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**ADAPTABILITY OF DIFFERENT FIELD CROPS
UNDER LAHAR-LADEN SOILS**

By

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ABSTRACT

Seventeen different annual field crops namely; sweet potato, cassava, upland gabi, arrowroot, yambean, peanut, mungbean, soybean, cowpea, pigeon pea, corn, sorghum, roselle, sesame, hot pepper, leguminous covercrops and tororo-aoi were tested on a formerly lowland rice irrigated area totally covered with lahar at a depth of 1.5 to 2.0 meters primarily to determine and identify which crop can be grown suitably and successfully after the rainy season wherein the danger of lahar flow is extremely low. This study was conducted at Barangay San Antonio, Bacolor, Pampanga from November, 1991 to July, 1992.

The agronomic and yield responses of the test crops were the parameters used as basis in assessing their adaptability to lahar. Test crops were critically observed under two growing scenarios (i.e., fertilized based on the recommended rate under normal condition and unfertilized).

After 3 to 8 months of growth, results showed that plant growth and yield depend largely on the kind of crops and cultural and management inputs given to them. Stunted growth was very evident on all test crops grown without fertilizer due to the inadequacy of nutrients present in the lahar that is necessary for the sustenance for a normal growth. Laboratory analysis of the lahar deposits in the test site revealed that it contained 0.12% total N, 0.13% total P_2O_5 , 0.38% total K_2O , 0.09 S, 0.30% total Fe and 7.96 pH value. However, when applied with the recommended rate of complete fertilizer (14-14-14), there was a great manifestation that some crops could thrive and performs well in lahar.

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Among the initially tested crops, sweet potato, cassava, mungbean, peanut, cowpea, pigeon pea, corn, sorghum, soybean, sesame and leguminous covercrops appear to be the most suitable for lahar. Although the growth and yield of these entries are not as superior as when grown under normal conditions, these crops showed better seedling vigor, uniform emergence, high percentage of survival, uniform crop stand and reasonable yield. These characteristics of the crops under strange environment made it suitable or adaptable to the prevailing situation in the area (lahar).

INTRODUCTION

The deposition of tons and tons of volcanic debris over wide agricultural areas in Central Luzon specifically in the provinces of Zambales, Bataan, Tarlac and Pampanga as a result of Mt. Pinatubo's eruption in June 15, 1991 has been a great concern as this affect the sustainability of agricultural production in the region. The eruption wrought great havoc and devastation to the once productive lands of these provinces. The ashfall has caused tremendous damage but greater damage was caused by lahar resulting in the siltation of vast agricultural lands specifically lowland rice areas.

In Tarlac alone, a total of 11,345 hectares of rice farm land covering eight municipalities have been damaged by lahar and in Pampanga, damaged rice farm land totaled 5,951 hectares covering thirteen municipalities. Lahar and sand deposits spilled from Mt. Pinatubo have rendered these farm lands uncropable or unproductive that have been giving income and source of livelihood to its people.

But hope is not lost in bringing back the lahar-laden soils to its original productive capability. The selection and identification of potential annual field crops adaptable or suitable under a set of adverse environment is imperative if only to help affected farmers regain their lost farm jobs and opportunities for a better tomorrow. Hence, this study with the objective of identifying and determining what crops can be grown suitably and successfully after the rainy season when the danger of lahar flow is extremely low.

MATERIALS AND METHODS

Place and Duration of the Study : This study was conducted at Barangay San Antonio, Bacolor, Pampanga from November 1991 to July 1992. The site was formerly a lowland rice irrigated area which was totally buried and covered with lahar at a depth of 1.5 meters to 2.0 meters.

Materials : The different annual field crops belonging to three distinct commodity groups used in the study were the following :

- A. Rootcrops
 - 1. Sweet potato
 - 2. Cassava

- 3. Taro (upland gabi)
- 4. Yambean
- 5. Arrowroot

- B. Cereal Crops

- 1. Corn
- 2. Sorghum

- C. Field Legume Crops

- 1. Peanut
- 2. Mungbean
- 3. Soybean
- 4. Cowpea
- 5. Pigeon pea

- D. Other Field Crops

- 1. Sesame
- 2. Roselle
- 3. Hot pepper
- 4. Leguminous cover crops
- 5. Tororo-aoi

Field Preparation : The experimental area was cleared of scattered and embedded volcanic debris like pumice and pumice stones and other debris. Plots were dug manually using garden tools as garden hoe, shovel, spade and spading fork and rake.

Laying Out of the Field : Test crops were planted at random at the experimental lot covering an area of 696.0 square meters. Each crop was planted on a single plot five meters long and four meters wide or a total area of 20.0 square meters. Each plot divided into two with one half fertilized with the recommended rate and the other half unfertilized. The recommended distances and systems of planting and the fertilization scheme for each crop based under normal growing condition were employed and strictly followed.

Care of the Plants : The test crops received uniform care and management throughout their growing period based on their specific cultural needs. Extra efforts were done in providing the necessary cultural provisions that the crops need such as shallow cultivation and water so as to maintain a good crop stand. Weeds were not a problem in the area. The crops were likewise sprayed with insecticides and fungicides at recommended dosage to minimize crop damage caused by insect pests and diseases.

Data Gathering : Records were made on specific parameters on growth and yield of each crop as a basis in assessing crop response. Plants selected at random from the middle rows were used as sources of data.

Computed yield per hectare was determined in terms of metric tons based on the actual yield performance of the crop harvested based on population.

Chemical Analysis of the Pyroclastic Material: A sample of the material taken from the experimental site was submitted for laboratory analysis at the BPI Laboratory Services Division for total N, P, K contents and other elements as well as pH level (Appendix 1).

RESULTS AND OBSERVATION

The growth and yield were the parameters used as basis in evaluating and assessing their adaptability or suitability of the annual crops planted under lahar condition.

The different field crops under study were given uniform treatment. In spite of this, it could be noted that the growth and yield responses depend largely on the kind of crops and the amount of fertilizer inputs given to them. But evidently, it was observed that the application of recommended rates of fertilizers greatly influenced the growth and yield of all test plants.

Observations taken for 3-8 months showed the following results:

Sweet Potato - This crop can be grown in a wide range of soil from heavy to light soils. However, for better yields, areas with sandy loam soils rich in organic matter is preferred. The results on the growth and yield response of sweet potato in lahar is shown in Table 1.

Results showed that Sweet Potato var. BPI Sp2 thrives and responds well in lahar when applied with a recommended rate of 6 bags of complete fertilizer (14-14-14) per hectare. Based on the results, lahar can sustain the growth of sweet potato at 100% survival of planted cuttings for both fertilized and unfertilized treatments but at varying degrees of growth development. It was observed that fertilized plants developed more main laterals at an average of two main laterals per plant while unfertilized plants developed only one main lateral. It was further observed that there was a marked difference on the length of vines. Sweet Potato vines when fertilized attained an average length of 83.4 cm and only 23.4 cm when unfertilized.

On yield response, fertilized plants yielded more number of marketable tuberous roots at an average of 3 tubers per plant. The sizes of marketable tubers were bigger with an average weight of 257.33 gm per tuber, while the unfertilized plants yielded an average of 1 tuber per plant with an average weight of 150.0 gm. With these figures, a yield of 30.9 MT/ha or even much higher will be attained when applied with the right amount of fertilizers compared to a yield of 6.0 MT/ha or even lower when grown without fertilizers.

Table 1. Observations on Agronomic Characters and Yield of Sweet Potato Tested in Lahar.

PARAMETERS	GROWING CONDITION	
	1/ FERTILIZED	Unfertilized
A. Growth		
1. Percentage of Emergence/ Survival	100 %	100 %
2. Number of main lateral stem/hill	2	1
3. Average Length of vine (cm) 2/	83.4	23.4
B. Yield		
1. Average number of tuberous roots/plant 2/	4.0	2.0
2. Average weight of tuberous roots. plant 2/	798.0 grams	130.0 grams
3. Average weight per tuber	199.5 grams	65.0 grams
4. Average number of marketable tuber/plant 2/	3.0	1.0
5. Average weight of marketable/tuber plant 2/	771.99 grams	150.0 grams
6. Average weight per marketable tuber	257.33 grams	150.0 grams
7. Number of plants per hectare 3/	40,000 hills	40,000 hills
8. Computed yield per hectare (marketable tubers)	30.9 MT	6.0 MT

* Variety Used : BPI Sp 2

1/ Applied with the recommended rate at six bags of complete fertilizer (14-14-14) per hectare based on normal condition.

2/ Average of 10 samples

3/ Planted at a distance of 1.0 m between rows and 0.25 meter within the row.

Based on this findings, it is concluded that Sweet Potato is considered a suitable/potential crop that could be grown as source of income for farmers in lahar affected areas.

Cassava - This crop performs best in light to medium textured soil that is friable, well-drained, well-aerated, rich in organic matter and with a good tilt. Presented in Table 2 are the percentage of survival, number of main stems, height of plant, number of marketable tubers produced per plant and the average weight per marketable tuber and yield per hectare.

Results showed that Cassava var. Golden Yellow can thrive and perform well in lahar when applied with a recommended rate of 5 bags of complete fertilizer (14-14-14) per hectare. Results demonstrated that lahar can support the growth of cassava whether fertilized or unfertilized as manifested by the high percentage of survival of planted cuttings at 100% but to a certain level of growth. Though the average number of main stems developed per plant on both fertilized and unfertilized treatments did not vary so much, there was a marked difference on plant height. Fertilized cassava plants were taller and attained an average height of 70.9 cm while the unfertilized plants attained an average height of 37.2 cm.

On yield, results showed that there was a marked difference on the number of tuberous roots produced per plant between fertilized and unfertilized plants. Cassava plant when fertilized yielded an average of 4.1 tubers per plant with an average weight of 195.0 gm per tuber, while the unfertilized plants yielded an average of 1.1 tuber per plant with an average weight of 113.5 gm per tuber. Furthermore, the sizes of tubers produced in terms of length were all considered marketable. However, fertilized plants produced longer and stouter tubers ranging from 8.0 cm to 35.0 cm in length while the unfertilized plants produced shorter and less stouter tubers which ranges from 6.0 cm to 22.0 cm. A yield of 15.6 MT/ha or higher will be attained when applied with the appropriate amount of fertilizer compared to 2.27 MT/ha or lower when unfertilized.

Based on the results, it is concluded that Cassava is considered a potential crop that can be growth suitably in lahar areas.

Peanut - This crop grows best in deep, well-drained and light textured soils such as loam, silt loam, silty clay loam, sandy clay loam and sandy loam soils. These types of soils are loose and friable which enhances the peg to penetrate the soil surface easily and to develop into well-formed pods. The results on the growth and yield performance of peanut in lahar are shown in Table 3.

Results showed that Peanut var. BPI Pn 2 can thrive and perform well in lahar when applied with a recommended rate of 4 bags of complete fertilizer (14-14-14) per hectare. It was observed that there was a marked difference on plant height between fertilized and unfertilized plants.

Table 2. Observation and Agronomic Characters and Yield of Cassava Tested in Lahar.

PARAMETERS	GROWING CONDITION	
	FERTILIZED 1/	Unfertilized
A. Growth		
1. Percentage of Emergence/ Survival	100 %	100 %
2. Average number of main stem/hill	2.1	1.6
3. Average Height of plant (cm) 2/	70.9	37.2
B. Yield		
1. Average number of tuberous roots / plant 2/	4.1	1.1
2. Average weight of tuberous roots/ plant 2/	780.0 grams	113.5 grams
3. Average weight per tuber	195.0 grams	113.5 grams
4. Average number of marketable tuber/plant 2/	4.1	1.1
5. Average weight of marketable tuber/plant 2/	780.0 grams	113.5 grams
6. Average weight per marketable tuber	195.0 grams	113.5 grams
7. Average length of tubers	20.5 cm	13.73 cm
8. Number of plants per hectare 3/	20,000 hills	20,000 hills
9. Computed yield per hectare (marketable tubers)	15.6 MT	2.27 MT

* Variety Used : Golden Yellow

1/ Applied with the recommended rate at five bags of complete fertilizer (14-14-14) per hectare based on normal condition.

2/ Average of 10 sample plants.

3/ Planted at a distance of 1.0 m x 0.50 m.

Table 3. Observations on Agronomic Characters and Yield of Peanut Tested in Lahar.

PARAMETERS	GROWING CONDITION	
	FERTILIZED 1/	Unfertilized
A. Growth		
1. Average plant height (cm) 2/	36.6	15.2
2. Number of days to flowering	51 DAS	51 DAS
3. Number of days to maturity	110 DAS	110 DAS
B. Yield		
1. Average number of pods per hill at 2 plants / hill 2/	25	4
2. Average number of seeds per pod 2/	2	2
3. Average weight in grams per pod (dried)	0.92 gms.	0.864 gms.
4. Wt. in Grams per 100 seeds	34.9 gms.	32.1 gms.
5. Number of hill per hectare 3/	100,00 hills	100,00 hills
6. Computed yield per hectare		
Unshelled	2.3 MT	0.346 MT
Shelled	1.7 MT	0.257 MT
7. Percentage of Shelling	74%	74%

* Variety Used: BPI Pn2

1/ Applied with the recommended rate at four bags of complete fertilizer (14-14-14) per hectare based on normal condition.

2/ Average of 10 sample hills.

3/ Planted at a distance of 0.50 m x 0.20 m at 2 seeds/hill.

Unfertilized plants had shown a very poor growth. It attained an average height of 15.2 cm at maturity. However, when fertilized, the growth of peanut improved immensely and attained a height of 36.6 cm at maturity, more than doubling its height when unfertilized. The number of days after planting to flowering and to maturity did not vary. Though there was a marked difference on plant height between the two treatments, lahar had demonstrated that it can sustain the growth of peanut.

The results showed further that peanut can develop and produce pods in lahar. The number of pods produced per plant, however greatly differed between fertilized and unfertilized plants. Unfertilized plants yielded lesser pods at an average of 4 pods per hill. The fertilized plants yielded more number of pods to the 6th fold at an average of 25 pods per hill. Furthermore, the seeds of fertilized plants were heavier compared to the seeds of unfertilized plants weighing 34.9 gm and 32.1 gm per 100 seeds, respectively.

With the good performance that peanut had shown in lahar, a yield of 1.7 MT/ha (shelled) or higher will be attained when the right amount of fertilizer will be applied. Therefore, peanut can be concluded as a potential crop that can be grown suitably in lahar as a source of income for the farmers.

Soybean - This crop performs best in a well-drained soil of silt loam or the loam type rich in organic matter in a level or slightly rolling topography. Light sandy soils and heavy clay soils do not induce a healthy root development. The results on plant height at maturity, days to flowering and maturity, height of lowest pod from the ground, pods per plant and seed weight of soybean grown in lahar are shown in Table 4.

Results showed that Soybean var. BPI Sy 4 can thrive and perform better in lahar when applied with a recommended rate of 4 bags of complete fertilizer (14-14-14) per hectare. Observations on growth showed that fertilized plants were taller with an average height of 32.1 cms than the unfertilized plants with 25.4 cms. It was noted that both fertilized and unfertilized plants did not differ on the number of days to flowering and to maturity as both plants flowered 48 days after seeding (DAS) and matured 79 DAS. On the height of the lowest pod that developed from the ground level, fertilized plants developed more closer to the ground at an average height of 12.3 cm compared to unfertilized plants which developed higher from the ground at an average of 16.8 cm.

In terms of yield, results showed mark difference on the number of pods produced. Fertilized plants yielded more pods at an average of 12 pods per plant while the unfertilized plants produced very few pods at an average of 3 pods per plant. The number of seeds per pod did not differ as both plants contained two seeds per pod. With regards to seed weight per 100 seeds, fertilized plants produced heavier seeds than the unfertilized

Table 4. Observations on Agronomic Characters and Yield of Soybean Tested in Lahar.

PARAMETERS	GROWING CONDITION	
	FERTILIZED	1/ UNFERTILIZED
A. Growth		
1. Average plant height at maturity (cm) 2/	32.1	25.4
2. Number of days to flowering	48 DAS	48 DAS
3. Number of days to maturity	79 DAS	79 DAS
4. Average height to lowest pod from the ground (cm) 2/	12.3	16.8
B. Yield		
1. Average number of pods per plant (2 plants/hill) 2/	12	3
2. Average number of seeds per 100 seeds	2	2
3. Weight in gram per 100 seeds	10.7 ges	8.4
4. Number of hill/plant per hectare 3/	80,000 hills (160,000 plants)	80,000 hills (160,000 plants)
5. Computed yield per hectare	0.411 MT	0.081 MT

* Variety Used: BPI Sy 4

1/ Applied with the recommended rate at four bags of complete fertilizer (14-14-14) per hectare based on normal condition.

2/ Average of 10 sample plants.

3/ Planted at a distance of 0.50 m x 0.25 m at 2-3 seeds/hill.

plants weighing 10.7 gm and 8.4 gm, respectively.

Based on its performance, a yield of 0.411 MT/ha is attained with the application of fertilizer. Though its yield performance is below par, soybean had shown promising signs as a potential crop in lahar laden soils.

Cowpea - This crop can do well on almost any type of soil provided it is well-drained and good crop can be grown on light sandy soils as well as on heavy clay soils. However, growing areas with lighter, loamy soil is more preferred because the plants mature earlier than on the heavier soils. The results on plant height, days to flowering and maturity, number of pods per plant, number of seeds per pod, seed weight and yield/ha are shown in Table 5.

Results showed that Cowpea var. E.G. Red can thrive and respond well in lahar when fertilizer was applied at recommended rate of 6 bags of complete fertilizer (14-14-14) per hectare. As to its growth performance, fertilized plants were taller and attained an average height of 27.5 cm while the unfertilized plants attained an average height of 9.2 cm at maturity. No differences were observed on the length of time from planting to flowering and maturity as both fertilized and unfertilized plants flowered 42 DAS and matured 58 DAS.

On yield, results showed a marked difference. Fertilized plants yielded more pods with an average of 11 pods per plant compared to 1 pod per plant when unfertilized. There was also a marked difference on the number of seeds per pod. Fertilized plants produced an average of 10 seeds per pod while the unfertilized plants produced an average of 1 seed per pod. However, on seed weight, no comparison can be made due to the insufficient number of seeds produced on unfertilized plants, but the weight in grams per 100 seeds from fertilized plants was 12.6 gm. With this performance, a yield of 0.924 MT/ha or higher will be attained when the right amount of fertilizer is applied.

Based on the results, it is concluded that Cowpea is a potential crop that can be grown suitably in lahar as a source of income by the affected farmers.

Mungbean - This crop can be grown in a wide range of soil type from clay loam to silty loam soils. For optimum bean yield, light clay loam soils with a depth of at least 50 cm, well-drained with a moderate supply of organic matter is more preferred. The plant height, days to flowering and maturity, number of pods per plant, number of seeds per pods, seed weight and yield/ha are shown in Table 6.

Results showed that Mungbean var. Pag-asa 7 can thrive and respond well in lahar when applied with fertilizer at recommended rate of 4 bags of complete fertilizer (14-14-14) per hectare. For its growth

Table 5. Observations on Agronomic Characters and Yield of Cowpea Tested in Lahar

PARAMETERS	GROWING CONDITION	
	FERTILIZED 1/	Unfertilized
A. Growth		
1. Average plant height (cm) 2/	27.5	9.2
2. Number of days to flowering	42 DAS	42 DAS
3. Number of days to maturity	58 DAS	58 DAS
B. Yield		
1. Average number of pods per plant (2 plants/hill) 2/	11	1
2. Average number of seeds per pod 2/	10	1
3. Weight in gram per 100 seeds	12.6 gms.	No enough seeds were produced
4. Number of hill per hectare 3/	33,333 hills (66,666 plants)	32.1 grams
5. Computed yield per hectare.	0.924 MT	

* Variety Used: EG Red

1/ Applied with the recommended rate at six bags of complete fertilizer (14-14-14) per hectare based on normal condition.

2/ Average of 10 sample plants.

3/ Planted at a distance of 1.0 m x 0.30 m, 2-3 seeds per hill.

Table 6. Observations on Agronomic Characters and Yield of Mungbean Tested in Lahar.

PARAMETERS	GROWING CONDITION	
	FERTILIZED 1/	Unfertilized
A. Growth		
1. Average plant height at maturity (cm) 2/	18.8	6.3
2. Number of days to flowering	61 DAS	61 DAS
3. Number of days to maturity	74-81 DAS	74-81 DAS
B. Yield		
1. Average number of pods per plant (2 plants / hill)	19	1
2. Average number of seeds per pod	8	1
3. Weight in gram per 100 seeds	5.3	No enough seeds were produced
4. Number of hill/ plant per hectare 3/	80,000 hills (160,000 plants)	
5. Computed yield per hectare	1.29 MT	

* Variety Used: Pag-asa 7

1/ Applied with the recommended rate at four bags of complete fertilizer (14-14-14) per hectare based on normal condition.

2/ Average of 10 sample plants.

3/ Planted at a distance of 0.50 m x 0.25 m at 2-3 seeds per hill.

response, fertilized plants are much taller than the unfertilized plants. They attained an average height of 18.8 cm and the latter attained an average height of 6.8 cm at maturity. However, plants on both treatments flowered within 61 DAS and matures within 13-20 days from flowering or 74-81 DAS.

In terms of yield, results showed that fertilized plants produced more pods with an average of 19 pods per plant compared to 1 pod per plant on unfertilized plants. Pods produced from fertilized plants contained more developed seeds with an average of 8 seeds per pod compared to only one developed seed per pod from unfertilized plants. Based on this results, a bean yield of 1.29 MT/ha or higher will be attained when the right amount of fertilizer is applied. Therefore, it is concluded that Mungbean is a potential crop that can be grown suitably in lahar as source of nutrition and income by the affected farmers.

Corn - The best soil for corn is silt loam or loam type, rich in organic matter, well drained with a level or slightly rolling topography. Light sandy soils and heavy clays do not induce healthy root development. The growth and yield responses of corn in lahar are shown in Tables 7 and 8.

Results revealed that Sweet Corn and Glutinous corn can thrive and perform well in lahar when applied with fertilizer at recommended rate of 4 bags of complete fertilizer (14-14-14) per hectare. For its growth performance, it is very evident that fertilized plants are much taller with an average height of 136.5 cm compared with 38.7 cm for unfertilized plants (Sweet Corn). On the other hand, Glutinous corn also attained an average height of 160.5 cm when fertilized and 46.4 cm when unfertilized. Furthermore, results revealed that fertilized plants were able to produce quality ears while the unfertilized plants failed to produced not even a single small ear. Corn ears produced by Sweet Corn and Glutinous Corn had an average length of 17.5 cm and 16.7 cm, respectively. Both green corn varieties silked within 48 days after seeding.

Results on yield showed that a minimum of 40,000 pieces of green corn ears per hectare will be attained or higher depending on the distance of planting (i.e., high density population). For as long as priority attention is given to the cultural and management practices that the crops need such as application of fertilizer, water/irrigation and control of pests, green corn production in lahar is feasible as demonstrated in the study. Therefore, it is concluded that corn is a suitable crop in lahar areas.

Table 7. Observations on Agronomic Characters and Yield of Sweet Corn Tested in Lahar.

PARAMETERS	GROWING CONDITION	
	FERTILIZED 1/	Unfertilized
A. Growth		
1. Average plant height at harvesting (cm) 2/	136.5	38.7
2. Average ear length (cm) 2/	17.5	No ear produced
3. Number of days to silking	48 DAS	
B. Yield		
1. Number of ear per plant	1	No ear
2. Number of seeds/ear	a/	
3. Weight in gram per 100 seeds	a/	
4. Number of hill/ plant per hectare (2 plants per hill) 3/	20,000 hills (40,000 plants)	
5. Computed yield per hectare (i.e. no. of ears) 4/	40,000 ears	

1/ Applied with the recommended rate at four bags of complete fertilizer (14-14-14) per hectare based on normal condition.

2/ Average of 10 sample plants.

3/ Planted at a distance of 1.0 m x 0.50 m at two seeds plants/hill.

4/ Test plants were harvested at 79 DAS.

a/ Harvested as green corn.

Table 8. Observations on Agronomic Characters and Yield of Glutinous Corn Tested in Lahar.

PARAMETERS	GROWING CONDITION	
	FERTILIZED 1/	Unfertilized
A. Growth		
1. Average plant height at maturity (cm) 2/	160.5	46.4
2. Average ear length (cm) 2/	16.7	No ear produced
3. Number of days to silking	48 DAS	
B. Yield		
1. Number of ear per plant	1	No ear
2. Average number of seeds / ear 2/	380	-
3. Weight in gram per 100 seeds	12.8 grams	-
4. Number of hill/ plant per hectare (2 plants per hill) 3/	20,000 hills (40,000 plants)	-
5. Computed yield per hectare (grain yield).	1.94 MT	-

* Variety Used : Macapuno

1/ Applied with the recommended rate at four bags of complete fertilizer (14-14-14) per hectare based on normal condition.

2/ Average of 10 sample plants.

3/ Planted at a distance of 1.0 m x 0.50 m at two seeds plants per hill.

Sorghum - This crop can be grown well on a wide range of soil types, but they do best on deep, fertile, sandy loam soils. Good yields are also obtained on heavy types of soil provided they are well-drained. The plant height, number of days to flowering, number of seeds or grain per panicle, grain weight and yield/ha are shown in Table 9.

Results showed that Sorghum var. IES Sor 4 thrives and performs well in lahar when fertilizer is applied at a recommended rate of 4 bags of complete fertilizer (14-14-14) per hectare. As to its growth, fertilized plants were taller with an average height of 118.4 cm compared to unfertilized plants with an average height of 33.4 cm only. Fertilized plants flowered and matured within 64 DAS and 96 DAS, respectively. Unfertilized plants were unable to flower.

On yield, results revealed that fertilized plants were able to produce panicles while the unfertilized plants failed to produce panicle. Furthermore, a panicle contained an average of 557 grains weighing 3.28 gm per 100 grains. Based on this yield response, a yield of 3.65 MT to 5.48 MT/ha is attained when the right amount of fertilizer is applied. It is concluded therefore, that Sorghum is a potential crop that can be grown suitably in lahar as source of income and livelihood for the farmers.

Pigeon Pea - This crop grows best on fertile and well-drained soil. They can be grown on most types of soil but they prefer loam soils especially clay loam soils. The plant height, days to flowering and maturity, number of pods per plant, seed weight and yield/ha are shown in Table 10.

Results showed that Pigeon Pea can thrive and perform well in lahar when applied with fertilizer at recommended a rate of 6 bags of complete fertilizer (14-14-14) per hectare. As to its growth performance, fertilized plants were taller than the unfertilized ones. The former attained an average height of 74.0 cm while the latter attained an average height of 30.2 cm. The number of days to flowering did not differ as both fertilized and unfertilized plants flowered 65 DAS. However, it was observed that only the fertilized plants were able to develop pods and matured 98 DAS or 33 days from flowering. Flowers of unfertilized plants were aborted.

In yield, results showed that fertilized plants were able to produce pods at an average of 109 well developed pods per plant while the unfertilized plants failed to produce pods because of flower abortion. The pods contained an average of two well developed seeds per pod weighing 11.6 grams per 100 seeds. With this yield parameter, a yield of 0.51 MT/ha is attained with the application of the right amount of fertilizer. Though the yield obtained is below par under normal conditions, it is not an indication that pigeon pea is not adaptable or suitable for lahar. There is a great possibility that the yield could be substantially increased as the population/ha be increased (i.e., high density planting). Therefore, it can

Table 9. Observations on Agronomic Characters and Yield of Sorghum Tested in Lahar.

PARAMETERS	GROWING CONDITION	
	FERTILIZED 1/	Unfertilized
A. Growth		
1. Average plant height (cm) 2/	118.4	33.4
2. Number of days to flowering	64 DAS	
B. Yield		
1. Number of panicle	1	No panicle produced
2. Average number of seeds per panicle 2/	557	-
3. Weight in gram per 100 seeds	3.28	-
4. Number of hill/plant/hectare 3/	1200,000 plants to 300,000 plants	-
5. Computed yield/hectare (grain yield)	3.65 MT to 5.48 MT	-

1/ Applied with the recommended rate at four bags of complete fertilizer (14-14-14) per hectare based on normal condition.

2/ Average of 10 sample plants.

3/ Planted at a distance of 0.50 m between rows by 10-15 plants per linear meter.

Table 10. Observations on Agronomic Characters and Yield of Pigeon Pea Tested in Lahar.

PARAMETERS	GROWING CONDITION	
	FERTILIZED 1/	Unfertilized
A. Growth		
1. Average plant height (cm) 2/	74.0	30.2
2. Number of days to flowering.	65 DAS	65 DAS
3. Number of days to maturity	98 DAS	
B. Yield		
1. Average number of pods per plant 2/	109	No pods produced
2. Average number of seeds per pod 2/	2	
3. Weight in gram per 100 seeds	11.6	
4. Number of hill/ plant/hectare 3/	20,000 hills	
5. Computed yield/hectare	0.51 MT	

1/ Applied with the recommended rate at six bags of complete fertilizer (14-14-14) per hectare based on normal condition.

2/ Average of 10 sample plants.

3/ Planted at a distance of 1.0 x 0.50 m (only a single plant was maintained/hill)

Table 11. Observations on Agronomic Characters and Yield of Yambean Tested in Lahar.

PARAMETERS	GROWING CONDITION	
	FERTILIZED 1/	Unfertilized
A. Growth		
1. Percentage of emergence/survival	100 %	100 %
2. Average Length of vine (cm) at harvesting or maturity (cm) 2/	31.38 cm	11.85 cm
B. Yield		
1. Average number of tuberous roots/plant	1.0	1.0
2. Average weight of tuber per plant 2/	27.5 grams	15.05 grams
3. Number of plants per hectare 3/	133,333	133,333
4. Computed yield per hectare	3.67 MT 4/	2.0 MT 5/

* Variety Used: Flat White Variety

1/ Applied with the recommended rate at three bags of complete fertilizer (14-14-14) per hectare based on normal condition.

2/ Average of 10 sample plants.

3/ Planted at a distance of 0.50 m x 0.15 m and harvested at 92 days after seeding (DAS).

population/ha be increased (i.e., high density planting). Therefore, it can be concluded that pigeon pea can be considered a promising crop for lahar laden soils as source of income in the affected areas.

Yambean - This crop can be grown in a wide range of soil type. However, for best results it thrives best on a deep loam soil rich in organic matter and well-drained. The percentage of plant survival, length of vine at maturity, weight per tuber and yield per hectare are shown in Table 11.

Results showed that Yambean var. Flat White can also thrive in lahar but it has a very poor performance. Though it attained 100 % germination and survival of plants, it showed a very poor growth. Fertilized plants attained an average vine length at harvesting time of 31.38 cm and 11.85 cm for unfertilized plants. Furthermore, results also showed that yambean had a very poor performance insofar as yield is concerned. Fertilized plants produced small tubers with an average weight of 27.5 gm/tuber while the unfertilized plants produced much smaller tuber with an average weight of 15.05 gm/tuber. The quality of tubers produced on both growing treatments were considered poor quality and unmarketable insofar as size is concerned.

Therefore, it can be concluded that yambean is not a potential crop for lahar.

Sesame - This crop can be grown in any type of soil provided it is well-drained, medium textured and fertile. The plant height at maturity, number of capsules per plant, number of seeds per capsule, seed weight per 100 seeds and the yield/ha are shown in Table 12.

Results showed that Sesame var. Guimaras White can thrive and perform well in lahar when applied with a recommended rate of 4 bags of complete fertilizer (14-14-14) per hectare. With reference to its growth, it attained an average height of 71.47 cm when fertilized and 51.53 cm when unfertilized at maturity.

In terms of yield, results also showed that fertilized plants produced more capsules at an average of 73.3 capsules per plant while unfertilized plants produced 28.8 capsules per plant. Furthermore, capsules from fertilized plants contained more seeds with an average of 216 seeds per capsule compared to 112.0 seeds per capsule from unfertilized plants. However, there was no marked difference on seed weight. Seeds of fertilized and unfertilized plants had a weight of 0.1395 gm and 0.1390 gm per 100 seeds, respectively.

Table 12. Observations on Agronomic Characters and Yield of Sesame Tested in Lahar.

PARAMETERS	GROWING CONDITION	
	Fertilizer 1/	Unfertilized
A. Growth		
1. Average height at maturity (cm) 2/	71.47 cm	51.53 cm
B. Yield		
1. Average number of capsules per plant 2/	73.3	28.8
2. Average number of seeds per capsule	216	112
3. Weight in grams per 100 seeds	0.1395	0.1390
4. Number of plants per hectare 3/	200,000 at 10 plants per linear meter	200,000 at 10 plants per linear meter
5. Computed yield per hectare	4.4 MT	0.987 MT

* Variety Used: Guimaras White

1/ Applied with the recommended rate at four bags of complete fertilizer (14-14-14) per hectare based on normal condition.

2/ Average of 10 sample plants.

3/ Planted at a distance of 0.50 m between rows at 10 plants/linear meter

Based on this performance, a yield of 4.4 MT/ha is attained when the right amount of fertilizer will be applied. With this encouraging performance of the crop, Sesame can be concluded as a potential crop that can be grown suitably in lahar areas.

Roselle - This crop can be grown in many types of soil but it thrives best in sandy and sandy loam soils with adequate organic matter. The response of roselle in lahar is shown in Table 13.

Results showed that Roselle can also thrive in lahar when applied with a recommended rate of 6 bags of complete fertilizer (14-14-14) per hectare. Fertilized plants had better growth performance with an average height of 44.5 cm compared to 6.65 cm for unfertilized plants. It was observed that the test plants had a very poor crop stand because 50% of the seeds planted were not able to germinate. In terms of yield response, it was observed that both fertilized and unfertilized plants were able to produce fruits. However, no yield data was obtained due to pilferage.

Although the test plants had a very poor crop stand, maybe because of the low quality of seeds used, fertilized plants had shown promising signs as a potential crop that could be grown suitably as indicated by its growth and its capability to bear fruit under strange environment. However, further test is necessary in order to finally determine its suitability in lahar.

Arrowroot - This crop requires a friable, well-drained loamy soil. Clayey soils induce poor rhizome development and usually cause the deformation of the rhizomes which tends to break during harvesting. The percentage of plant survival, height of plant and number of suckers per hill are shown in Table 14.

Initial results showed that arrowroot can thrive and perform well in lahar when applied with a recommended rate of 8 bags of complete fertilizer (14-14-14) per hectare. Again, fertilized plants performed better than the unfertilized plants insofar as growth is concerned. The former attained an average height of 69.7 cm while the latter attained an average height of 37.0 cm. Furthermore, fertilized plants developed and produced more suckers at an average of 12.8 suckers per hill compared to 3.5 sucker per hill on unfertilized plant. In terms of yield, no data is available yet because the test plants are not yet harvested (i.e., to be harvested by the end of November, 1992). However, there are already strong indications that arrowroot can develop and produce rhizomes in lahar.

Upland Gabi - This rootcrop can be grown in a wide range of soil types. However, deep, loose and friable sandy loam soils with sufficient organic matter and moisture is the most ideal. The average number of suckers per hill and average plant height are shown in Table 15.

Table 13. Observations on Agronomic Characters and Yield of Konalae Tested in Lahar.

PARAMETERS	GROWING CONDITION		
	FERTILIZED	1/	Unfertilized
A. Growth			
1. Average plant height (cm) 2/	44.5		6.65
B. Yield			
1. Average number of fruits/plant	3/		3/

1/ Applied with the recommended rate at six bags of complete fertilizer (14-14-14) per hectare on normal condition.

2/ Average of 10 sample plants.

3/ No data on yield due to pilferage. It was observed however, that plants were able to bear fruits.

Table 14. Observations on Agronomic Characters of Arrowroot Tested in Lahar.

PARAMETERS	GROWING CONDITION		
	FERTILIZED	1/	Unfertilized
A. Growth			
1. Percentage of Emergence/ Survival	68.0%		44.0%
2. Average height of plant (cm) 2/	69.7		37.0
3. Average number of suckers per hill 2/	12.8		3.5
B. Yield	3/		3/

1/ Applied with the recommended rate at eight bags of complete fertilizer (14-14-14) per hectare based on normal condition.

2/ Average of 10 sample plants.

3/ No yield data is available yet because the test crop are not yet harvested (i.e., to be harvested by the end of November, 1992).

Table 16. Observations on Agronomic Characters of Covercrops Tested in Lahar.

PARAMETERS	VARIETY			
	Calipogonium moconoides	Calipogonium cerillum	Centrosema	Kudzu
A. Fertilized 1/				
1. Average length of main vine 2/	3.89 m	2.79 m	2.80 m	4.63 m
2. Average number of main laterals (i.e., from the base of the plant) 2/	8	9	26	14
B. Unfertilized				
1. Average length of main vine 2/	0.725 m	0.77 m	1.7 m	10.87 m
2. Average number of main laterals (i.e., from the base of the plant) 2/	2	2	6	2

1/ Applied with the recommended rate of two bags of complete fertilizer (14-14-14) per hectare.

2/ Average of five sample plants.

PESTS AND DISEASES - Yellow beetle was observed as the most prevalent insect pest (Appendix 2) attacking some of the test crops. The presence of other insect pests such as mites, corn earworm and caterpillar were also observed infesting some test crops. However, their population was very negligible. These insect pests which infested the test crops were controlled by spraying them with the appropriate insecticide at manufacturer's recommended rate of application.

On the other hand, Fusarium wilt was the only disease (Appendix 2) found infecting a number of test crops. Further infection was remedied by spraying the test crops with appropriate fungicide at manufacturer's recommended rate of application.

Appendix 1. Nutrient Analysis of Lahar Taken from the Experimental Site **/

NUTRIENT ANALYZED **/	PERCENT
Total Nitrogen (N)	0.12
Total Phosphorus (P O) 2 5	0.13
Total Potassium (K O) 2	0.38
Sulfate (S)	0.09
Magnesium (Mg)	nil
Boron (B)	nil
Total Iron (Fe)	0.30
pH Level	7.96

*/ Taken from Barangay San Antonio, Bacolor, Pampanga.

**/ Analyzed by the Laboratory Services Division of the Bureau of Plant Industry, San Andres Street, Malate, Manila.

Appendix 2. Observations on Pests and Diseases to Various Crops Tested in Lahar.

C R O P S	Degree of Injury 1/	
	PESTS	DISEASES
1. Sweet Potato	2 a/ c/	1
2. Cassava	2 b/	1
3. Yambean	1	1
4. Arrowroot	1	1
5. Upland Gabi	2 b/	1
6. Peanut	1	2 e/
7. Mungbean	2 a/	1
8. Soybean	2 a/	2 e/
9. Cowpea	2 a/	1
10. Pigeon Pea	1	1
11. Sesame	1	1
12. Roselle	1	1
13. Hotpepper	1	1
14. Corn	2 d/	1
15. Sorghum	1	1
16. Cover Crops	1	1
17. Tororo	1	1

1/ = 1 = No injury
 2 = Slight injury
 3 = Moderate injury
 4 = Severe injury

Caused by :
 a/ = Yellow beetle
 b/ = Mites
 c/ = Caterpillar
 d/ = Corn earworm
 e/ = Fusarium wilt

Appendix 3. Computed Yield of the Different Test Crops Grown in Lahar In Comparison to its Potential Yield Under Normal Condition.

TEST CROPS	COMPUTED YIELD/HA UNDER LAHAR (MT)	COMPUTED YIELD/HA UNDER NORMAL (MT)
1. Sweet Potato (BPI Sp 2)	30.9	18.5
2. Cassava (Golden Yellow)	15.6	20.0 - 40.0
3. Yambean (Flat White)	3.67	15.0
4. Peanut (BPI Pn 2); Shelled	1.7	1.8 - 2.1
5. Soybean (BPI Sy 4)	0.411	1.79 - 2.07
6. Cowpea (E.G. Red)	0.924	1.5 - 2.0
7. Mungbean (Pag-asa 7)	1.29	1.1 (DS) 1.48 (WS)
8. Corn (Sweet Corn) - Green	40,000 pcs.	
9. Sorghum (IES Sor 4)	3.65	3.75 - 5.25 (DS) 3.5 - 5.0 (WS)
10. Pigeon Pea	0.51	1.5 - 2.0
11. Sesame (Guimaras White)	4.4	0.350 - 1.7
12. Arrowroot	a/	18.47 - 26.73
13. Upland Gabi	a/	15.0
14. Hot Pepper	b/	8.10 (DS) 7.48 (WS)
15. Roselle	c/	
16. Leguminous Covercrops	-	-
17. Tororo-aoi	-	-

a/ = No yield data is available yet because the test plants are not yet harvested (i.e., to be harvested at the end of November, 1992).

b/ = No yield data was recorded due to the inability of the crop to grow.

c/ = No yield data was recorded due to pilferage.

CONCLUSION AND RECOMMENDATIONS

After 3 to 8 months of critically observing the responses of the different test crops planted in lahar, the following observations, conclusions and recommendations were arrived at:

1. The study had demonstrated that lahar can support the growth and development of selected farm crops and ultimately gave reasonable yields when provided with adequate amount of water and fertilizer.
2. The growth and yield responses of the different test crops, though not as superior as when grown under normal condition, showed good seedling vigor, uniform emergence, high percentage of survival, uniform crop stand and reasonable yields. These characteristics of the crops under different environmental condition made them adaptable and suitable for growing in lahar laden areas.
 - Sweet Potato
 - Cassava
 - Mungbean
 - Peanut
 - Red Cowpea
 - Pigeon Pea
 - Corn
 - Sorghum
 - Sesame
 - Leguminous Covercrops
3. Results of the study can give new hope in life specifically for farmers whose fields/farms were deeply buried or covered with lahar.
4. Results of the study have aroused the interest of affected farmers as well as other organizations or agencies both private and public.
5. It is strongly recommended that only those crops identified in the study suitable to be grown in lahar be considered either for backyard or small scale production. Caution must be observed in the commercial production as this is not yet verified.

6. It is recommended that planting should be done at the flow is extremely low, preferably during the months of November or December.
7. To exploit the yield potentials of the most suitable field crops identified for lahar, further research undertakings (OFR) on variety trials as well as cultural and management practices are recommended.
8. The testing and evaluation of other annual field crops with market potential should be vigorously continued.

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