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PERFORMANCE OF SOME VEGETABLE CROPS ON DYKES IN LOW-LYING LANDS IN THE LOW COUNTRY WET ZONE

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ABSTRACT

Approximately 28,000 ha of low-lying lands are situated in the low country wet zone of Sri Lanka. Major portion of these lands are not cultivated to rice due to poor drainage, frequent flooding, coastal salinity and other soil related problems. Though growing highland crops upon changing the physical features can increase productivity of these lands, technical know-how is lacking. For this purpose, one acre block of low-lying land was converted to 3 m wide dykes and ditches at the land ratio of 1:1 and ten vegetable crops were grown to test their adaptability on dykes for 6 seasons (3 *yala* and 3 *maha* seasons) and compared with the growth of the crops in highland alluvials. As such, unsuitable soil properties of low-lying lands were converted to suitable level by making dykes. Results showed that vegetable crops such as brinjal, okra, cucumber, raddish and spinach were well adapted to dykes in low-lying land in both seasons. But it was observed that growth of *maha* crops was much better than *yala* crops. Knolkhol, cabbage and beet were adapted to these dykes only during *maha* season. This study revealed that changing the physical features of the low-lying lands can increase their productivity. In addition, two cropping periods, from November 15 to May 15, (*maha*) and from June 15 to October 15 (*yala*), should strictly be followed to avoid flood damage to the crops.

KEY WORDS: Dykes, Low-Lying Land, Vegetable Crop Adaptability

INTRODUCTION

Approximately, 28,000 ha of low-lying lands are situated in low country wet zones (LCWZ) of Sri Lanka (Panabokke, 1977) mainly in Colombo, Kalutara, Galle, Gampaha and Matara districts. These low-lying lands are the low-lying flood plains of streams, minor rivers, major rivers and low-lying lands bordering lagoons, lakes, filled up marshes (Panabokke, 1977). Since these lands occur largely in flood plains, deposition of alluvium is the major soil forming process in these areas. In area adjacent to residual highlands, depositions of colluvial materials are also taking place. As such, these soils should be more fertile than other soils in the area. Being low-lying relative to surrounding landscape, these lands suffer from poor drainage, anaerobic conditions and reducing soil processes (Dimantha, 1977). The soils are strongly acidic, low in bases and high in organic matter content (Dimantha, 1977). These areas get an annual rainfall of more than 2,500 mm from the two monsoons and inter monsoonal rains.

Soils classified into 3 Great Groups, bog, half bog and alluvial soils are found on these lands. Soils with more than 30% organic matter are classified as bog soils. Soils with less organic matter contents which are relatively better drained than bog soils are called alluvial and the soils with intermediate features are called half bog soils (Dimantha, 1977). Rice crop seems to be the obvious choice for these poorly drain soils (Mooryamsi, 1984). However frequent floods, salinity and soil toxic problems make rice cultivation difficult in these lands (Jayawardana, 1984).

To increase the rice yields within existing system of cultivation, the drainage has to be improved while preventing salt-water intrusion. However, initial investment and maintenance cost of drainage systems are very high and therefore these lands are either sparingly utilized or remains abandoned. Furthermore, these lands are of high value as they are located in densely populated west and southwest coastal plains where agricultural lands are diminishing due to urbanization. Therefore, these lands should receive serious consideration in order to increase their productivity through development programs like introduction of special farming system (Demanik, 1990, Bandara 1995, Syarifuddin, Manwan, 1988 CEA/EN, 1994 CEA/EN, 1994).

Therefore, this study was conducted to investigate the possibility of growing vegetable crops other than rice in low-lying lands by changing physical features of these lands.

MATERIALS AND METHODS

One acre of low-lying land with half bog soils at Agricultural Research Station, Bentota was selected for the experiment. The ground water level was monitored for 2 years before reclamation of the land for crop establishment. This land had stagnant water of more than 20 cm for most of months of the year except February, March and August and floods occur at least two times a year. Soil was sampled randomly from this field before reclamation and analysed for organic matter content, pH, electrical conductivity and nutrient contents (available P and exchangeable K) to determine the initial fertility level of the land.

After initial observations on soil fertility characteristic of the land, it was converted to ditches and dykes of 3 m wide and 70 m in length. Soil was removed to one-meter depth and dumped on to adjacent dykes making 3-meter wide ditches and dykes. Topsoil of the land converted to ditches was placed on the surface of the dykes to make it one meter height from natural landscape. Therefore dykes were always with typical low-lying land soil profile but at higher elevation to avoid flood hazards. The soils on dykes were leveled and prepared for crop establishment as recommended by the Department of Agriculture. Soil samples at monthly intervals and water samples at weekly intervals were obtained to determine pH and electrical conductivity, soil exchangeable K (1N NH_4OAc at pH 7), available P (Olsen P) and organic matter content (Walkley and Black method). Ground water level and rainfall were also monitored through out the year. Following vegetable crops were grown in this experimental plots to test their adaptability on these dykes. Radish (*Raphinus sativas*), Brinjal (*Solunum melongina*), Okra (*Abelmoscus* *esculentus)*, Cucumber *(Cucumis sativàs)*, Capsicum *(Capsicum anum)*, Spinach *(Basella alba)*, Knolkhol *(Knolkhol)*, Cabbage *(Brassica oleracea)*, Beet *(Beta valgaris)* and carrot were the tested vegetable crops.

Data was analyzed as a two-factor factorial (cropping season and soil condition). Two soil conditions (factor 1) were manmade dykes on low-lying land (site 1) and alluvial soils at higher elevation in the close vicinity which had ideal soil conditions for these crops (site 2) and two seasons (factor 2), one from June 15 to October 15 *(yala)* and another from November 15 to May 15 *(maha)* were used in the experiment. Experiment was laid out as a randomized complete block design with unequal replicates (6 replicates on dykes and 3 replicates on alluvial soils).

Crops were cultivated on site 1 and site 2 with recommended lėvels of management practices, *viz.* plant density, plant spacing, fertilization and other agronomic practices (DOA, 1990) for 6 seasons (3 *yala* seasons and 3 *maha* seasons) and observations on plant growth and marketable yield of each crop were recorded.

Yields of each crop from different treatments for six seasons were statistically analyzed by t-test at 5% probability levels and mean of yields of each crop for both sites and two seasons were compared to determine their performances on dykes and to determine most suitable cropping period for each crop on the dykes.

RESULTS AND DISCUSSION

Some important chemical properties of the soils from two sites at the beginning of the experiment are given in Table 1. Soil of the experimental site 1 was high in organic matter, acidic in reaction with medium electrical conductivity and contained low levels of exchangeable potassium and available phosphorus (Table 1).

Table 1. Some chemical properties of the soils at the experimental sites before reclamation

Property	*Site 1 (Dykes in Low-lying Soil)*	*Site 2 (Alluvial Soil)*
Organic matter % (Walkley and Black method)	26.8	7.2
pH (1:2.5 soil : water)	4.6	6.0
Electrical conductivity (1:2.5 mixture, ms/cm)	2.8	0.4
Excha. K (meq/100g)(1N NH_4OAc at pH 7)	0.06	0.1
Available P (mg/kg) (Olsen method)	4.1	6.2

However, alluvial soils (site 2) were low in organic matter, slightly acidic in reaction, very low in electrical conductivity, exchangeable K and available P (Table 1). Therefore soil of low-lying land selected for experiment was marginally suitable for rice cultivation and alluvial soil at comparatively higher elevation in site 2 was suitable for highland crop cultivation with suitable soil fertility management.

Rainfall and changes of ground water level in man made dykes

Weekly mean rainfall and ground water level for 3 years cropping period is given in Figure 1. It shows that rainfall received is bimodal and high rainfall was experienced in months of May and June for *yala* season and October and November for *maha* season. Rainfall intensity was higher during *yala* season than that of *maha* season.

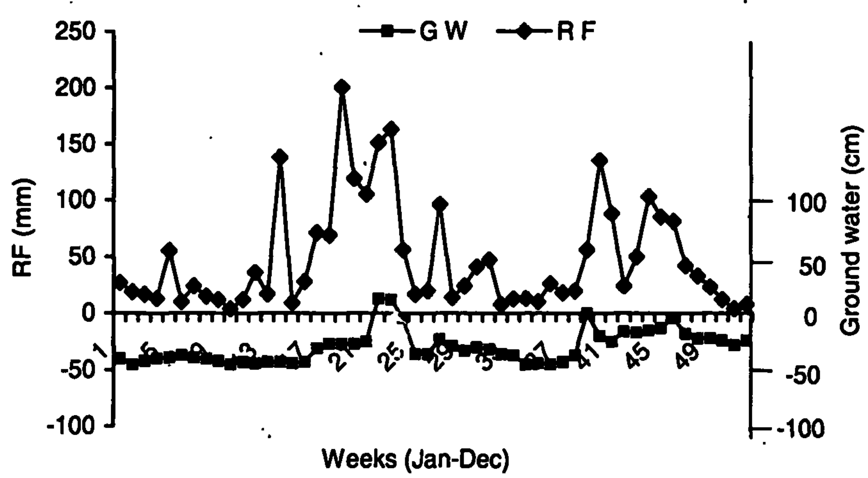

Figure 1. Weekly rainfall (RF) and ground water level (GW) in the experimental site 1 (mean for three years)

The month that received high intensive rainfall was subjected to high ground water level in dykes and sometimes caused flooding (Figure 1). Figure 1 also indicates that floods occur at least two times a year and remained for maximum of 6 days. Probability of floods was higher in the *yala* compared with the *maha* season. It also observed that ground water level in dykes in last season of the experimental period was high compared with previous seasons. This may be due to compaction and subsidence of soil mass of man made dykes with time. Therefore overtopping of soil is necessary in order to increase the elevation of dykes for protection of crops from floods.

Soil pH

Initial soil pH of the experimental site 1 was 4.6 (Table 1). It increased up to 5.9 after making dykes on this site due to mixing of surface soil with subsurface soil and aerobic decomposition of organic matter in soil (Ponnamperuma, 1977). Seashells found in subsurface soils of low-lying land area also caused increasing pH of site 1 with time (Figure 2). Within 3 years, pH was increased up to 6.9 which is optimum for normal plant growth.

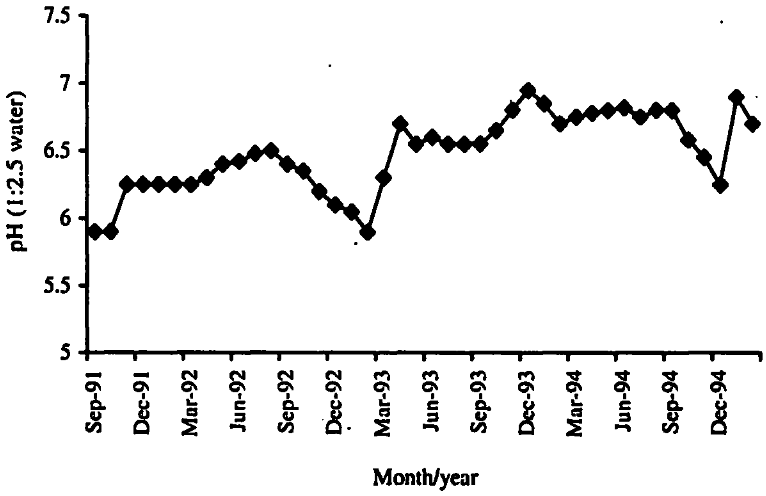

Figure 2. Soil pH in experimental site -1 from 1991-1995

Electrical Conductivity

Electrical conductivity of soil in 1:2.5 soil to water mixture ranged form 0.7 to 1.9 ms/cm in *yala* 1992, 1.8 - 2.9 ms/cm in *maha* 1992/93, 1.1 - 2.9 ms/cm in *yala* 1993, 1.2 - 3.6 ms/cm in *maha* 1993/94, 0.3 - 3.1 ms/cm in *yala* 1994 and 0.7 - 1.8 in *maha* 1994/95. EC was high in March and August when precipitation was low and sea water intrusion was high. EC was low in months of May, June, October and November when rainfall was high. Variation of electrical conductivity of soil during 3-year experimental period was ranged from 1.1 to 3.6 ms/cm (Figure 3).

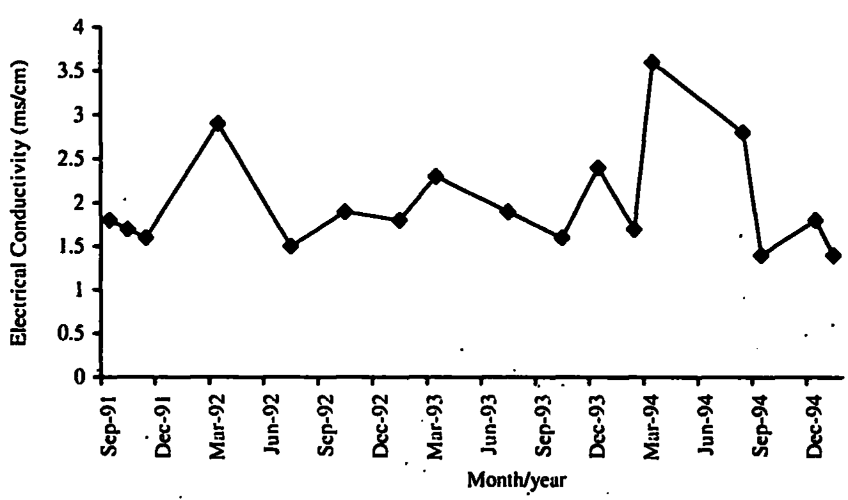

Figure 3. Electrical conductivity of soil from 1991 to 1995

High EC values reported in month of March (Figure 3) were due to salt-water intrusion to low lying land by high tide during months receiving very low or no rainfall (Figure 1). Although EC values of the soil observed in 1:2.5 soils to water mixture was low, it was high in saturated paste extract, which is the standard method for EC determination (Figure 4). Correlation between the two methods of EC determination showed that 3.0 ms/cm of EC in 1:2.5 soils to water mixture was equivalent to 8.0 ms/cm of EC in saturated paste extract (Figure 4). Therefore, in certain period of the year, soil of the experimental site 1 was saline in reaction.

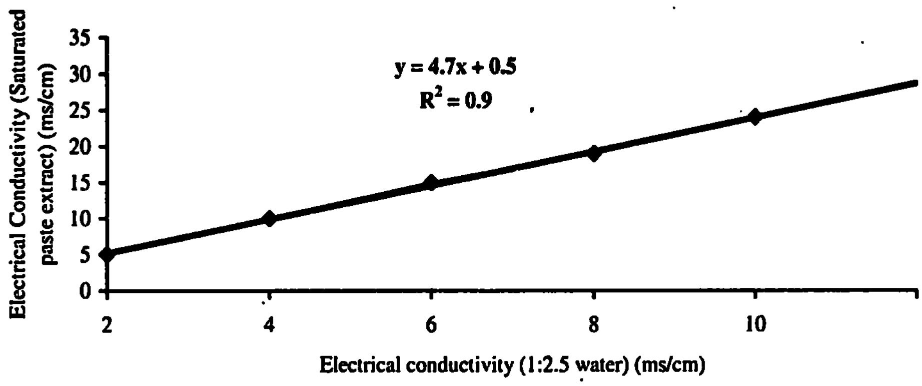

Figure 4. Relationship between two methods of electrical conductivity determination (1:2.5 soil to water mixture and Saturated paste extract)

Soil organic matter

Initial organic matter content of the experimental site 1 was 26%, indicating it was in a category of half bog soil (Table 1). However, initial organic matter content in dykes at the beginning of the crop establishment was 9.0% due to the mixing of surface soil with subsurface soil (Figure 5). This organic matter level was decreased upto 6.1% within 2-year period due to aerobic decomposition after reclamation (Figure 5).

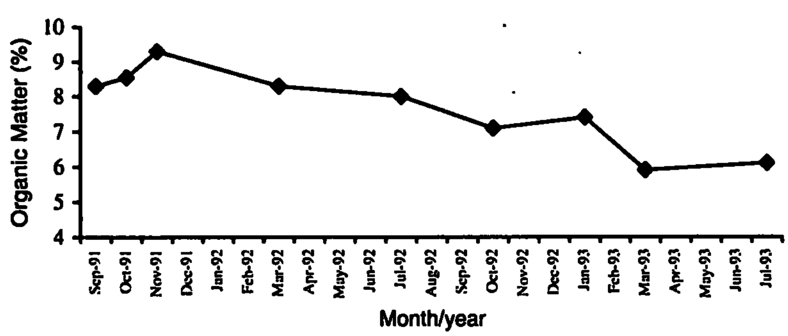

Figure 5. Organic matter content of soil in site 1 from 1991 to 1993

Therefore it can be concluded that reclamation of boggy soils to dykes provide good soil environment for plant growth.

Exchangeable potassium and available P

Initial exchangeable K in soils of site-1 at first planting was about 0.15 meq/100g soil, which was insufficient level for plant growth. However, it further decreased with time due to uptake by crops grown for 3 years (Figure 6).

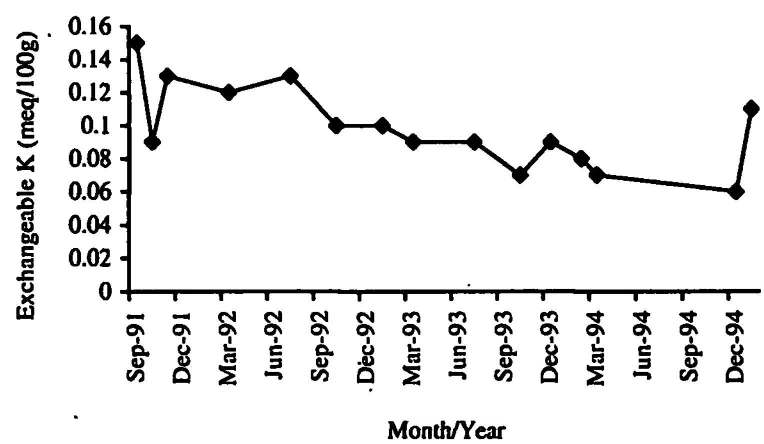

Figure 6: Exchangeable K of soil in site 1 from 1991 to 1995

Figure 6 shows that immediately after reclamation of soil, it was rich in exchangeable K which was released upon the decomposition of O M under aerobic condition. Soil available P during experimental period is shown in Figure 7. Available P in soil of site 1 extracted by Olsen method has increased due to decomposition of organic matter under aerobic condition and increased in soil pH. Therefore, reclamation of low-lying land to dykes increases the availability of soil P.

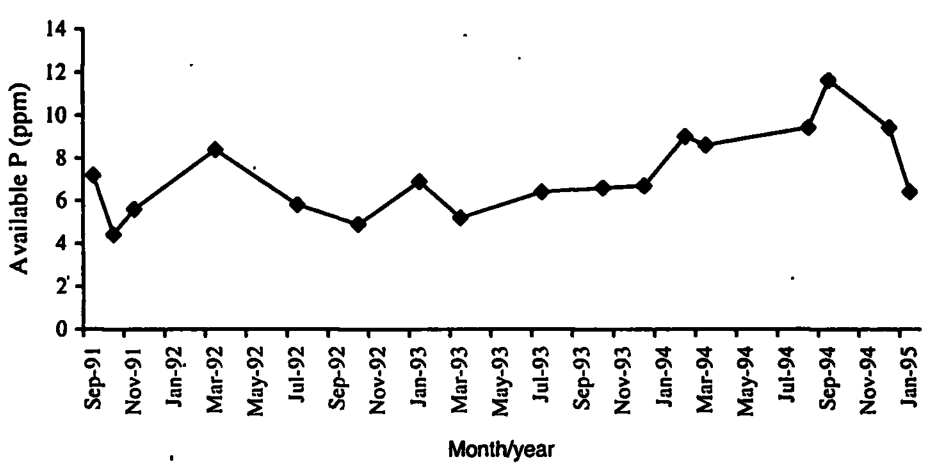

Figure 7. Available P of soil in site 1 from 1991 to 1995

Crop performance

Growth of raddish on dyke was better and gave a marketable yield of 27.6 t/ha where as yield of 30.2 t/ha was given from site 2 which has alluvial soil during *yala* season. No significant differences between the yields of raddish were obtained from 2 sites during *yala* and *maha* seasons. But comparatively higher yield was reported in *maha* season than *yala* (Table 2). Brinjal crop was not performed well on dykes compared with alluvials soils in site 2 during *yala* season. But marketable yields of Brinjal from both sites were higher during *maha* season (Table 2). Shorter period available for harvesting due to heavy rainfall for long period and low crop growth due to bad weather conditions would be the reason for lower yield during *yala* season. Growth and yield of cucumber from both sites were comparable but lower yield was recorded during *yala* (Table 2). Yield of okra from site 1, where dykes were made, was low when compared to site 2 in *yala* season, however *maha* crop of okra on both sites gave comparatively higher yield (Table 2).

Table 2. Marketable yield (t/ha) of different vegetable crops (Mean yield for three seasons) grown on dykes on low-lying lands in site 1 and alluvial upland soils in site 2.

Crop	*Yala*			*Maha*			
	Site 1	*Site 2*	*LSD (0.05)*	*Site 1*	*Site 2*	*LSD (0.05)*	*cv %*
Raddish	27.6	30.2	3.1	35.1	36.6	3.8	12.3
Brinjal	2.5	9.3	1,8	20.1	21.6	1.4	17.0
Cucumber	17.1	12.8	2.3	21.3	20.0	2.4	14.3
Okra	9.6	13.0	2.8	17.8	17.5	3.2	14.9
Spinach	23.5	19.2	4.4	18.4	19.4	2.8	10.2

Spinach, a leafy vegetable which uses more water for growth performed well on site 1 and gave higher yield during *yala* than *maha* season (Table 2). Therefore, out of all crops established on dykes, spinach is well adapted on dykes even during *yala* season. Early growth of upcountry vegetables such as capsicum, beet, and carrot was good but had problem of surviving on dykes during *yala* due to heavy rainfall and high ground water level in latter part of the growing period on dykes (Figure.1). But reasonable yields of these crops were reported from dykes during *maha* season but it was always lower than the yield from site 2 (Table 3).

Growth and yield of knolkhol on both sites were comparable showing its adaptability to man-made dykes on low-lying land in both seasons (Table 3). Growth of cabbage was relatively better in both sites during *maha.* But yields from both sites were comparatively lower during *yala* season (Table 3). Growth and yield of beet were better in *maha* season in both sites (Table 3). Carrot could be grown only during *maha* and its yield form site-1 was low.

Leaf rot disease in cabbage and root rot disease in beet crop due to bad weather condition prevailed during *yala* season attributed for lower yields

Table 3. Marketable yield (t/ha) of different vegetable crops (Mean yield for three seasons) grown on dykes on low-lying lands in site 1 and alluvial upland soils in site 2

Crop	*Yala*			*Maha*			
	Site 1	*Site 2*	*LSD (0.05)*	*Site 1*	*Site 2*	*LSD (0.05)*	*cv%*
Capsicum	2.3	5.6	1.4	6.8	10.6	2.8	16.3
Knokhol	12.7	12.9	2.3	12.9	12.8	2.8	8.5
Cabbage	10.6	14.8	3.8	33.2	34.3	2.1	17.3
Beet	4.8	4.4	1.2	10.4	15.5	3.1	18.0
Carrot	-	-	-	8.6	11.6	2.6	9.3

Tested crops performed better during *maha* season, which has a longer cropping period as compared to *yala*. High rainfall, high ground water level and shorter cropping period during *yala* lead to a lesser crop adaptability to dykes. Comparatively medium rainfall and longer cropping period during *maha* provide better soil environment for vegetable crop growth. High ground water level as a result of lower elevation of dykes due to subsidence and compaction of soil has affected the crop growth during latter stages of the experiment.

Rainfall pattern of the year showed that heavy rainfall experienced during May and June for *yala* and October and November for *maha* caused high ground water level in dykes or flood for 2-4 days (Figure 1). Therefore, cropping period should be strictly followed to avoid flood damage to the crops established. Accordingly two cropping periods or calendars, one from June 15 to October 01 when most of the cropping time fall in to *yala* and the other one from November 15 to May 15 when most of the cropping time falls into *maha* season can be proposed. However, crops are more adaptable on dykes during second cropping period.

As soil compaction and subsidence in dykes occur due to aerobic decomposition of soil organic matter, overtopping of dykes with soils from the bottom of ditches is needed at least once in 3 years in order to increase the elevation of dykes for crop cultivation. Initial unsuitable soil chemical properties such as low pH and high organic matter content in soil for crop growth can be converted to suitable level by reclaiming of this land to ditches and dykes.

Crop adaptability tests on dykes compared to good soil environment conducted for 3 year period indicated that low country vegetable such as raddish, okra, brinjal, spinach, cucumber and upcountry vegetable such as knolkhol can be successfully cultivated on man made dykes in both seasons if cropping periods are strictly followed. Adaptability of cabbage and beet crops on dykes is better in second cropping period which ranges from November 15 to May 15. Cultivation of capsicum and carrot cannot be recommended on this dyke in low-lying land.

CONCLUSIONS

Systematical conversion of the low lying lands in low country wet zone into dykes and ditches appears to be a logical land management technique to improve crop productivity. Dyke and ditch system found to be successful to convert abandoned low lying lands for cultivation of vegetables such as raddish, okra, brinjal, spinach, cucumber and knolkhol.

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