EFFECT OF IMPROVED CULTURAL TECHNIQUES ON GROWTH AND ORGANOLEPTIC PROPERTIES OF *CORCHORUS OLITORIUS* IN THE LUSAKA PROVINCE OF ZAMBIA

BY

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I, Ruth Nyathi hereby declare that all the work presented in this dissertation is my own and has never been submitted for a degree at this or any other University.

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This dissertation of Ruth Nyathi is approved as fulfilling part of the requirements for award of Master of Science in Agronomy (Crop Science) by the University of Zambia.

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ABSTRACT

Optimum spacing and nitrogen fertilizer application rates for maximum yield and quality of edible fresh leaves of *Corchorus olitorius* were studied at the University of Zambia Field Station during January to May 1992. The nitrogen levels were 0, 40, 80, 120, 160 kg ha^{-1}. Intra-row spacings were 20 cm, 30 cm, 40 cm and broadcasting. Inter row spacing was 40 cm in all plots.

The results indicated that leaf yields were higher with nitrogen fertilizer application as topdressing than the control. The highest leaf yield was 1.44 t ha^{-1} obtained at 40 kg N ha^{-1} with the lowest yield of 1.02 t ha^{-1} from the control. There were little difference in crude protein and taste between control and fertilized plots. The crude protein was highest in wide spacing of 40 cm x 40 cm and was lowest in broadcasting treatments.

It was concluded from the results of this experiment that maximum leaf yields were obtained through applying topdressing fertilizer of 40 kg ha-*1*. The crude protein and taste improved where spacing was done compared to broadcasting. Positive correlation indicated that an increase in leaf yield was accompanied by crude protein increase.

There is need to repeat the study during adequate rainfall conditions as the present results under drought may not be a true reflection of the performance of the crop.

To my husband Elijah Nyathi and my children.

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ABBREVIATIONS

1. MAWD - Ministry of Agriculture and Water Development.
2. NIRS - National Irrigation Research Station.
3. FAO - Food and Agriculture Organization.
4. N - Nitrogen
5. SADC - Southern African Development Community.
6. DM - Dry Matter.
7. SADDC - Southern African Development Coordination Conference.
8. SACCAR - Southern African Centre for Cooperation in Agricultural Researh.
9. $t\ ha^{-1}$ - Tonnes per hectare.
10. ml - Millilitres.
11. m - Metres.
12. mm - Millimetres.
13. P - Phosphorus.
14. Ca - Calcium.
15. Fe - Iron.
16. K - Potassium.
17. Cp - Crude protein.
18. cm^3 - Cubic centimetres.
19. N - Normal.
20. M - Molar.
21. °C - Degrees celcius.
22. % - Percentage.
23. App - Appendix.

1. INTRODUCTION

1.1 A BRIEF HISTORICAL BACKROUND

Corchorus olitorius is both a leafy vegetable and stem fibre crop of international importance (Akodora 1985). It's origin is thought to be India (Tindall 1988), but Grubben (1977) as quoted by Akodora (1985) maintained that its primary centre of origin is South China and the species was taken to India at any early date.

The species is known by several names. In English it is called Jew's mallow or Jute leaves (Cobley 1965) and in Zambia it is called Lusakasaka (Bemba) and Cikombo (Tonga) (Ministry of Agriculture and Water Development 1983 and Muntemba 1977). It is one of the indigenous vegetables in Zambia (Mingoshi *et al.* 1990). It's production is in small quantities for local consumption and is used as a relish taken with nshima (cooked maize flour) in Zambia (Chibiliti 1991).

Generally this vegetable appears as a weed in cultivated crop fields and its potential as a cash crop has not been fully exploited (Vernon 1983).

Although some studies have been done about its fertilizer and spacing requirements, little has been done to assess its taste as affected by nitrogen fertilization.

1.2 IMPORTANCE OF *CORCHORUS OLITORIUS*

Corchorus olitorius is widely used as a leaf green vegetable in the Middle East, Egypt, the Sudan and Tropical Africa (Purseglove 1968, Vernon 1983, Westphal-Stevels 1986, Mingoshi *et al.* 1990 and Chibiliti 1991). The leaf lamina is mucaliginous (slippery) and in most areas it is cooked with bicarbonate of soda (MAWD 1983, Purseglove 1968, and Whitby 1972). Consumer preference is for young leaves with low fibre content obtained from terminal parts of mature stems and its immature seeds called 'Bush Okra' are eaten in Nigeria (Akodora 1985).

Corchorus olitorius is also be used as medicine for diseases such as gonorrhoea, bladder complaints, chest pains and tooth ache (FAO 1988 and Cobley 1965). The seeds are used for chicken feed (Johnson and Toleman 1982). It can also be dried and preserved for use during periods of scarcity (Gill 1972).

Table 1 has data comparing the nutritive value of *Corchorus olitorius* to other vegetables. Nutritionally, tropical indigenous vegetables are a cheap source of protein, vitamins and minerals in the diet of people living in rural areas of Zambia (Mingoshi *et al.*1990). Tropical indigenous vegetables are easy to produce with minimum inputs, produce seed under local conditions, are relatively free of pests and diseases. They are highly adapted to the local

TABLE 1: COMPOSITION OF CERTAIN LOCAL VEGETABLES COMPARED WITH CONVENTIONAL VEGETABLES PER 100G OF EDIBLE PORTIONS

Name	Protein (g)	Minerals (g)	Ca (mg)	Iron (mg)	Vit A (IU)	Thiam. (mg)	Ribflav. (mg)	Vit C (mg)
CONVENTIONAL VEGETABLES								
Cabbage	1.8	0.6	64	0.7	75	0.05	0.05	62
Lettuce	2.1	0.2	97	4.3	3340	0.06	0.13	21
Carrot	0.9	1.1	80	2.2	3150	0.04	0.02	3
Tomato	1.9	0.6	20	-	3300	0.07	0.01	31
UNCONVENTIONAL VEGETABLES								
Amaranthus	4.0	2.7	397	25.5	9200	0.03	0.01	99
Cleome gynandra	4.8	-	288	6.0	5000	-	-	135
Corchorus Sp	4.5	-	538	19.8	12510	0.13	0.21	81
Sweet potato leaves	--	-	107	6.0	5565	0.12	0.20	32

SOURCE: ANON (1971) - FOODSTUFFS, NATIONAL FOOD AND NUTRITION COMMISSION, LUSAKA.

tropical environment and soil conditions when compared to their exotic counterparts (Mnzava 1989 and Chibiliti 1991).
However, indigenous African vegetables are often neglected or unused due to ignorance about the essential nutrients they contain in preference to usually expensive foreign foods. This has at times led to nutritional deficiences resulting in miserable diseases such as kwashiorkor, marasmus, night blindness, beriberi and oedema (Maing 1985).

Nutritionists and others have started to encourage people to grow and eat local vegetables on a large scale. Presently most of indigenous vegetables are not really cultivated instead they grow as weeds in cultivated fields (Nkhoma 1989). Research and Extension should embark on the multiplication and popularization of *Corchorus olitorius* in the Southern African Development Community (SADC) region and add information on indigenous vegetables.

1.3 STATEMENT OF THE PROBLEM

Some of the problems associated with *Corchorus olitorius* are lack of awareness abot its nutritional value (Anon 1971) and inadequate information about its cultural practises (Attere 1990). It has relatively low yiels about 4 tons/ha (Mingoshi 1987). More attention is paid to cash crops than indigenous vegetables (Youdeowei *et al.* 1986, Nkhoma 1989 and Ferguson 1990), and generally it is considered as an inferior crop (Temba 1985 and Mingoshi *et al.* 1990).

1.4 STATEMENT OF OBJECTIVES

This trial was aimed at:

(a) establishing the optimum level of nitrogen application needed to give maximum leaf yields and quality of *Corchorus olitorius* in Lusaka

(b) determine the optimum plant spacing required to achieve maximum leaf yields and good leaf quality, and,

(c) to identify phenotypic correlations which might exist between plant growth components studied.

2. LITERATURE REVIEW

2.1 BOTANY

Corchorus olitorius Linn (2n = 14) belongs to the family Tiliacea (Vernon 1983) with the genus *Corchorus* containing over thirty species which are fairly widely distributed throughout the tropics (Cobley 1957). It is an annual plant which matures in three to five months on average depending on the variety, the length of the growing season and the environmental conditions (Das 1958).

The species though an annual may exhibit facultative perenniality under "dump heap" environments with good drainage particularly among the late flowering types (Akodora 1985).

The species can tolerate shade and it is recognized by simple undivided leaves with toothed edges arising singly. A pair of stiff hairs are found near the bottom of the leaf and another pair where the leaf joins the stem. The leaf has a shiny upper surface and rougher under the surface and it is tasteless when chewed (Kirby 1963). The flowers, are small and yellow, with a 10- ribbed pod without horns at the top which splits when ripe into five segments (Vernon 1983).

2.1.1 ADAPTATION

Corchorus olitorius occurs wild in Asia and Africa and has become naturalized as an escape from cultivation in most tropical regions

(Purseglove 1968). It is an annual weed that grows in areas less than 1000 mm rainfall (Vernon 1983). It does well in hot wet conditions (MAWD 1983) with a maximum temperature of 35°C and minimum temperature of 22°C (Tindall 1988). Although it is treated as a " tolerated" weed and allowed to grow with the crop, in some areas the seeds are saved and sown deliberately in the fields or garderns (MAWD 1983) for future use.

2.2 MANAGEMENT AND MARKETING

Production of local vegetables is done in a traditional manner with a minimum of inputs. People rely on themselves or on their elders in management of local vegetables and no guidance is given by extension workers (Mingoshi *et al.* 1990). Although horticulture is covered in the training of extension workers, students learn more about exotic varieties than indigenous vegetables. Local vegetable production, gathering, preservation, marketing, purchasing and preparation are largely the responsibilities of women (Mingoshi *et al.* 1990).

In rural areas vegetable production conflicts with intense labour periods for major food crops and cash crops and the production of vegetables is given lower priority. Little or no support is given to encourage continued cultivation of local vegetables Mingoshi *et al.* (1990) yet the cost of producing and buying conventional vegetables are ever increasing (Nkhoma 1989).

Mingoshi et al.(1990) reported that marketeers of local vegetables often have their business in separate stalls, on the side of the market, on the ground rather than on tables. In recent years the governments of SADCC member states have begun to recognize the strategic importance of horticulture especially vegetables (SADCC 1987 and Kyomo 1988). In nutrition posters the local vegetables are presented together with the exotic vegetables (MAWD 1983) and there should be more programs aimed at encouraging families to consume local vegetables (Mingoshi *et al.* 1990).

In town people consume less local vegetables because of the following reasons:

- Local vegetables are not in abundance in the markets because they are not commercially grown; and
- some people feel that local vegetables are inferior to exotics so they do not buy them even if they find them at the market.

In rural areas people consume more local vegetables than in towns for the following reasons:-

- In rural areas, local vegetables are easily available especially at the beginning of the rainy season and during the rainy season.
- Money is not required to buy vegetables because the majority grow wild;

- Families save seeds of some types of local vegetables and they grow them yearly.
- The production of exotic vegetables is low in most of the areas, and,
- relishes like meat and fish are very scarce in some areas and chickens though plentiful are in some homes rarely consumed (MAWD 1983).

2.3 NITROGEN RATE AND LEAF YIELD

Nitrogen is the most limiting nutrient element in most tropical soils (Youdeowei *et al.* 1986) and nitrogen deficiency is one of the problems that concern farmers. Nitrogen deficiency can result in a complete crop failure and as a result, it is now a common practise to apply nitrogen fertilizer to most crops, as a precautionary measure (Siyinda 1989).

Nitrogen applied as top dressing was better utilized by the plants than nitrogen applied as base dressing in eggplants (Zyambo 1989).

Crop responses to N, can vary widely among sites and years, according to the prevailing weather and soil fertility (Hay and Walker 1989). Local vegetables such as *Corchorus* species are capable of producing at low levels of available nitrogen at which exotic vegetables fail (Mingoshi 1987).

Chikoye (1986) found that nitrogen source did not have a significant effect on leaf yield of *Brassica carinata, Cleome gynandra* and *Corchorus olitorius.* Other studies done to some indigenous vegetables in Zambia indicated that nitrogen fertilization increased leaf yields. For example, Nkhoma (1989) did a study on the response of *Cleome* to nitrogen fertilization and found that 40 kg N ha^{-1} of ammonium nitrate gave maximum leaf yield.

2.4 SPACING AND LEAF YIELD

Adequate spacing for crops is important for good yields since it optimally reduces interplant competition for sunlight, moisture, and nutrients (Youdeowei *et al.* 1986). Plants branch freely when found singly on fertile spots while close spacing reduces branching, but rather increases plant height due to competition for sunlight (Akodora 1985).

Mathai (1988) indicated that farmers should use wide spacing between rows and within rows if the moisture supply is likely to become deficient. This allows the root system of each plant a greater volume of soil from which to absorb water and nutrients. Row and plant spacings may be close if the plants, requirement for water and nutrients are adequately provided.

The control of plant population is one of the simplest ways to control the amount of light received by individual plants. When plants are grown close together mutual shading prevents direct light from reaching all but the tops (Marschner 1990).

2.5 PLANT HEIGHT

Gupta (1953) observed that the height and number of internodes of *Corchorus olitorius* were significantly reduced in plants deficient in nitrogen. Akodora (1985) indicated that the vegetable jute types are shorter than fibre jute types and branch profusely.

Hay and Walker (1989) reported a significant correlation between plant height and number of leaves per plant. Tall plants had more leaves per plant than shorter ones.

2.6 NUMBER OF BRANCHES PER PLANT

Competition between adjacent plants especially for solar radiation results in a large proportion of the potential branches not developing beyond the bud stage or to die prematurely (Marschner 1990). The extent of branching in a given crop is largely determined by management and in particular by choice of species, cultivar, plant population density and by nitrogen fertilizer application (Marschner 1990).

2.7 LEAF NITROGEN

Of all essential nutrients nitrogen appears to have the most profound effect on plant growth and development. It promotes vegetative growth and imparts deep green colour to foliage (Youdeowei *et al.* 1986). Generally, a number of factors inherent to local environment can considerably influence the nutrient contents of foods. These factors include seasonal variations, soil fertility, maturity, time of harvesting, length of storage and exposure to market (Vujicic and Vujicic 1971).

The nutritional status of a plant is better reflected in the mineral element content of the leaves than in that of other plant organs. Thus leaves are usually used for plant analysis (Marschner 1990).

2.8 CRUDE PROTEIN

Opena and Kyomo (1990) indicated that *Corchorus olitorius* had crude protein of 4.7%. FAO (1982) reported its protein content to be 3.6%. MAWD (1983) indicated that it contained 4.5 % of protein per 100g of edible portions. The protein content of *Corchorus olitorius* ranges from 1.5 - 6% (Tindall 1988).

2.9 TASTE

Taste is sensation which is appreciated by the taste buds on the tongue (Arthey 1965). Local vegetables like *Corchorus olitorius* are often cooked with sodium bicarbonate (MAWD 1983). However, most local vegetables are popular and often preferred to the exotic ones, because of a better taste (MAWD 1983).

3. MATERIALS AND METHODS

3.1 EXPERIMENTAL SITE

This experiment was carried out at the University of Zambia, School of Agricultural Sciences Field Station in LUSAKA during the 1992 growing season. Lusaka is located between 15°23'S and 23°28'S at an altitude of 1140 - 1254 m above sea level. It experiences an average annual rainfall amount of about 800 mm. The climatological data which prevailed during the period of the experiment has been given in Appendix 1 - 11.

Soil analysis which was done at the beginning of the experiment indicated that the soil is sandy loam with both clay and silt being less than 50 percent. It had low amounts of nitrogen (0.2%), 6.00 ppm P/kg soil and low K (0.11 mg/ 100 g of soil). The soil pH was 6.3 in $CaCl_2$.

SITE HISTORY

1989 - Tomatoes.

1990 - Green beans.

1991 - Maize.

1992 - *Corchorus olitorius* (Lusakasaka).

3.2 EXPERIMENTAL DESIGN

The experimental design was a split plot with nitrogen levels as the main plot factor and spacing as the subplot factor, and replicated three times.

3.3 CULTURAL PRACTISES

3.3.1 Land preparation

The experimental land with a total experimental area of 750 m^2 was ploughed using a disc plough in December 1991 and harrowed to give a fine tilth. It was then divided into three blocks which were 230 m^2 with five main plots which were 30 m^2 each. Each main plot had four subplots of 6 m^2. The plots had ridges at the edges to prevent fertilizer drift effects.

3.3.2 Planting/sowing

The trial was conducted from 30th January to 16th May, 1992. The seeds were sown 0.5 centimetres deep in the subplots. Intra-row spacings were 20 cm, 30 cm, 40 cm and broadcasting respectively. Each subplot had four rows which were 3.75m long with an inter-row spacing of 40cm. The width of the subplot was 1.6m. The field plan showing blocks, main plots and subplots has been given in Appendix III. In this study *Corchorus* was grown under rainfed conditions. Although 1/4 kg seed was used in each subplot , thinning was done to get the correct plant population just before topdressing was done.

Spacing codes were:

CODE	SPACING (cm)
1	40 x 20
2	40 x 30
3	40 x 40
4	BROADCASTING

A basal dressing of Compound 'D' (N10), P(20), K(10) and S (10) was applied to all subplots at a rate of 200g and this was broadcasted prior to sowing seeds. Seeds were obtained from the Zambia Seed Company (ZAMSEED) in Lusaka and were locally produced.

The germination percentage of seeds determined in the laboratory was 85% (Appendix IV). The subplot with spacing 40 cm x 20 cm had 57 plants, subplot with 40 cm x 30 cm spacing had 39 plants, subplot with 40 cm x 40 cm spacing had 27 plants and the broadcasting subplot had approximately 150 plants.

3.3.3 Weeding

First weeding was done two weeks after planting using a hoe and thereafter weeding was done twice every two weeks till plants formed a dense canopy. Gapping was done to replace seedlings that showed signs of wilting by transplanting thinned plants at two weeks after planting.

3.3.4 Fertilizer application

Nitrogen (Ammonium nitrate, 34%N) was top-dressed to relevant subplots in 5 split applications starting two weeks after emergence. The total amounts applied per treatment were as follows:

CODES	TREATMENT kg N ha^{-1}
N_0	0
N_1	40
N_2	80
N_3	120
N_4	160

The ammonium nitrate was applied every two weeks at a rate of 0 per subplot for N0, 24g per subplot for N1, 48g per subplot for N2, 72g per subplot for N3, and 96g per subplot for N4 applied five times (Chilufya 1990). It was broadcast and incorporated into the soil using a hand hoe.

3.4 DATA COLLECTION AND ANALYSIS

During the experiment, the data recorded was collected from plants in two middle rows at the same time at ten o'clock in the morning at 90 days from planting.

The parameters recorded were:

(a) Number of branches per plant from five plants picked at random per subplot.

(b) Plant height of five plants picked at random per subplot.

(c) Fresh leaf yield per plant in grams (g) from five plants picked at random per subplot.

(d) Dry weight of harvested leaves

(e) Leaf nitrogen in percentage

(f) Crude protein calculated from leaf nitrogen analysis.

(g) Taste of cooked leaves using scores 1, 2 and 3, where 1 is Good, 2 is Average and 3 is Bad.

a) Number of branches per plant was obtained by counting the number of branches of five plants per subplot picked at random.

b) Plant height was determined from five plants picked at random per subplot using a ruler measuring from soil surface to the shoot apex. It was also recorded at 9, 11, 13 and 15 weeks after sowing to observe a trend in the growth of the plants.

c) Leaf yield (fresh weight) data was obtained by harvesting six trifoliate leaves from two branches per plant above twenty centimetres height so as to get leaves which were not touching the ground. All leaves collected from each subplot were placed in plastic bags with moistened paper to reduce moisture loss and taken to the laboratory for weighing using an electric balance.

The leaf yield was determined from any five plants picked at random. It was also determined at 9, 11, 13 and 15 weeks after sowing to get a trend for dry matter yield.

d) Dry weight of harvested leaves was determined after oven drying of fresh leaves. The leaves were placed in separate paper bags and oven dried for 24 hours at 105-110° C and cooled prior to weighing.

e) Leaf nitrogen was determined using the method of Braadstreet (1965).

METHOD

1. Leaf laminae collected from the field were put in plastics to avoid moisture loss and taken to the laboratory for analysis.
2. The samples were oven dried at 105-110 °C to constant weight for 24 hours.
3. The dry samples were ground using a Glen Creston Micro Hammer Cutter Mill (680) to pass through 1-mm sieve
4. Dried leaves (2g) and catalyst (2g) (composed of 100g K_2SO_4, 10g $CuSO_4.5H_2O$ and 1g Selenium powder separately ground, mixed together and the mixture again ground in an agate mortar) were covered in ashless Whatman Paper No. 41 and put in Macro-Kjeldahl flask and 30 mls of concentrated H_2SO_4 (98%) was added

5. The mixture was heated for three hours at 450 ºC and brought to the steam distillation apparatus.
6. The solution was made alkaline with NaOH. The distillation started immediately.

$(NH_4)_2SO_4 + 2NaOH = Na_2SO_4 + 2NH_3 + 2H_2O$

The ammonia that was released was captured quantitatively in an excess of boric acid (H_3BO_3) in the presence of a mixed indicator and finally the solution 0.01M Hydrochloric acid.
The boric acid was prepared by adding 20g Analar Boric acid dissolved in about 900 ml of hot water, cooled and 20 ml of a mixed indicator added which was also prepared by dissolving 0.1g bromocresol green and 0.75g methyl red in 100 ml of ethanol.
Then 0.1M sodium hydroxide (NaOH) solution added dropwise until the colour was reddish purple with a pH 5.01. The ammonium borate formed ($NH_4H_2BO_4$) by the reaction of NH_3 with H_3BO_3 was titrated back to H_3BO_3 with a standard HCl (0.01M) solution.

Braadstreet (1965) formula to covert cm^3 HCl used during the titration to % N in the leaves is :-

$$\% N = \frac{(cm^3 \text{ HCl used} - \text{blank}) \times 0.14 \times 10^{-3} g \times 100}{\text{Weight of oven dry samples}}$$

1 ml of 0.01N HCl neutralizes 0.0014 g of N, therefore,

$$\% N = \frac{0.0014 \times (\text{Volume of HCl used for sample} - \text{blank}) \times 100}{\text{weight of sample}}$$

2. CRUDE PROTEIN

The percentage of N was then expressed in terms of Crude Protein (CP) and calculated as follows:-

% CP = % N x 6.25 (FAO 1982).

3. TASTE DETERMINATION

This was done following the recommendations of the National Food and Nutrition Commission (Personal Communication) in Lusaka. Fresh leaves harvested from the plot (100g) were cooked in a stainless steel pot with bicarbonate of soda (1/4 teaspoon), sodium chloride (1/2 teaspoon) and 250 ml water. The cooking time was 15 minutes per sample.

The leaves were cleaned to remove the dirt and cut into smaller pieces using the knife, and then put in boiling water. Soda and salt was added.

Nine panelists tasted all cooked samples *Corchorus olitorius* and rated using score 1,2, and 3 where 1 was Good, 2 was Average and 3 was Bad. The aftertaste was killed betwwen samples by cleaning the mouth with water. Spoons and saucers were used whilst tasting.

4. RESULTS

GENERAL

The results of plant height, number of branches per plant, leaf fresh yield, crude protein and taste are represented in Tables 2 - 6. Nitrogen fertilization had significant effect on leaf yield while spacing had a significant effect on plant height. There was significant interaction between leaf crude protein and taste.

EFFECTS OF NITROGEN AS TOPDRESSING

The highest leaf yield was 1.44 t ha^{-1} when 40 kg N ha^{-1} was applied while the lowest yield was 1.02 t ha^{-1} when nitrogen was not applied as topdressing (0 kg N ha^{-1} CONTROL) (Table 2). The trend of leaf dry matter accumulation decreased as the plant approached maturity (Fig.1)

Nitrogen as topdressing had little effects on plant height, number of branches per plant, (%) crude protein and taste. Plant height was (71 cm) when 120 kg N ha^{-1} was applied and lowest (59 cm) when nitrogen was not applied (0 kg N ha^{-1} (CONTROL). Crude protein was 2.43% at 120 kg N ha^{-1} and 2.10% at 0 kg N ha^{-1} (CONTROL). The taste score was 2.17 at 0 kg N ha^{-1} and 1.83 at 80 kg N ha^{-1} (Table 2).

Table 2: Effect of nitrogen as topdressing on plant growth parameters of *Corchorus olitorius*

NITROGEN kg/ha	Plant Height (cm) at 90 days from planting	Number of branches/plant at 90 days from planting	Total Fresh Leaf Yield (10^{-2}) tons/ha	Crude Protein (10^{-2})%	Taste
0	59b 1)	12.13a	102.11b	203.75b	2.17a
40	67ab	12.77a	144.04a	233.60a	2.06a
80	65ab	12.97a	132.09a	221.40ab	1.83c
120	71a	11.62a	132.99a	243.47a	1.89bc
160	67ab	13.31a	140.92a	236.71a	1.89bc
MEAN	66	12.56	130.43	228.99	1.97
LSD (5%)	8.51	2.67	4.83	24.99	0.19
C.V. (%)	13.77	22.57	12.83	14.41	13.74

1) Means in each column followed by the same letter are not significantly different at P = 0.05.

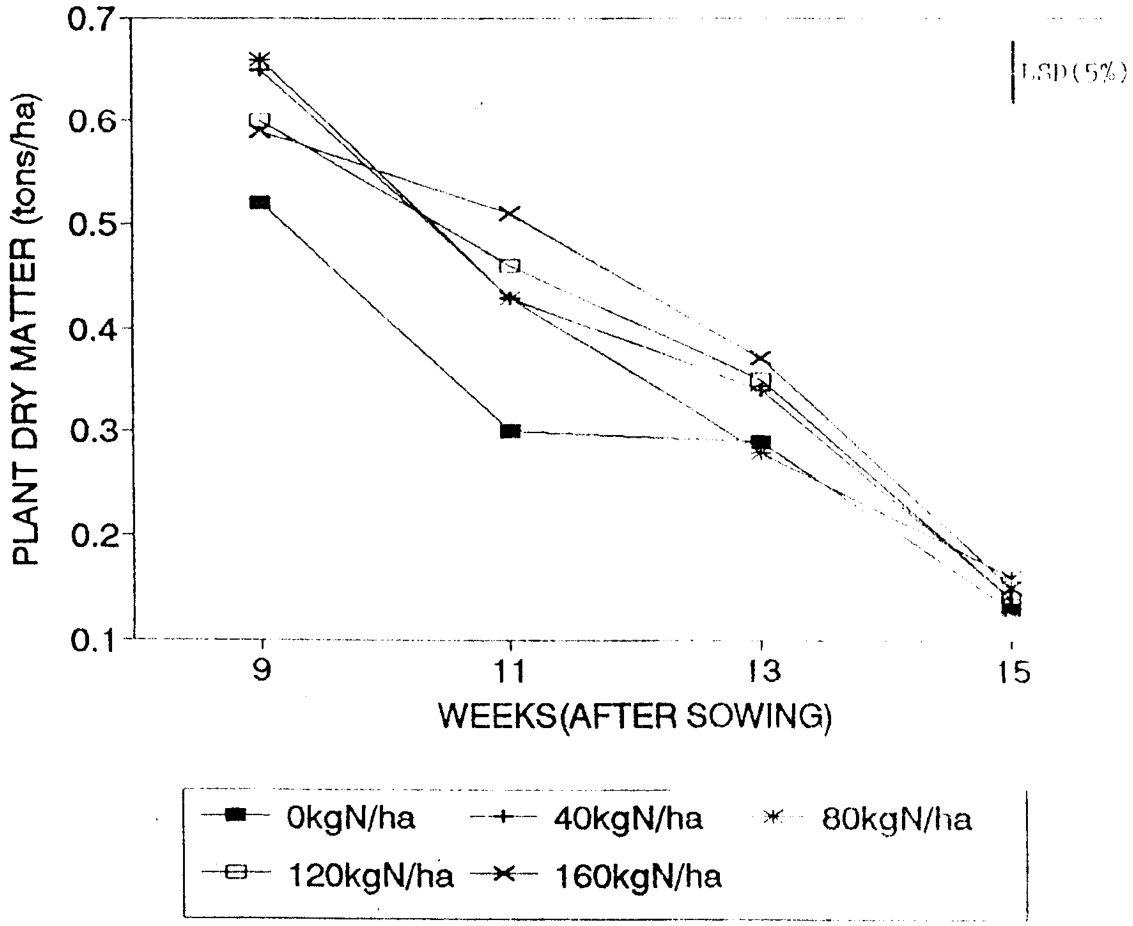

Fig 1. Effect of nitrogen on dry matter yield during the growth period.

EFFECTS OF PLANT SPACING

Plant spacing had significant effects on crude protein and taste (Table 3). The highest value of crude protein was 2.61% from 40 cm x 40 cm plant spacing and the lowest value was 1.98% from broadcasting. The highest taste score was 2.09 from 40 cm x 20 cm and 40 cm x 30 cm plant spacings and 40 cm x 40 cm spacing and broadcasting gave the lowest taste score of 1.85 (Table 3).

Plant spacing had little effects on leaf yield. The leaf yield was high at 40 x 30 cm spacing being 1.36 t ha^{-1} and low from broadcasting being 1.23 t ha^{-1} (Table 3).

Plant height was highest in broadcasting plots and lowest in 40 cm x 40 cm spacing (Fig.2). The interaction of nitrogen and spacing was significant for crude protein and taste. Crude protein was highest at 3.06% at 0 kg N ha^{-1} and spacing of 40 cm x 40 cm and lowest (1.55%) at 160 kg N ha^{-1} and broadcasting (Table 4).

For taste, the highest score was 2.78 obtained from 0kg N ha^{-1} and 40 cm x 30 cm spacing. The lowest score was 1.22 obtained from 80 kg N ha^{-1} and 40 cm x 20 cm spacing (Table 5).

Components that were highly significant in correlation were fresh leaf yield against crude protein ($r = 0.558^{**}$) (Table 6).

Table 3: Effect of spacing on plant growth parameters of *Corchorus olitorius*.

Plant Spacing (cm)	Plant Height (cm) at 90 days from planting	Number of branches/plant at 90 days from planting	Total Fresh Leaf Yield (10^{-2}) tons/ha	Crude Protein (10^{-2})%	Taste
40 x 20	67a [1]	12.40a	132.90ab	222.16b	2.09a
40 x 30	66a	13.36a	135.84a	234.63b	2.09a
40 x 40	59b	12.58a	130.15ab	260.77a	1.85b
Broadcasting	70a	11.89a	122.83b	198.39c	1.85b
MEAN	66	12.56	130.43	228.99	1.97
LSD (5%)	7.04	1.36	11.01	19.80	0.17
C.V. (%)	14.39	14.54	11.32	11.59	11.38

1) Means in each column followed by the same letter are not significantly different at $P = 0.05$.

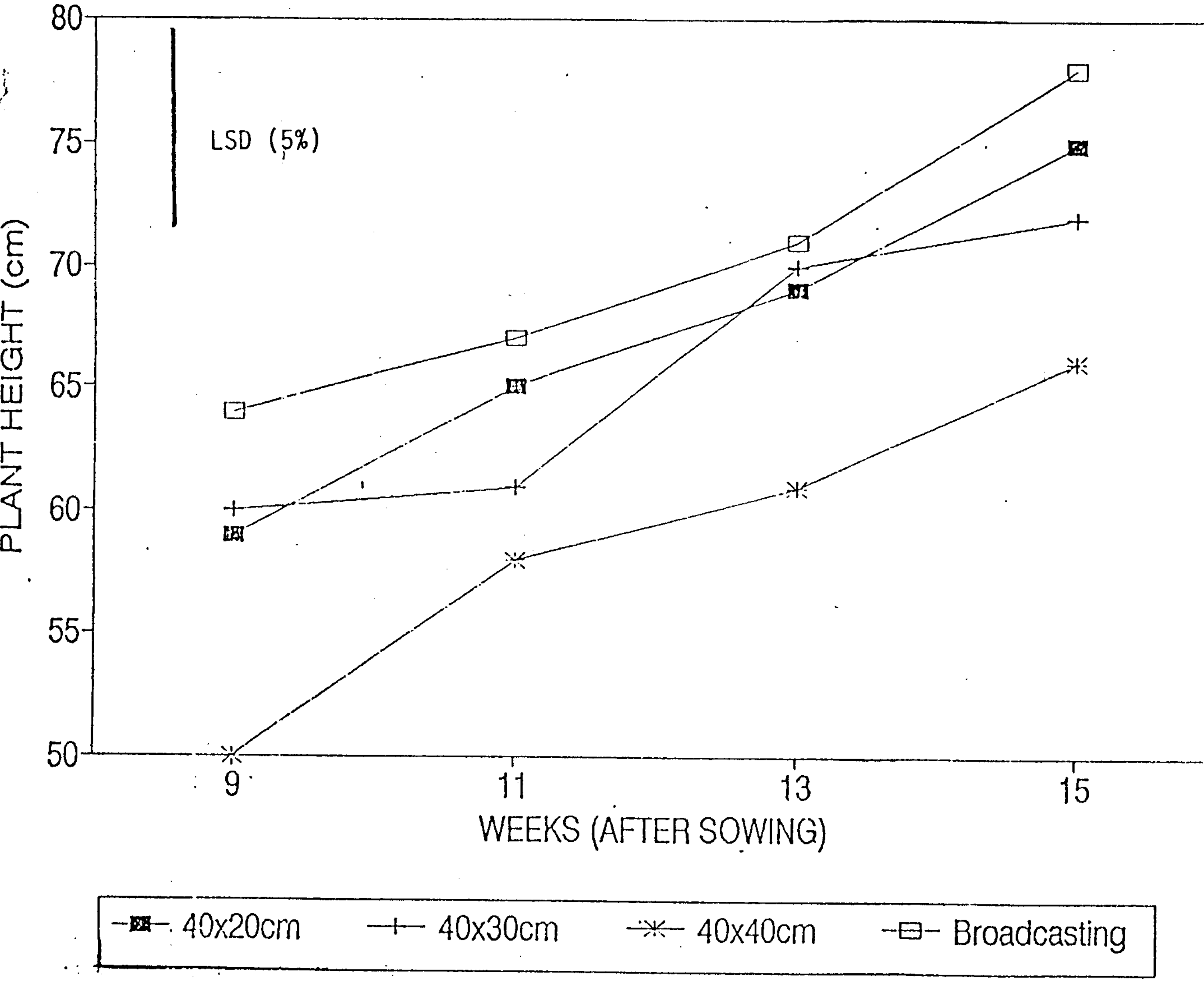

Fig 2. EFFECT OF SPACING ON PLANT HEIGHT

Table 4: Crude protein (10^{-2})% of *Corchorus olitorius* at different levels of nitrogen and spacing.

SPACING (cm)	NITROGEN LEVELS (Kg N ha^{-1})					MEAN
	0	40	80	120	160	
40 x 20	181.27 fgh 1)	220.29cdef	179.60fgh	270.60abc	259.35bcd	222.16
40 x 30	175.00gh	268.69abc	229.54bcde	243.81bcde	276.56ab	255.09
40 x 40	306.27a	251.56bcd	264.00abc	225.77bcdef	265.25bcd	260.77
Broadcasting	196.92fgh	193.85efgh	212.46defg	234.02cde	154.69h	198.39
MEAN	214.87	233.60	221.40	243.47	236.71	228.99
LSD (5%)	Nitrogen (N) = 24.99 Spacing (S) = 19.80 Interaction (N x S) = 15.33					
C.V.(%)	= 11.59					

1) Means followed by the same letter are not significantly different at P = 0.05.

Table 5: Taste of *Corchorus olitorius* at different levels of nitrogen and spacing.

SPACING (cm)	NITROGEN LEVELS		(Kg N ha^{-1})			MEAN
	0	40	80	120	160	
40 x 20	2.45ab [1)]	2.33ab	1.22i	2.11bcdefg	2.33bcd	2.09
40 x 30	2.78a	1.89efgh	2.22bcde	1.56hi	2.00cdefg	2.09
40 x 40	1.67gh	2.11bcdef	2.00cdefg	1.89efgh	1.55hi	1.84
Broadcasting	1.78fgh	1.89efgh	1.89efgh	2.00cdefg	1.67fhg	1.85
MEAN	2.17	2.06	1.83	1.89	1.89	1.97
LSD (5%)	Nitrogen (N) = 0.19 Spacing (S) = 0.17 Interaction (N x S) = 0.37					
C.V. (%)	= 11.38					

1) Means followed by the same letter are not signficantly different at P = 0.05

Table 6: Phenotypic Correlation Coefficient between plant growth components of *Corchorus olitorius*.

CHARACTER	Crude Protein	Taste	Plant Height	Total Fresh Leaf Yield
Number of branches per plant	-0.096	-0.052	0.003	0.117
Total Fresh Leaf Yield	0.558**	0.349*	0.378*	-
Plant Height	0.205	0.203	-	
Taste	0.189	-		

*,** Indicates significance at $P \leq 0.05$ and $P \leq 0.01$ respectively.

Significant correlations were observed between taste and fresh leaf yield (r=0.349*) and between plant height and fresh leaf yield (r=0.378*) (Table 6).

For the rest of the parameters, there were no significant correlations (Table 6).

5. DISCUSSION

First of all the results indicated that nitrogen fertilization given as topdressing increased leaf yields of *Corchorus olitorius* (Table 2). All fertilized plots had higher leaf yields than the control. A similar observation was also reported by Mnzava (1986) and Chilufya (1990) where nitrogen fertilization increased leaf yields of *Corchorus olitorius* as compared to the control which resulted in low leaf yields. The highest leaf yield of the present study of 1.44 t ha^{-1} was obtained at 40 kg N ha^{-1}. The lowest leaf yield of 1.02 t ha^{-1} was from the control (0 kg N ha^{-1}) as topdressing (Table 2). The response of *Corchorus* in this study is similar to the study done by Mnzava (1986) who found that there was no response in increased leaf yield beyond 40 kg N ha^{-1} although he grew on a clay soil on a different location.

In spite of the findings of the present study Chilufya (1990) achieved the highest yield of *Corchorus* at a nitrogen level of 120 kg N ha^{-1}, but using a different spacing, irrigation and no basal nitrogen dressing. In the present study under rainfed conditions and low moisture supply a nitrogen topdressing above 40 kg N ha^{-1} could not be used for leaf production by the *Corchorus* plants. It seems that for resource poor small scale farmers without irrigation facilities only low nitrogen levels of costly fertilizers contribute to a yield increase.

The control resulted in the lowest leaf yield in this study probably due to small size of leaves observed in the field. Similar observation was reported by Eddows (1969) who indicated that nitrogen deficiency leads to relatively underdeveloped plants and the leaves become small.

Whereas Gupta (1953) found that nitrogen deficiency significantly reduced the plant height of *Corchorus*, only little differences were found in the present study refering to plant height, leaf crude protein and taste where nitrogen fertilization was done. Nevertheless, a trend was that plant height and crude protein were higher in fertilized plots than in the control. The taste also improved where fertilization was done than in the control (Table 2). The only little effects of nitrogen on plant height, leaf crude protein and taste could also be a result of low moisture received during the study period which was 380mm. Tindall (1988) indicated that the amount of rainfall needed should be 1000mm for the proper growth and yield of this species.

There were positive correlations between leaf yield and crude protein (r = 0.558), leaf yield and taste (r = 0.349) and leaf yield and plant height (r = 0.378) (Table 6). Under better growing conditions a higher correlation between plant height and leaf yield could be expected as was the case observed by (Hay and Walker 1989).

As shown in Fig. 1, dry matter accumulation decreased as the plant approached maturity. This confirms a study done by Marschner (1990), which showed that the accumulation of dry leaf matter increases in the young plant and decrease in the mature plant, and this was attributed to remobilization of high phloem -mobile mineral nutrients as plants change from vegetative stage to reproductive stage.

It was found in the present study that spacing had a significant effect on plant height. Plants were taller under broadcasting and shorter at 40 x 40 cm spacing (Fig. 2). Similar observation was reported by Tesar (1984) who showed that plant height actually increases in competition for sunlight because of etiolation effect of heavy shade. The leaf crude protein was high (2.61%) where wide spacing 40 cm x 40 cm was used and it was low (1.98%) where broadcasting was used. The trend was that where spacing was done the crude protein increased as compared to broadcasting (Table 3). Increasing spacing between plants led to higher crude protein contents but did not increase leaf yield and the number of branches of *Corchorus olitorius* . This could also be due to the drought experienced during the study period, since according to the study by Akodora (1985) the pattern of branching of *Corchorus olitorius* improved in number with wider spacing, high soil fertility and adequate water supply.

Although little effects were observed in leaf yield when spacing was done, the trend was that leaf yield increased where spacing was done compared to broadcasting (Table 3). The results from this study tend to be similar to NIRS (1986) study where leaf yields of *Corchorus* selections were not greatly influenced by differences in the spacing rather the yield was influenced by cultivar differences. However, spacing helps in increasing leaf crude protein which is needed by people who cannot afford animal proteins which tend to be costly.

The nitrogen and spacing interaction values indicated that the control (0 kg N ha^{-1}) gave the lowest crude protein across all spacings, and 120 kg N ha^{-1} resulted in the highest crude protein across all spacings (Table 4). The taste in the control was not so good compared to where nitrogen fertilization and spacing was done (Table 5).

The present study of effects of nitrogen levels and spacing on leaf yield and quality characteristics of *Corchorus olitorius* was done at one location (Lusaka Province), under rainfed conditions, in summer season and during a drought period. Before final recommendations can be given to the small scale farmers further research in the following aspects is recommended.

a) Trials in different provinces in Zambia and at different seasons, with adequate rainfall conditions or irrigation practised are necessary because the conditions of drought in the present study may not be a true reflection of the performance of the crop.

b) The sample of five plants per plot from which data were collected could be too small to have reliable data on which to base recommendations. For further field experimentation, larger sample size should be considered.

6. CONCLUSION

The purpose of this study was to determine the optimum level of nitrogen fertilizer and spacing needed to obtain maximum leaf yield and good quality of *Corchorus olitorius*, and to find out if phenotypic correlations existed between the plant parameters studied.

Results indicated that maximum leaf yields were obtained when 40 kg N ha^{-1} was applied as topdressing fertilizer. The control had the lowest yields indicating that nitrogen fertilization is necessary for improved yield of this crop. There were little difference in crude protein and taste between control and fertilized plots.

It is recommended that a repetition of this trial should be done under normal rainfall condition and at different locations with larger sample size for data collection to have more reliable data for basing recommendations, because the present study under drought condition might not represent the true performance of the crop.

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Appendix I: Rainfall data for University Field Station for 1991/92 growing season

Days	Dec.	Jan.	Feb.	Mar.	April	May
1	-	-	-	-	-	-
2	-	-	-	13.4	-	-
3	-	15.6	-	1.0	-	-
4	-	-	-	0.7	-	-
5	-	-	1.4	-	-	-
6	23.8	-	-	-	-	-
7	-	28.2	-	-	-	-
8	-	-	-	-	-	-
9	-	-	-	-	-	-
10	-	3.0	-	-	-	-
11	-	-	-	-	-	-
12	-	3.6	-	-	-	-
13	-	-	-	-	-	-
14	-	-	-	10.4	-	-
15	-	1.0	-	-	-	-
16	28.0	-	-	6.0	-	-
17	-	-	-	-	-	-
18	-	18.6	-	-	-	-
19	1.4	-	-	-	-	-
20	-	11.6	-	10.1	-	-
21	-	2.0	-	0.6	-	-
22	-	-	-	43.0	-	-
23	4.0	-	-	1.4	-	-
24	23.6	8.6	-	10.5	-	-
25	-	6.0	38.1	2.0	-	-
26	3.0	4.6	-	-	1.2	-
27	-	-	4.9	-	3.2	-
28	-	-	4.9	-	40.8	-
29	-	-	-	-	-	-
30	-	-	-	-	-	-
31	-	-	-	-	-	-
	83.8	102.8	49.3	99.1	45.2	

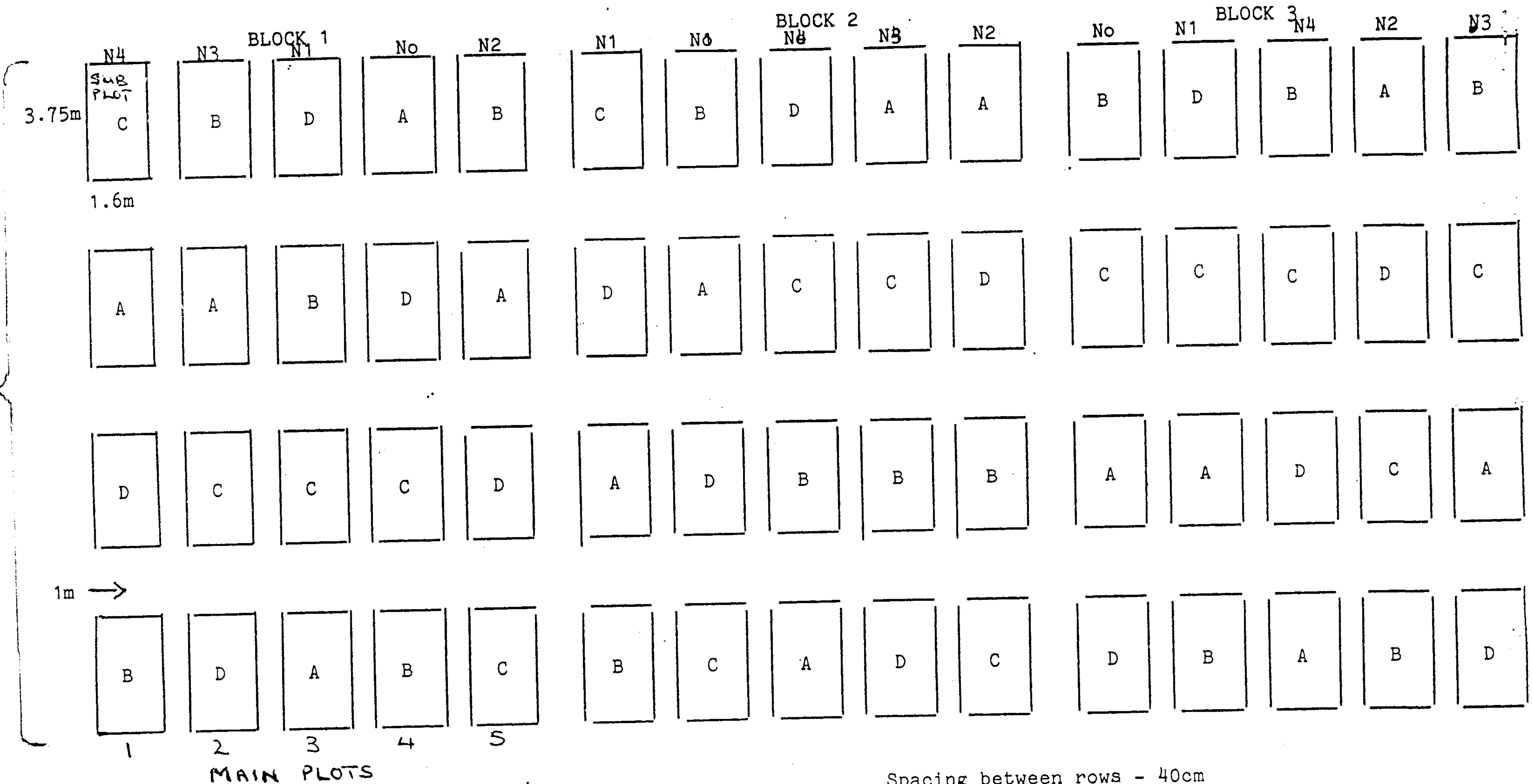
Total rainfall received during the growing season = 380 mm

Source: Department of Geography, University of Zambia, Lusaka.

Appendix II: Temperature data at University Field Station in Degrees celsius for 1991/92 growing season.

Days	December	January	February	March	April	May
1	30(19)	28(19)	32(19)	28(20)	20(7)	24(5)
2	29(17)	82(16)	31(19)	31(16)	21(6)	23(6)
3	29(19)	29(16)	30(18)	28(19)	19(10)	31(5)
4	30(17)	26(16)	29(17)	30(19)	28(8)	29(12)
5	23(16)	28(17)	27(16)	27(18)	29(8)	29(13)
6	29(16)	27(16)	29(16)	28(17)	28(15)	30(15)
7	24(16)	29(16)	28(16)	30(18)	27(11)	28(14)
8	25(17)	28(17)	30(18)	29(16)	28(16)	28(11)
9	29(19)	29(16)	29(19)	32(16)	29(16)	
10	27(18)	27(17)	29(16)	26(19)	29(17)	
11	26(19)	30(19)	30(19)	31(19)	72(11)	
12	25(20)	28(16)	92(16)	31(16)	30(11)	
13	28(19)	27(15)	32(15)	29(19)	29(16)	
14	26(19)	29(16)	32(16)	29(18)	28(12)	
15	27(20)	30(19)	33(16)	29(16)	26(14)	
16	29(12)	31(19)	32(19)	28(19)	28(13)	
17	28(17)	31(16)	33(19)	28(19)	29(10)	
18	30(19)	29(16)	32(16)	28(18)	27(8)	
19	72(20)	28(71)	29(17)	82(19)	20(8)	
20	28(17)	29(16)	32(19)	29(19)	21(17)	
21	25(19)	24(17)	31(19)	29(19)	30(22)	
22	26(18)	28(16)	31(19)	29(20)	29(20)	
23	25(19)	30(16)	33(20)	30(19)	29(21)	
24	25(16)	29(17)	33(19)	27(19)	28(17)	
25	26(19)	29(17)	33(19)	26(16)	29(17)	
26	28(17)	29(19)	25(16)	26(16)	28(17)	
27	25(16)	26(15)	31(20)	25(19)	29(18)	
28	28(17)	26(15)	28(18)	25(16)	28(18)	
29	28(19)	28(11)	31(19)	25(12)	28(18)	
30	26(20)	30(17)		27(12)	25(6)	
31	27(16)	32(17)		24(13)		
MEAN	27(18)	29(17)	31(18)	28(16)	27(13)	28(10)

Figures in brackets are minimum temperatures.



Spacing between rows - 40cm

Intra row spacing

A - 20cm
B - 30cm
C - 40cm
D - Broadcasting

Appendix IV. Laboratory seed germination percentage for *Corchorus olitorius* done at UNZA, CROP SCIENCE BOTANY LABORATORY, LUSAKA. ZAMBIA in 1992.

Type	**% germination**
Lusakasaka (*Corchorus olitorius*)	85

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Dear Ruth

Thank you for your letter of 7th April, 1992, and also for your interest to our information services on Tropical vegetable.

We are enclosing a printout of abstracts which your requested. Please note that Nos 0015 and 0056 do not include abstracts. We also add your name on our SDI Bulletin mailing lists.

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