cake, poultry manure increased the yield (19.7 to 24.3 tha^{-1}) by 21 to 49 % over non fertilized crop (16.3 tha^{-1}). Increased proportions (75 %) of inorganic N-source along with organic N-source (25 %) recorded the maximum stolon production (25.2 tha^{-1}). Interaction effect of N-source and its combination was found significant and 50% mustard cake + 50% urea recorded the highest stolon yield of 27.6 t ha^{-1}. The stolon length, stolon number basal girth and plant height were significantly influence by the N-source and its combinations.

Introduction

Swamp taro, a wet land tropical minor edible aroid has long been growing in sub-tropical humid and tropical climate of East Asia. There is an urgent need for substantial increase in production of root and tuber crops to provide food for the ever increasing population (Onwumme, 1999). Swamp taro is one such crop which although considered for the poorer section of the population is gaining importance especially for intensive farming under the low lying humid agro-ecosystem. Swamp taro is made up of two genera viz. *Colocasia* and *Cyrtosperma*. The former produces many stolons from the developing sucker, which are the main edible parts, while the later hardly produces any stolon but the whole plant including the sucker is edible. The trailing suckers (stolons) emerging from the base of the developing sucker corm serve as important starchy vegetable for the people in areas where traditional vegetables becomes scarce during monsoon months. Different delicious and palatable dishes prepared from taro are now widely accepted by the middle and upper middle class people. The crop yields between 20-30 t/ha of stolons with lucrative monetary return from a hectare of land. Swamp taro is a long duration crop covering winter, summer and monsoon seasons. It is normally cultivated in flooded situations and it depletes major plant nutrients from the soil. Researches in India and elsewhere pointed to the need of integrated use of organic and inorganic manures for sustaining the productivity of soil and crops in an intensive cropping system (Tiessen *et al*., 1994; Sarkar *et al*., 2003). However, information regarding nitrogen requirement of this crop is very scanty (Pena and Plucknett, 1967; Sen *et al*., 1999). Therefore, a study was undertaken to determine crop response to organic sources of nitrogen and their combination levels in sandy loam soils of West Bengal, India.

Materials and Methods

Field experiments were conducted at the University Research Farm, Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal which lies at 23.5^0 N latitude and 89^0 E longitude at a mean sea level of 9.75 m. Some weather parameters of this area are shown in Table 1. The soils are newly developed alluvial, olive grey in colour, slightly acidic (pH 6.5), clay loam in texture with a bulk density of 1.36 Mg m^3. The chemical composition of the soil was organic carbon 0.56%, total nitrogen 0.59%, available P_2O_5 15.6 kg ha^{-1} and available K_2O 153.7 kg ha^{-1}.

The trial was made up of 14 treatments comprising of three organic nitrogen sources (mustard cake, neem cake and poultry manure) and their four application levels in addition to urea (100% inorganic source) and an absolute control. The treatment combinations were laid out in a randomised block design with three replications. Organic manure was applied on the basis of equivalent Nitrogen as mustard cake 39 qha^{-1}, neem cake 40 qha^{-1} and poultry manure 200 qha^{-1}. A common dose of 150 kg P_2O_5 ha^{-1} and 100 kg K_2O ha^{-1} was applied as basal. Organic N-sources were applied 10 days before planting. For urea, one third was applied one month after the establishment of the crop and the rest intwo equal splits at 30-day intervals.

The stolons were harvested periodically at 15-day intervals starting from April and continued up to October. Stolon production was almost ceased with withdrawal of monsoon (October). Observations were recorded on growth and yield attributes like plant height, basal girth, stolon length, number of stolons per plant, and periodic stolon yield. Data were analysed following the method of Panse and Sukhatme (1989). Sustainable stolon production index (SYI) of swamp taro under different N- sources were analysed with time following the equation proposed by Singh *et al*. 1990 as:

$$SYI = ('Y - d) / Y_{max}$$

Table 1: Crop weather parameters of swamp taro cultivated in humid tropical climate.

Month	Ep (mm)	Rainfall (mm)	Max.RH (%)	Max.Temp. (^{0}C)	BRS ($hrsd^{-1}$)
January	1.6	1.4	99.5	24.7	8.8
February	2.2	9.9	96	29.2	9.4
March	3.6	10.9	95.4	32.5	8.9
April	4.8	46.2	91.8	35.8	8.5
May	4.6	173.9	93	34.2	8.6
June	2.6	250.9	96.2	32.1	3.6
July	2.9	174.8	96.2	31.4	3.9
August	2.7	318.9	96.8	32.8	5
September	2.9	350.6	98.3	32.7	4.9
October	2.3	156.4	98.4	31.6	4.4

where'Y is the estimated average stolon yield of each harvesting, d is the estimated standard deviation; Y_{max} is the observed maximum stolon yield.

Results and Discussion

Effect of N-source. The stolon production of swamp taro was significantly influenced by different organic sources and its proportionate use with inorganic nitrogen. The use of urea increased stolon production (27.3 tha^{-1}) by 38-67%, whereas, organic sources of nitrogen increased stolon yield (19.7-24.3 tha^{-1}) by 21-49%. Mustard cake and poultry manure were better sources of N compared to neem cake. Das Adhikari *et al.* (1992) also obtained the higher yield of potato from poultry litter (20 t/ha) along with ammonium sulphate (150 $kgha^{-1}$). Among the organic sources neem cake recorded 23% less stolon production (19.7 t ha^{-1}) over other organic sources. There was no significant influence of neem cake on tuber yield of potato at higher levels (Sahota and Singh, 1985). Crop growth and yield parameters were much influenced by N-source. The use of inorganic N-source like urea increased plant height, basal girth and stolon length of the crop substantially.

Production consistency of stolon was measured through the yield stability index over time. The results revealed that inorganic N- source had a faster rise and fall of stolon production over the growing period (Table 2). Yield gain was slow but consistent with the use of organic sources of nitrogen and neem cake. The non-fertilized crop had a slow but steady yield gain or fall. Mineralized nitrogen from organic sources meets the crop nutrient requirement slowly but continuously in combination with readily available inorganic nitrogen (Omarhttab *et al.*, 1998 and Sarkar *et al.*, 2003).

Effect of combinations of organic and inorganic N. Crop response to integrated use of organic and inorganic sources of nitrogen was found significant (Table 3). The result

Table 2: Stolon production consistency over time as influenced by N-Source.

N-Source	Yield change (ΔY, $kgha^{-1}$ day^{-1})					
	April - May	May - June	June - July	July - August	August - September	September - October
Mustard cake	91.3	40.3	42.6	-30.3	-78.6	-34.6
Neem cake	78	33.6	37.0	-31.6	-53.0	-38.0
Poultry cake	12	27.0	19.0	-22.2	-76.6	-42.6
Urea	140.7	36.3	7.6	-57.3	-68.3	-39.0
Control	46.6	36.6	46.0	-11.3	-33.3	-54.6

Table 3: Crop response to nitrogen- sources and its combination levels in swamp taro.

Treatment	Stolon production and its attributes				
	Stolon yield (t ha^{-1})	Plant height (cm)	Basal girth (cm)	Stolon (No.$plant^{-1}$)	Stolon length (cm)
N-Source (@ 200 kg ha^{-1})					
Mustard cake (MC)	23.8	105.4	22	35.7	112.5
Neem cake (NC)	19.7	115.5	17.4	35.5	109.2
Poultry manure (PM)	24.3	109.2	20	35.5	110.2
Urea (U)	27.3	125.8	22.4	38	116
Control* (WN)	16.3	88.1	12.8	28	100
N-Source combination (N_{or} + N_{inorg} %)					
0+100	27.3	125.8	22.4	38	116
25+75	25.2	122.2	22.4	35.6	112.3
50+50	24.3	115.7	21.3	38	114
75+25	21.6	104.1	18.9	34.6	108.6
100+0	19.1	98.1	16.7	34	107.6
CD (P=0.05)					
Source (S)	3.84	12.4	3.53	3.41	5.33
Combination (C)	2.86	10.5	2.22	1.68	3.18
S x C	2.72	6.87	3.44	1.67	2.87

Table 4: P rominent interaction effects of N-source and its combination on stolon production and its yield parameters.

Combination (N_{or} + N_{inorg} %)	Stolon production and its parameters				
	Stolon yield (t ha^{-1})	Plant height (cm)	Basal girth (cm)	Stolon No.$plant^{-1}$	Stolon length (cm)
MC 25 + U75	26	123.5	22.8	35	117
MC 50 + U50	27.6	114.6	25.5	40	118
NC 50 + U 50	20.4	126	15.4	37	112
PM 50 + U 50	25.2	106.7	23	37	112
PM 25 + U 75	26.6	119.6	23.4	36	111
CD (P=0.05)	2.72	6.87	3.44	1.67	2.89

Table 5: Periodical stolon production as influenced by N-source.

N-Source	Monthly stolon yield (t ha^{-1})							δ	SYI
	April	May	June	July	August	September	October		
Mustard cake	0.66	3.4	4.61	5.89	4.98	2.62	1.58	1.75	0.28
Neem cake	0.47	2.81	3.82	4.98	3.98	2.39	1.25	1.47	0.26
Poultry cake	0.55	4.21	5.02	5.59	4.92	2.62	1.34	1.82	0.29
Urea	0.93	5.15	5.79	6.02	4.9	2.85	1.68	1.9	0.23
Control	0.25	1.65	2.75	4.13	3.79	2.79	1.15	1.3	0.25
Mean	0.57	3.44	4.28	5.43	4.51	2.65	1.4		
δ	0.22	1.19	1.04	0.69	0.51	0.16	0.19		
SYI	0.37	0.43	0.57	0.77	0.8	0.87	0.72		

δ- standard deviation; SYI- stability yield index.

revealed that sole inorganic-N recorded 43% increased stolon production over sole organic nitrogen. Among the organic and inorganic combinations-organic 25% + inorganic 75% gave higher stolon yield than the other combinations. Organic 75% + inorganic 25% recorded the lowest stolon production. This was due to availability of higher amounts of readily available nitrogen to the crop, which encourages higher leaf growth of the crop.

Organic and inorganic N source interaction effect was significant for stolon production. Mustard cake 50% + urea 50% resulted into the highest yield (Table 4) whereas, neem cake 50% + urea 50% recorded the lowest.

Periodical stolon production. The monthly stolon production as influenced by organic sources revealed that there was much variation between harvestings from April to October (Table 5). The stolon yield peaked in the month of July irrespective of organic sources and its combinations with chemical fertilizer. Stolon production stability index (SYI) was also high during monsoon months irrespective of nutrient source. High stolon yields might be attributed to higher leaf growth as result of higher degree of air temperature and high intensity of solar radiation (Chan *et al.,* 1998). Among the N-sources, inorganic source like urea recorded higher yields from May to July, whereas, organic sources like mustard cake, poultry manure and neem cake attained maximum stolon production in the month of July. The non-fertilized crop laged much behind the organic and inorganic source of N fertilized crop.

Conclusion

The integrated use of organic sources of nitrogen with the chemical fertilizers in long duration crop like swamp taro proved beneficial for maintaining consistent stolon production over a long period. Inclusion of organic source to the chemical source in the proportion of 25% + 75% increased the production of swamp taro in sandy soil of lower Gangetic plains.

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