EFFECT OF SPACING AND CORMEL SIZE ON THE GROWTH AND YIELD OF MUKHIKACHU (*Colocasia esculenta* L. Scott)

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CERTIFICATE

This is to certify that the thesis entitled **"Effect of Spacing and Cormel Size on the Growth and Yield of Mukhikachu (*Colocasia esculenta* L. Scott)"** submitted to the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **Master of Science in Horticulture**, embodies the result of a piece of *bona fide* research work carried out by **Ripon Kumar Sikder**, Registration No. **26261/00548** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or source of information, received during the course of this investigation has been duly acknowledged.

Date: June, 2013
Dhaka, Bangladesh

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DEDICATED

TO

MY BELOVED PARENTS

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All praises to Almightly and Kindfull trust on to "Omnipotent Creator" for His never-ending blessing.

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ABSTRACT

A study was conducted at the Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka during the period from February 2012 to March 2013. Cormels of mukhikachu cv. Bilashi were used for the research work. The experiment consisted of two factors: Factor A: Plant spacing (4 levels) as- S_1: 60 cm × 20 cm, S_2: 60 cm × 30 cm, S_3: 60 cm × 40 cm and S_4: 60 cm × 50 cm; Factor B: Cormel size (3 levels) as- C_1: Small size (5.0-7.5 g), C_2: Medium size (7.5-10.0 g) and C_3: Large size (10.0-12.5 g). The two factors experiment was laid out in Randomized Complete Block Design with three replications. For plant spacing and cormel size, most of the studied characters showed statistically significant variation. The highest yield of corm and cormel per hectare (5.58 and 26.15 ton) was attained from S_3, whereas the lowest (4.45 and 16.64 ton) from S_1. In case of cormel size, the highest yield of corm and cormel per hectare (5.87 and 23.89 ton) was found from C_3, again the lowest (4.39 and 21.10 ton) from C_1. For interaction effect, the highest weight of corm and cormel per hectare (6.76 and 28.19 ton) was recorded from S_3C_3, while the lowest (3.96 and 15.16 ton) from S_1C_1. It was revealed that 60 cm × 40 cm plant spacing with large size (10.0-12.5 g) cormel was best in consideration of growth and yield of mukhikachu.

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CHAPTER I

INTRODUCTION

Mukhikachu (*Colocasia esculenta* L. Scott) is a perennial, cormous plant belongs to the family Araceae and well known as Taro, Old Cocoyam, Dasheem and Eddoeis an important edible aroid in Bangladesh, as well as the world. It is originated in South Central Asia, probably in India or Malaysia (Onwueme, 1978). But it is commonly grown throughout the tropical and subtropical regions on the world (Ghosh *et al*., 1988). It is normally 0.4-2.0 meter tall, with large heart shape leaves variable in size and color, arising from an under ground, farinaceous corm, surrounded by a number of secondary corm or cormels, which also vary greatly in size and shape and are also farinaceous (Kay, 1973). It is extensively grown in Bangladesh in kharif season and contributes a considerable part in the total supply of bulky vegetables are scarce in the market (Siddique *et al.*, 1988).

The corm and cormel are the major economic part of the taro. Occasionally, the leaves and petioles also used as food. The main stored food in the corm is carbohydrate (mostly starch). The starch of taro consists of 17-28% amylase, while the rest is amylopectin. Taro starch is readily digestible when used as food. The approximate composition of the *Colocasia* cormel per 100 g is moisture 64.4 g, carbohydrate 32.4 g, protein 1.8 g, fat 0.06 g, crude fiber 0.09 g, total mineral materials 1.5 g, calcium 22 mg, phosphorus 52 mg, vitamin B_1 0.04 mg, vitamin B_2 and vitamin C in trace amount. Total food value is 266 kilo calorie. The corms of taro contain rap hides, these are minute bundles of crystals of calcium oxalate, 0.1-0.4% fresh weight (Onwueme, 1978), which account for the irritating effect of the raw corm. The protein content of the taro corm is slightly higher than of yam, cassava or sweet potato. It is widely cultivated in the south-west region of Bangladesh, mainly concentrated in Jessore, Meherpur, Kushtia, Chuadanga and Satkhira. Taro production in the year 2009-10 was about 224,546 ton in 23,000 hectare of land (BBS, 2011). Average production is about 9.76 ton per hectare in our country and the production is very low compared to other countries.

Yield of mukhikachu are very low in Bangladesh and such low yield however is not an indication of low yielding potentiality of this crop, but may be attributed to a number of reasons, viz. unavailability of quality seeds of high yielding varieties, delayed sowing after the harvest of boro rice, use of undetermined size of cormels, fertilizer management, disease and insect infestation and improper or limited irrigation facilities. Among different factor plant spacing and corm size are the most important factor.

Plant spacing is an important aspect of crop production for maximizing the yield. It helps to increase the number of leaves, branches and healthy foliage. Densely planted crop obstruct the proper growth and development. On the other hand, wider spacing ensures the basic requirements but decrease the total number of plants as well as total yield. Crop yield may be increased upto 25% by using optimum spacing. In Bangladesh like other management practices information about spacing to be used in mukhikachu cultivation is scanty. Different yield attributes response for different plant spacing. Many scientists earlier reported the wider spacing produced maximum plant height, functional leaves and leaf area index were, while the minimum of these parameters were produced at closer spacing. Greater number of suckers and cormels were also obtained at the wider spacing and lesser number at narrow spacing (Ira, 2004; Sarma and Narzary, 2000 and Sarma and Narzary, 1999). Generally in closer spacing plant competed for light than wider spacing which helps to elongation of plant with minimum number of leaves per plant than the wider spacing.

Mukhikachu is largely propagated by its corms and cormels. Reports indicated that growth and yield are affected by various factors of which size of corm is one of the main factors. The diameter and weight of corm greatly influence yield and quality of mukhikachu (Siddique *et al*., 1988). Thititaweesin *et al*. (2010) reported that the biggest corm size (5 cm) gave the highest total dry weight and corm dry weight yield while the smallest corm size (1 cm) gave the lowest.

There is a scope of increasing the yield as well as economic benefits of mukhikachu with the appropriate spacing and cormel size.

Considering the above mentioned facts and based on the prior observation, an investigation was undertaken with the following objectives:

- To find out the suitable spacing for production of mukhikachu;
- To find out the optimum cormel size for higher yield of mukhikachu; and
- To find out interaction effect among different spacing and cormel size for yield contributing characters and yield of mukhikachu.

CHAPTER II

REVIEW OF LITERATURE

Mukhikachu is considered a summer vegetable in Bangladesh and its popularity is increasing day by day because of its high nutritive value and possible diversified use. Due to some advantages of mukhikachu cultivation in Bangladesh is becoming more popular and total yearly production is increasing gradually. But the farmers of Bangladesh are not knowledgeable regarding its cultivation with aiming to maximum yield. A very few research works related to mukhikachu cultivation especially emphasis on plant spacing and cormel size have been carried out in Bangladesh. Nevertheless, some of the important and informative works regarding the plant spacing and cormel size so far been done at home and abroad of this crop have been reviewed below under the following headings-

2.1 Growth and yield of mukhikachu in different plant spacing

Field experiments were conducted by Abd-Ellatif *et al.* (2010) at the experimental farm of the Horticultural Research Station of Barrage, Qalyubia Governorate to evaluate the influence of planting date (mid-November, mid-December, mid-January and mid-February) and intra-row spacing (20, 30, 40 and 50 cm) on growth, yield and quality of taro (*Colocasia esculenta* cv. Balady), with a particular attempt to establish an early planting system under Egyptian conditions. Planting date × intra-row spacing interaction had a significant effect on vegetative growth parameters and total yield/feddan. Early planting dates with closer distances between plants gave the highest values for these characters. This study demonstrated that planting date and intra-row spacing affect growth and yield of taro. Early plantings in mid-November or mid-December along with close spacing of 20 cm can be recommended for obtaining early and high production of taro under Qalyubia conditions.

Performance of taro (*Colocasia esculenta*) under six nitrogen levels and three poplar (Populus deltoides Bartr. Ex. Marsh) spacing (Open, 5 m × 4 m and 5 m × 3 m) was investigated by Pant *et al*. (2010) in subtropical zone of Himachal Pradesh. The average relative illumination below 5 m × 4 m and 5 m × 3 m poplar spacing was 48 and 40%, respectively.

A field trial was conducted by Tumuhimbise *et al*. (2009) over two cropping seasons at Kabanyolo in central Uganda, to determine the effect of three taro plant populations (10,000, 17,760 and 40,000 pph) and two seedbed types (flat and ridged seedbed) on growth and yield of taro (*Colocasia esculenta*). During a 5-month growth period, leaf area index (LAI) and corm yield were significantly ($P < 0.05$) higher in closely spaced plants (high plant population). However, using high plant population may not be recommended because of the enormous amount of planting material that would be needed. From this study it was revealed that a moderately wide spacing of 0.75 m × 0.75 m which produced an acceptable yield of 5.5 – 6.8 t ha^{-1} would be recommended.

The effects of sowing date, spacing (45×20, 45×30, 60×15, 60×22.5, 60×30, 75×18 and 75×24 cm), P (0, 50 and 100 kg/ha) and N (0, 50, 100 and 150 kg/ha) on the growth and yield of taro were determined by Gill *et al*. (2005) in a field experiment conducted in Ludhiana, Punjab, India. Plant spacing of 45×20 cm resulted in the highest fresh corm yield (349.8 q/ha), returns (Rs. 92,380/ha) and benefit : cost ratio (4.07), whereas plant spacing 45×30 cm resulted in the highest number of leaves per plant (8.1) and corm weight (29 g).

Field experiments were conducted by Soumik and Sen (2005) at the Horticultural Research Station, Bidhan Chandra Krishi Viswavidyalaya, West Bengal, India, to find out the effect of fertilizer levels (50:25:50, 75:50:75 and 100:75:100 kg N, P_2O_5 and K_2O ha^{-1}) and spacings (60×30 cm, 60×40 cm and 60×50 cm) on plant vigour, yield components and yield of eddoe taro. The number of shoots per clump, number of leaves per plant and yield components increased, while the plant height and total cormel yield per unit area decreased with increase in spacing.

As far as the interaction effects were concerned, the highest cormel yield (14.99 t ha^{-1}) was obtained with the highest fertilizer level i.e., 100:75:100 kg N, P_2O_5 and K_2O ha^{-1} coupled with closer spacing (60×30 cm).

Scheffer *et al*. (2005) reported that Japanese taro (*Colocasia esculenta*) was introduced into New Zealand in 1992 as a potential new crop. Crop evaluation studies have been carried out at Pukekohe Research Centre in the Auckland region where frost-free conditions for 7-8 months and warm summer temperatures provide a suitable environment for production. A comparison of four intra-row spacings of 200, 300, 400 and 500 mm with an inter-row spacing of 750 mm revealed that total cormel yield increased from 47 to 60 t/ha as plant density increased. The average cormel size of 47 g remained similar at all spacing treatments.

The effects of spacing on the incidence of Phytophthora leaf blight in *C. esculenta* (cv. Telia) and the extent of leaf area damage were studied by Misra *et al*. (2004) in Bhubaneswar, Orissa, India, during 1999 and 2000. The closer spacing (40×20, 30×30 or 40×30 cm) enhanced the spread of the disease and the total leaf area damaged compared to wider spacing (60×40, 60×30 and 60×20 cm). However, the yield loss due to the disease was compensated by the yield attributed to the higher number of plants per unit area in closely spaced plots.

In a study conducted by Ira (2004) in Assam, India, six growth parameters were studied in five *Colocasia esculenta* cultivars (Bor kachu, Ahina black, Mohkhuti, Tekelikachu and Konikachu) at different stages of growth in four spacings (60×35, 60×45, 60×55 and 60×65 cm). Plant height, functional leaves and leaf area index increased up to 120 days after planting and thereafter declined until maturity, while the number of suckers and cormels increased with the age of the crop. The maximum plant height, functional leaves and leaf area index were produced at 60×45 cm, while the minimum of these parameters were produced at 60×35 cm. Greater number of suckers and cormels were obtained at the wider spacing i.e. 60×65 cm and lesser number at narrow spacing i.e. 60×35 cm.

Sarma and Narzary (2000) carried out an experiment with the tubers of 5 *Colocasia esculenta* cultivars, Bor Kachu, Ahina-Black, Mohkhuti, Tekeli Kachu and Koni Kachu, were analysed for moisture, dry matter and ash contents at various stages of growth under 4 different spacings (60 × 35, 60 × 45, 60 × 55 and 60 × 65 cm) and the finding revealed that the spacing had no effect on quality attributes in *C. esculenta* cultivars.

Ortiz *et al*. (2000) reported that a research project has been conducted to obtain quantitatively based information for the improvement of management practices for taro production under upland conditions in Puerto Rico. Experiments included evaluation of sett size, plant spacing, weed interference, and nitrogen side dressing. Results revealed that a 38.1 cm planting distance in the row decreased yield and dry weight compared with wider spacing. Plant spacing had a significant effect on the percentage of dry matter partitioning into the corm at harvest. Planting at 45.7 cm spacing, rather than at 61.0 cm, may result in more leaf area per land area early in the crop cycle, thus reducing weed interference.

Field experiments were conducted by Sarma and Narzary (1999) at Jorhat during 1996 to study the effect of spacing (60 × 35, 60 × 45, 60 × 55 and 60 × 65 cm) on weight of corms and cormels per plant, total tuber yield and economics of five *Colocasia esculenta* cultivars. Among the four spacings, 60 × 45 cm was the best with respect to total tuber production and economics, resulting in higher net income. Among the cultivars, Tekeli Kachu produced the highest total tuber yield and gave the highest net returns in and across all the spacing.

An experiment was conducted by Basak *et al*. (1999) at five locations (Kishoreganj, Kuliarchar, Katiadi, Netrokona and Kendua) to evaluate the agro-economic performance of Panikachu (*Colocasia esculenta*) under different spacings and fertilizer levels in 1992 and 1993. Three spacings (75×45 cm, 60×45 cm and 45×45 cm) and two fertilizer levels (recommended dose and farmers dose, the latter varying with location) were used. Per plant yields were significantly higher in wider spacings but total yields were higher in the closer spacings.

The highest stolon yield (41.06 t/ha) was given by farmers fertilizer treatment and 60×45 cm spacing, and the highest rhizome yield (25.61 t/ha) from farmers fertilizer rate and 45×45 cm spacing. The benefit:cost ratio of different treatments ranged from 3.44 to 3.91 indicating profitability of all the treatments.

The study was evaluated by Ortiz and Gonzalez (1999) to find out the effect of practical combinations of sett size and plant spacing on taro (*Colocasia esculenta*) cv. Blanca yield and dry matter distribution at harvest. Spacing were 38.1, 45.7 and 61.0 cm between plants. Plants grown at 61.0 and at 45.7 cm spacing differed neither in yield nor in dry weight measurements. Reduction of the planting distance to 38.1 cm decreased yield and dry weight. The sett size and plant spacing combinations used were not effective in reducing the number of suckers per plant nor in improving the dry matter partitioning into the main corm. Plants averaged yield was 13.8 cormels.

A field experiment was conducted by Mehla *et al.* (1997) at Haryana, India to assess the effect of spacing and fertilizer levels on the growth and yield of Colocasia (*Colocasia esculenta* L. Schott) during rainy season with three spacing (30 × 30 cm, 45 × 30 cm and 60 × 30 cm) and four fertilizer levels consisting of various combinations of N and P. The yield attributes, viz. number of leaves, number of corms and weight of corms per plant and corm yield (q/ha) were increased significantly with plant spacing 60 × 30 cm.

2.2 Effect of cormel size

Generally corm and cormels are used as planting materials for propagating mukhikachu. Size of corm used at planting has direct effects on corm and cormels production of this crop and also other crop that produced in same way.

Thititaweesin *et al*. (2010) conducted a study the effects of corm size on growth and yield of four taro cultivars. The experiment was conducted at experimental paddy field of Faculty of Agriculture Technology, King Mongkut's Institute of Technology, Ladkrabang. A Split plot in randomized complete block design with 3 replications was employed. Main plot were four local taro cultivars (Saraburi, Nakhon Pathom, Pichit and Chiangmai) and five diameter-corm sizes (such as 1, 2, 3, 4 and 5 cm. corm size diameter) were considered as sub plot. The results disclosed that as taro grown by using different corm sizes, the biggest corm size (5 cm) gave the highest total dry weight and corm dry weight yield while the smallest corm size (1 cm) gave the lowest. However, there were no interaction between taro cultivars and corm sizes.

Modi (2010) conducted an experiment with taro [*Colocasia esculenta* (L.) Schott] corms of different sizes (80-100 g corm-1, 40-60 g corm-1 and 20-30 g corm-1) that had been stored in soil pits at different depths (10, 20, 30, 40 and 50 cm) were compared for stand establishment, leaf area and yield during two seasons, under rainfed (upland) conditions. Propagule size and pre-planting storage depth increased both the number of plants reaching the third leaf stage and leaf area per plant one month after planting. The large propagules improved stand establishment and yield significantly ($P<0.01$) better than the smaller propagules. For all propagule sizes, the optimum storage depth to enhance taro propagule performance for crop production was ~40 cm. When the large propagules were compared with the smaller propagules at the optimum pre-planting storage depth, there was 10% to 30%, no difference and 5% to 35% improvement in leaf area, stand establishment and yield, respectively. This study confirmed the potential role of local knowledge in traditional agriculture, and the findings can be used to extend the planting season for dryland taro production in South Africa.

The experiments were conducted by Khan *et al*. (2010) to determine the suitable planting geometry for better yield from TPS mini tubers. It was revealed that even small size (5-20 g, 20-30 g) tubers planted at closer row and plant spacing (60 cm × 15 cm, 70 cm × 15 cm) produced 31.00%, 31.33% and 28.33%, 32.33% medium size tubers (35-55 mm size). Whereas wider spacing (70 cm × 20 cm, 50 cm × 20 cm) produced relatively higher number of large size tubers.

The effects of different in-row spacing (20, 25, 30 and 35 cm) and seed size (small, medium and large) treatments on yield components and tuber yield of early potato were studied by Gulluoglu and Aroglu (2009) in Adana, Turkey and reported that planting larger seeds positively affected all growth and yield components.

Tuber yield hectare^{-1} was increased up to certain stem density and then was started to decline at all seed sizes. However, the optimum stem density for the maximum tuber yield hectare^{-1} markedly differed depending on size of seed tubers. The optimum stem density increased with increasing seed size .The authors indicated that size of seed tuber has further importance for growth of potato plant as well as competition aspect in early potato production in the mediterranean-type environments. The author concluded that using larger tubers had an advantage for vigorous early growth and for obtain high tuber yield in early potato production in the mediterranean-type environments. Seed size should be considered during recommendation for planting density in potato production.

An investigation was carried out by *Faisal et al*. (2009) at Agricultural Research Station, Pahartali, Chittagong to select suitable size of planting material and proper time of earthing-up to obtain higher yield of Mukhi Kachu. Three planting materials, primary corm (40g), half cut corm (20g), and secondary corm (10g) and four times of earthing-up, 1 month, 2 months, 3 months, and 4 months after planting were used. Different planting materials showed significant difference on weight of total corms/plot, weight of total cormels/plot and cormel yield. The highest (3.71 t/ha) corm yield was obtained when primary corms were planted and earthing-up was done three months after planting.

An experiment was conducted by Verma *et al.* (2007) at Muzaffarpur, Bihar, India, during rabi 2001-02 with 15 treatment combinations which included five seed tuberlet sizes (<10, 10-20, 20-30, 30-40 and >40 g) and three true potato seed (TPS) cultivars (92-PT-27, TPS C-3 and HPS 1/13). They reported that the seed tuberlet size of 30-40 g resulted in significantly superior tuber yield, which was at par with the tuber yield obtained from 10-20 and >40 g seed tubers in all the three TPS cultivars. Use of large seed generally results increased seed rate.

An experiment was conducted by Sonawane and Dhoble (2004) during the winter (*robi*) seasons in Maharashtra, India, to find out suitable and economical combination of inter- and intra-row spacing with seedling tuber size of potato (*Solanum tuberosum*) and reported that the tuber yield increased with the increase in seedling tuber size.

Significantly highest tuber yield was recorded by large seedling tuber size of 11-15 g over 1-5 g and 6-10 g sizes. Similarly, 6-10 g seedling tuber weight was significantly superior to 1-5 g size. Benefit: cost ratio decreased as the seedling tuber size increased from 1 to 15 g.

A field experiment was conducted by Shingrup *et al.* (2003) on clayey soil during the rabi season at the farm of the Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India, to study the effect of row spacing, seed tuber size and fertility level on the economics of potato cultivation. The authors reported that seed tubers size of 26-45 g recorded significantly higher tuber yield, gross monetary returns, net monetary returns and benefit-cost ratio than seed tubers of 6-25 g size.

A study was conducted by Wadhwa *et al.* (2002) to investigate the effects of four different 'seed' tuber weights and three intra-row spacing on the yield and yield components of 'Frafra' potato. The 'seed' tubers were categorized according to weight: A (≥10. 0 g), size B (7.0-9.9 g), size C (3.0-6.9 g) and size D (<3.0 g); three intra-row spacing of 20 cm, 30 cm and 40 cm were also used. The authors reported that leaf area index (LAI) and crop growth rate (CGR) were greater in larger seeds than smaller ones. The authors further reported that yield increased with the use of heavier 'seed' tubers. On the average, yield of plants of category B 'seed' tubers was 52% higher than those obtained from 'seed' tubers of category A and 58% and 59% higher than those of categories C and D, respectively.

An experiment was conducted by MacKerron (2002) in SCRI and Terrington, UK, to test the effects of potato seed size and plant spacing in 8 combinations of seed size and plant spacing in 6 cultivars (King Edward, Marfona, Maris Piper, Pentland Dell, Pentland Squire and Shepody). Treatments comprised: the combinations of 5 seed sizes (30-35, 35-40, 40-45, 45-50, 50-55 mm) and 5 row spacings (15, 18, 25, 33 and 45 cm). The differing sensitivities of showed an inverse relation between average tuber size and stem density that provides the means of controlling tuber size distribution.

A field experiment was carried out by Patel *et al.* (2002) during 2000 and 2001 in Kargil, Jammu and Kashmir, India, to investigate the effect of seed size [medium (25-50 g), big (50-75 g) and large (75-100 g)] and intra row spacing (20, 25 and 30 cm) on the yield of potato cv. Kufari Chandramukhi. The authors reported that growth, total yield, tubers plant^{-1} and average weight per tuber were greatly affected by seed size and spacing. Tuber yield (305.24 q ha^{-1}) and the number of tuber plant (10.40) were significantly highest with big seed size and 25 cm intra row spacing, while average weight per tuber (53.93 g) was highest with large seed size and 30 cm intra row spacing.

A three year field trial was carried out by Reust (2002) at the Swiss Federal Research Station for Plant Production of Changins [Switzerland] with different seed tuber sizes (25-35, 35-50 and 50-65 mm) to find out the effect of seed tuber size on yield in potato and reported that yields were not different between small graded seed (25-35 mm) and normal seed size (35-50 mm). The author further reported that small seed tubers had a longer dormancy and produced less stems and tubers plant^{-1} than large ones. The author opined that by using small graded seed, farmers might significantly reduce production costs.

The effect of tuber size (25-30, 30-55, 55-75 and 75-85 mm) on potato growth and yield was determined by Divis and Barta (2001) in Czech Republic in 1996-98. The authors reported that increasing seed tuber size produced an increase in emergence percentage. Larger tubers produced higher stems plant^{-1}, crop growth rate as compared to small tubers which resulted in higher yield compared to small ones.

Bongkyoon *et al*. (2001) conducted an experiment with tubers of potato (*Solanum tuberosum*) cv. Dejima weighing 10, 20, 30, 40, and 50 g were planted in plug trays with vermiculite-based root medium to determine the effects of mini-tuber size on plug seedling growth and field performance of plug seedlings. For a control, common potato tubers weighing 50 g were also planted. The authors reported that as size of seed tubers planted increased from 10 to 50 g, seedling height decreased from 24.6 to 20.0 cm while shoot number per seedling increased from 2.0 to 3.5, main stem diameter from 4.3 to 6.1 mm, and fresh weight of root + top from 9.3 to 19.4 g seedling^{-1}. At 90 days after transplanting, the total tubers plant^{-1} was increased from 3.62 to 4.72, average tuber weight from 62.9 to 72.8 g, and total tuber yield 20.5 to 23.6 t/ha with increase in seed tuber size. Plug seedlings raised from 50 g tubers was produced 22% more tubers plant^{-1} and had 21% higher >80 g tuber yield than the directly planted potatoes.

Three experiments were conducted by Khalafalla (2001) to know the effects of intra-row spacing (15, 25 and 35 cm) and seed size (whole, half-seed and farmer's seed piece) on the growth and yield of potato and reported that yield decreased with decrease in seed size and increase in spacing at all locations. Seed size had significant effect on marketable tubers plant^{-1}, marketable tuber weight, and stems plant^{-1}.

Gregoriou (2000) studied the effect of tuber size (30, 40, 50 and 65 mm) and row spacing (10, 20, 30 or 40 cm) on yield in potato cv. Cara and reported that seedling emergence was reduced at 10 cm spacing. Tuber yield decreased with increasing spacing. The tubers stem^{-1} and the yield per stem decreased as stem number per unit area increased. The best combination of total and baking (>65 mm) potato yield was estimated to be with a 27-cm planting distance.

Four sizes of seedling tubers (5 g, 10 g, 20 g and 30 g) in combination with four interplant spacing (10, 15, 20 and 25 cm) were studied for potato production by Rashid *et al.* (1993). Closer planting as well as larger seedling tubers increased tuber yield significantly. Closer spacing produced a higher proportion of small tubers, while larger seedling tubers produced more large tubers. In case of multiplication rate, when the seed weight was considered, smaller seeds yielded much higher than larger ones. The multiplication rate was 31.3 and 8.3 times for 5 g and 30 g seeds, and 14.6 and 19.0 times for 60 × 15cm and 60 × 30 cm spacing respectively.

Singh *et al*. (1999) reported that four sizes of seedling tubers (5-10, 10-20, 20-40 and >40 g) in addition to 40-60 g size seed tubers of Kufri Badsha were compared for tuber yield. The total tuber yield as well as marketable tuber yield increased with increase in seedling tuber size, however, seedling tuber sizes 10-20, 20-40 and >40 g were not significantly different. Yield of Kufri Badsha was statistically at per with the yield of 5- 10 g size seedling tubers.

The main difference between plants grown from small and large seedling tubers was the comparatively slower growth rate of those small tubers. Karle *et al.* (1997) reported that with same spacing large seedling tubers (5-10 g) produced significantly higher yield over small seed size (up to 5 g). The multiplication rate and benefit cost ratio was highest in small sized seeds. Thus planting small sized seedling tubers seems to be an attractive low investment technology for potato production, provided tubers are healthy.

Khurana (1990) reported that seedling tubers of nine TPS families were tested against two seed sizes (10 g and 20 g). Seedling tubers of 10 g were planted at 60 × 12 cm and 20 g at 60 × 20 cm spacing. The crop raised from 10g tubers gave lower yield than that raised from 20 g tubers. Major difference in yield was due to a reduction in proportion of large size tubers. The mean tuber weight of the crop raised from 10 g tubers was also lower than that for the crop raised from 20 g tubers.

CHAPTER III

MATERIALS AND METHODS

The study was conducted during the period from February 2012 to March 2013 to study the effect of spacing and cormel size on the growth and yield of mukhikachu. The chapter includes a brief description of the location of experimental site, soil and climate condition, materials used for the experiment, design of the experiment, intercultural operation, data collection procedure and procedure of data analysis. The details materials and methods are presented below under the following headings-

3.1 Experimental site

The experiment was conducted at the Horticultural Farm of Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagar, Dhaka, Bangladesh. The location of the study site is situated in $23^{0}74^{/}$N latitude and $90^{0}35^{/}$E longitude (Anon., 1989). The altitude of the location was 8 m from the sea level (The Meteorological Department of Bangladesh, Agargaon, Dhaka).

3.2 Characteristics of soil

The soil of the experimental area belongs to the Modhupur Tract (UNDP, 1988) under AEZ No. 28. The selected plot was medium high land and the soil series was Tejgaon (FAO, 1988). The characteristics of the soil under the experimental plot were analyzed in the Soil Testing Laboratory, SRDI Farmgate, Dhaka and details soil characteristics were presented in Appendix I.

3.3 Climatic condition of the experimental site

The experimental site was under the subtropical climate, characterized by three distinct seasons, winter season from November to February and the pre-monsoon or hot season from March to April and the monsoon period from May to October (Edris *et al.*, 1979). Details of the meteorological data during the period of the experiment was collected from the Bangladesh Meteorological Department, Agargoan, Dhaka and presented in Appendix II.

3.4 Planting materials

Cormels of mukhikachu cv. Bilashi were used as a test crop for the research work. The cormels were collected from TCRC, BARI, Joydebpur, Gazipur.

3.5 Treatment of the experiment

The experiment consisted of two factors:

Factor A: Plant spacing (4 levels) as

i S_1: 60 cm × 20 cm

ii. S_2: 60 cm × 30 cm

iii. S_3: 60 cm × 40 cm

iv. S_4: 60 cm × 50 cm

Factor B: Cormel size (3 levels) as

i. C_1: Small size (5.0-7.5 g)

ii. C_2: Medium size (7.5-10.0 g)

iii. C_3: Large size (10.0-12.5 g)

There were 12 (4 × 3) treatments combination such as S_1C_1, S_1C_2, S_1C_3, S_2C_1, S_2C_2, S_2C_3, S_3C_1, S_3C_2, S_3C_3, S_4C_1, S_4C_2 and S_4C_1.

3.6 Design and layout of the experiment

The two factors experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The total area of the experimental plot was 291.00 m^2 with length 29.10 m and width 10.0 m which was divided into three equal blocks. Each block was divided into 12 plots where 12 treatments combination were allotted at random. There were 36 unit plots altogether in the experiment. The size of the each plot was 2.0 m × 1.8 m. The distance maintained between two blocks and two plots were 1.0 m and 0.5 m, respectively. Corms were sown in the plot with maintaining distance as per treatment. The layout of with maintaining distance as per treatment. The layout of

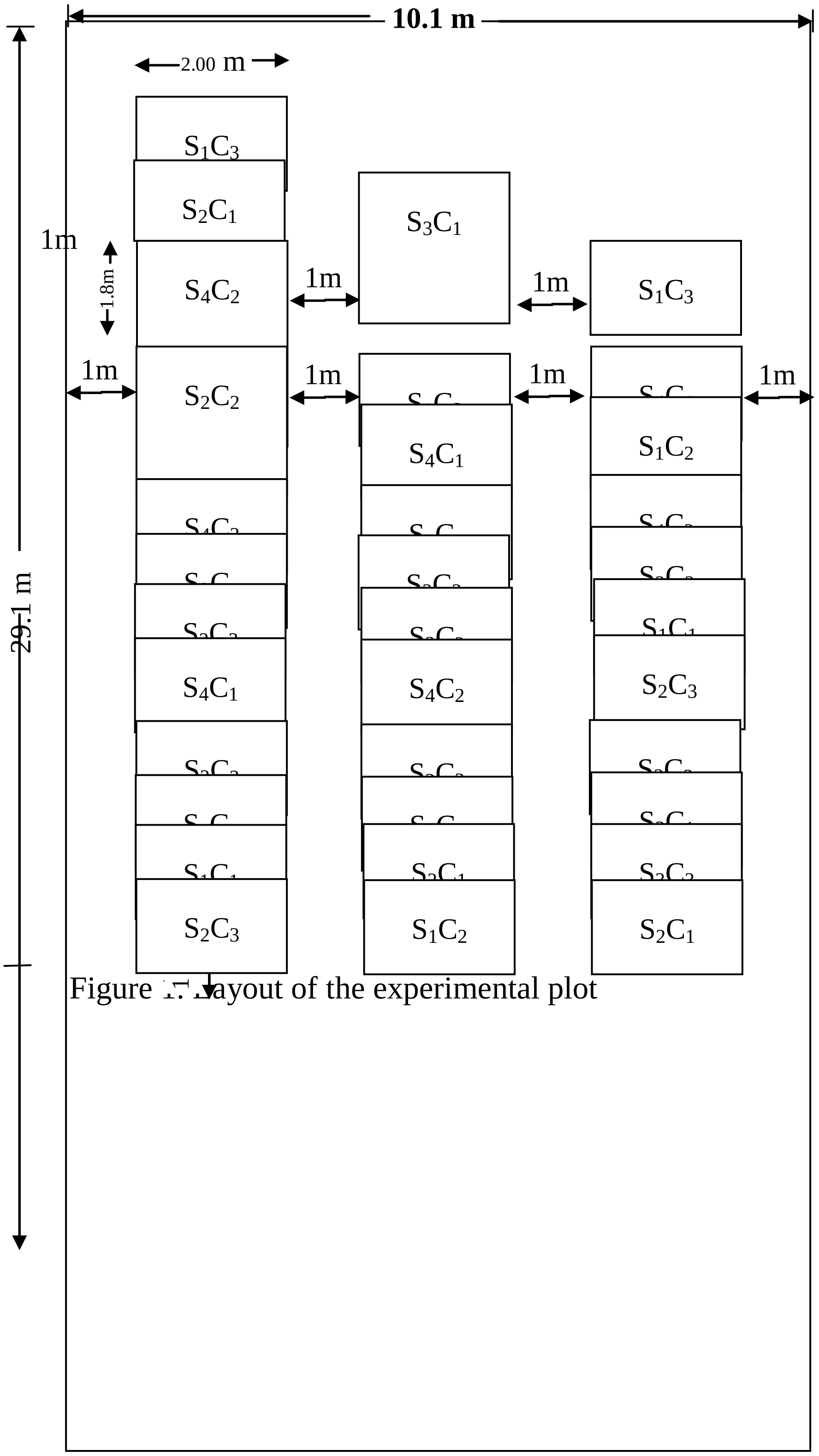
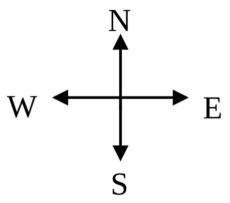


Figure [illegible] Layout of the experimental plot



Plot size: 2.0 m × 1.8 m

Plot spacing: 50 cm

Between replication: 1.0 m

Factor A: Plant spacing

S_1: 60 cm × 20 cm

S_2: 60 cm × 30 cm

S_3: 60 cm × 40 cm

S_4: 60 cm × 50 cm

Factor B: Cormel size

C_1: Small size (5.0-7.5 g)

C_2: Medium size (7.5-10.0 g)

C_3: Large size (10.0-12.5 g)

3.7 Preparation of the main field

The plot selected for conducting the experiment was opened in the last week of February 2012 with a power tiller and left exposed to the sun for a week to kill soil born pathogens and soil inhabitant insects. After one week the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain until good tilth. The land was leveled, corners were shaped and the clods were broken into pieces. Weeds, crop residues and stables were removed from the field. The basal dose of manure and fertilizers were applied at the finally ploughing. The plots were prepared according to design and layout of the experiment. The soil of the plot was treated by Sevin 50WP @ 5 kg/ha to protect the young plants from the attack of ants and cutworm.

3.8 Application of manure and fertilizers

The fertilizers N, P, K, S, Zn and B in the form of urea, TSP, MoP, gypsum, zinc sulphate and boric acid, respectively were applied. The entire quantity of cowdung, TSP, gypsum, zinc sulphate and boric acid and half urea and MoP was applied during final land preparation. The remaining half Urea and MoP were applied in two equal installments at 45 DAP and 100 DAP. The dose and method of application of fertilizer are shown in Table 1.

Table 1. Dose and method of application of fertilizers in mukhikachu field

Manure and Fertilizers	Dose (ha)	Application (%)		
		Final land preparation	Installments	
			45 DAP	100 DAP
Cowdung	15 ton	100	--	--
Urea	150 kg	50	25.00	25.00
TSP	125 kg	100	--	--
MoP	175 kg	50	25.00	25.00
Gypsum	30 kg	100	--	--
Zinc sulphate	15 kg	100	--	--
Boric acid	5 kg	100	--	--

Source: BARI, 2008

3.9 Planting of cormel

As per the treatment small size (5.0-7.5 g), medium size (7.5-10.0 g) and big size (10.0-12.5 g) cormel were planted in the plot dated on 11 March 2012. In accordance with plant spacing 30, 21, 15 and 12 cormel were planted for plant spacing of 60 cm × 20 cm, 60 cm × 30 cm, 60 cm × 40 cm and 60 cm × 50 cm, respectively. The seeds cormels were planted at a depth of 7-8 cm. After planting the cormel were covered with soil by pressed by hand. In the border area similar size cormel were plant for replacing (if necessary) any damaged plant.

3.10 Intercultural operation

After emergence of seedlings, various intercultural operations such as gap filling, weeding, earthing up, irrigation pest and disease control etc. were accomplished for better growth and development of the mukhikachu seedlings.

3.10.1 Gap filling

The germinated seedlings in the experimental plot were kept under careful observation. A very few seedlings were damaged after germination and such seedling were replaced by new seedlings from the border side stock seedlings raised from same cormel size. Those seedlings were transplanted with a big mass of soil with roots to minimize transplanting stock. Replacement was done with healthy seedling having a boll of earth. The transplants were given watering for their proper establishment.

3.10.2 Weeding

The hand weeding was done 30, 60, 90 and 120 days after planting to keep the plots free from weeds.

3.10.3 Earthing up

Earthing up was done at 60 and 120 days after planting followed by weeding on both sides of rows by taking the soil from the space between the rows by a small spade.

3.10.4 Irrigation and drainage

Light watering was given by a watering can at morning. Following seedling germination immediately after planting and it was continued for a week for rapid and well establishment of the newly germinated seedlings. Stagnant water in the field was effectively drained out at the time of heavy rains.

3.10.5 Pest and disease control

Few young plants were damaged due to attack of mole cricket and cut worm. Cut worms were controlled both mechanically and spraying Darsban 29 EC @ 3%. Some of plants were infected by leaf blight diseases caused by *Phytopthora colocasiae*. To prevent the spread of the disease Rovral @ 2 gm per liter of water was sprayed in the field. The diseased leaves were also collected from the infested plant and removed from the field.

3.11 Harvesting

Harvesting of mukhikachu was done at November 28, 2012 at 280 days of planting, when the leaves of all main plants died.

3.12 Data collection

Three plants were randomly selected for data collection from each unit plot for avoiding border effect, except yields of mukhikachu, which was recorded plot wise. Data were collected in respect of the following parameters to assess plant growth, yield attributes and yields.

3.12.1 Plant height

Plant height of mukhikachu was measured from sample plants in centimeter from the ground level to the tip of the longest leaf and mean value was calculated. Plant height was recorded starting from 60 days after planting (DAP) upto 210 days at 30 days interval and at harvest to observe the vegetative growth.

3.12.2 Number of leaves per plant

The total number of leaves per plant was counted from each selected plant. Data were recorded as the average of 3 plants selected at random from each plot starting from 60 days after planting (DAP) upto 210 days at 30 days interval and at harvest to observe the vegetative growth.

3.12.3 Foliage coverage

A good foliage coverage indicates good growth and development of mukhikachu that is directly related to yield. The foliage coverage was determined by visual observation of % soil coverage by the foliage. Foliage coverage was recorded starting from 60 days after planting (DAP) upto 210 days at 30 days interval and at harvest.

3.12.4 Number of sucker per hill

The total number of suckers per hill was counted from each selected hill. Data were recorded as the average of 3 plants selected at random from each unit plot starting from 60 days after planting (DAP) upto 150 days at 30 days interval.

3.12.5 Individual corm weight

It was determined by weighing the corms from the three randomly selected plants and mean weight was calculated and expressed in gram.

3.12.6 Corm yield per plot and hectare

Total corm yield per plot was recorded by weighing the total harvested corm in a plot and expressed in kilogram and converted to yield per hectare and expressed in t/ha.

3.12.7 Number of cormel per plant

It was calculated from the number of cormels obtained from three randomly selected plants and mean was recorded.

3.12.8 Cormel yield per plot and hectare

Cormel yield per plot was recorded by adding the total harvested cormel in a plot and expressed in kilogram and converting the yield of mukhikachu cormel per plot to per hectare and expressed in t/ha.

3.13 Statistical analysis

The data obtained for different characters were statistically analyzed to find out the significance of the difference among the treatment combinations. The mean values of all the characters were evaluated and analysis of variance was performing by the ‘F’ test. The significance of the difference among the treatments means was estimated by the least significant difference (LSD) test at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The study was conducted to find out the effect of spacing and cormel size on the growth and yield of mukhikachu. Data on different growth and yield of mukhikachu were recorded. The analyses of variance (ANOVA) of the data on different growth and yield parameters are presented in Appendix III-VII. The results have been presented and discusses with the help of table and graphs and possible interpretations given under the following headings:

4.1 Plant height

Statistically significant variation was recorded for plant height of mukhikachu due to different plant spacing at 60, 90, 120, 150, 180, 210 DAP and harvest under the present trial (Figure 2). At 60, 90, 120, 150, 180, 210 DAP and harvest, the tallest plant (23.78, 32.56, 53.22, 65.80, 68.75, 62.90 and 53.96 cm) was recorded from S_3 (60 cm × 40 cm) which followed by S_4 (60 cm × 50 cm) and S_2 (60 cm × 30 cm) and they were statistically similar. On the other hand, the shortest plant (18.78, 27.83, 46.37, 57.97, 59.79, 58.30 and 49.04 cm) was observed from S_1 (60 cm × 20 cm) for 60, 90, 120, 150, 180, 210 DAP and harvest, respectively. It was revealed that with the increases of spacing plant height showed increasing trend upto certain level than decreases. In case of closer spacing plant compete for light and other macro and micro nutrients than closer spacing which greatly effect plant growth that produced comparatively shorter plant than wider spacing. On the other way excess wider spacing do not create and competition within the species and produce comparatively shorter plant than the suitable spacing. Abd-Ellatif *et al.* (2010) reported that intra-row spacing interaction had a significant effect on vegetative growth parameters as well as plant height. Ira (2004) reported that maximum plant height were produced at 60 × 45 cm, while the minimum were produced at 60 × 35 cm and plant height increased up to 120 days after planting and thereafter declined until maturity.

Different cormel size showed significant variation for plant height of mukhikachu at 60, 90, 120, 150, 180, 210 DAP and harvest (Figure 3). At 60, 90, 120, 150, 180, 210 DAP and harvest, the tallest plant (22.95, 31.27, 51.88, 64.50, 67.87, 63.28 and 53.65 cm) was observed from C_3 (large size cormel, 10.0-12.5 g) which was closely followed (21.59 cm) by C_2 (medium size cormel, 7.5-10.0 g) at 60 DAP and statistically similar (30.95, 51.15, 63.76, 66.69, 61.55 and 52.13 cm) with C_2 for other DAP, again the shortest plant (20.24, 29.21, 48.61, 60.28, 63.29, 59.01 and 50.80 cm) was recorded from C_1 (small size cormel, 5.0-7.5 g). The plant height was higher in larger cormel size because of larger cormel had huge stored food material that support to increase vegetative growth of the plants. Thititaweesin *et al*. (2010) reported that largest cormel size gave the highest vegetative growth and ultimately produced tallest plant which in agreement with the findings of the present study.

Interaction effect of different levels of plant spacing and cormel size showed significant differences on plant height of mukhikachu at 60, 90, 120, 150, 180, 210 DAP and harvest (Table 2). At 60, 90, 120, 150, 180, 210 DAP and harvest, the tallest plant (26.04, 33.96, 56.30, 69.07, 73.48, 66.93 and 56.84 cm) was observed from S_3C_3 (60 cm × 40 cm spacing and large size cormel, 10.0-12.5 g), while the shortest plant (18.20, 27.14, 44.61, 56.77, 59.10, 56.34 and 48.44 cm) was recorded from S_1C_1 (60 cm × 20 cm spacing and small size cormel, 5.0-7.5 g).

4.2 Number of leaves per plant

Number of leaves per plant of mukhikachu showed significant variation for different plant spacing at 60, 90, 120, 150, 180, 210 DAP and harvest (Table 3). At 60, 90, 120, 150, 180, 210 DAP and harvest, the highest number of leaves per plant (3.33, 4.11, 5.20, 6.11, 7.76, 5.56 and 4.69) was observed from S_3, while the lowest number (2.13, 3.31, 4.00, 4.98, 5.51, 4.38 and 3.69) from S_1. It was revealed that with the increases of spacing number of leaves per plant also increases upto a certain level after that it decreases with the increase of spacing.

Table 2. Interaction effect of plant spacing and cormel size on plant height at different days after planting (DAP) of mukhikachu

Treatments	Plant height (cm) at						
	60 DAP	90 DAP	120 DAP	150 DAP	180 DAP	210 DAP	Harvest
S_1C_1	18.20 f	27.14 f	44.61 e	56.77 g	59.10 e	56.34 e	48.44 e
S_1C_2	18.97 ef	27.79 ef	47.71 c-e	59.80 e-g	59.34 e	58.13 de	49.56 c-e
S_1C_3	19.18 ef	28.56 d-f	46.79 e	57.34 fg	60.93 de	60.43 b-e	49.12 de
S_2C_1	19.77 ef	29.21 c-f	47.05 de	60.22 d-g	63.89 c-e	58.46 c-e	50.55 c-e
S_2C_2	21.10 c-e	30.18 c-e	50.71 b-d	62.73 b-e	67.55 bc	61.58 b-d	51.96 b-e
S_2C_3	23.66 b	31.52 bc	52.93 ab	67.02 ab	70.85 ab	64.72 ab	55.16 ab
S_3C_1	22.24 b-d	30.84 b-d	50.98 bc	62.63 b-e	63.76 c-e	58.53 c-e	51.68 b-e
S_3C_2	23.07 bc	32.88 ab	52.38 b	65.71 a-c	69.02 a-c	63.24 a-c	53.36 a-d
S_3C_3	26.04 a	33.96 a	56.30 a	69.07 a	73.48 a	66.93 a	56.84 a
S_4C_1	20.74 de	29.65 c-e	51.78 b	61.51 c-f	66.43 b-d	62.72 a-d	52.52 b-e
S_4C_2	23.23 bc	32.95 ab	53.82 ab	66.78 ab	70.84 ab	63.23 a-c	53.64 a-c
S_4C_3	22.93 b-d	31.05 b-d	51.49 bc	64.60 a-d	66.25 b-d	61.06 b-e	53.48 a-c
$LSD_{(0.05)}$	2.042	2.239	3.546	4.211	5.274	4.366	3.764
Level of significance	0.05	0.05	0.05	0.05	0.05	0.05	0.05
CV(%)	5.58	4.34	4.14	5.96	4.72	6.21	4.26

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

S_1: 60 cm × 20 cm　　C_1: Small size (5.0-7.5 g)

S_2: 60 cm × 30 cm　　C_2: Medium size (7.5-10.0 g)

S_3: 60 cm × 40 cm　　C_3: Large size (10.0-12.5 g)

S_4: 60 cm × 50 cm

Table 3. Effect of plant spacing and cormel size on number of leaves per plant at different days after planting (DAP) of mukhikachu

Treatments	Number of leaves per plant at						
	60 DAP	90 DAP	120 DAP	150 DAP	180 DAP	210 DAP	Harvest
Plant spacing							
S_1	2.13 b	3.31 b	4.00 d	4.98 c	5.51 b	4.38 c	3.69 c
S_2	3.22 a	3.87 a	4.76 c	5.82 b	7.42 a	5.22 b	4.44 b
S_3	3.33 a	4.11 a	5.20 a	6.11 a	7.76 a	5.56 a	4.69 a
S_4	3.18 a	4.00 a	4.96 b	5.82 b	7.49 a	5.38ab	4.58ab
$LSD_{(0.05)}$	0.362	0.285	0.178	0.257	0.336	0.292	0.175
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Cormel size							
C_1	2.55 b	3.52 c	4.45 c	5.83 a	6.72 b	4.72 b	4.08 b
C_2	3.07 a	3.85 b	4.77 b	5.47 b	7.13 a	5.25 a	4.47 a
C_3	3.28 a	4.10 a	4.97 a	5.75 a	7.28 a	5.43 a	4.50 a
$LSD_{(0.05)}$	0.313	0.247	0.154	0.222	0.291	0.253	0.152
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CV(%)	12.49	7.62	5.82	4.62	4.88	5.81	6.14

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

S_1: 60 cm × 20 cm
S_2: 60 cm × 30 cm
S_3: 60 cm × 40 cm
S_4: 60 cm × 50 cm

C_1: Small size (5.0-7.5 g)
C_2: Medium size (7.5-10.0 g)
C_3: Large size (10.0-12.5 g)

Gill *et al*. (2005) reported that plant spacing 45×30 cm resulted in the highest number of leaves per plant (8.1). Ira (2004) reported that maximum leaves were produced at 60×45 cm and leaves increased up to 120 DAP and thereafter declined until maturity.

Significant variation was observed for different cormel size on number of leaves per plant of mukhikachu (Table 3). At 60, 90, 120, 150, 180, 210 DAP and harvest, the highest number of leaves per plant (3.28, 4.10, 4.97, 5.75, 7.28, 5.43 and 4.50) was found from C_3, which was statistically similar (3.07, 7.13, 5.25 and 4.47) with C_2 at 60, 180, 210 DAP and at harvest, again the lowest number (2.55, 3.52, 4.45, 5.83, 6.72, 4.72 and 4.08) from C_1. Increased leaf number in larger cormel might be due to increased suckers per hill.

Different levels of plant spacing and cormel size showed significant differences on number of leaves per plant of mukhikachu due to their interaction effect (Table 4). At 60, 90, 120, 150, 180, 210 DAP and harvest, the highest number of leaves per plant (4.00, 4.40, 5.40, 6.60, 8.13, 6.00 and 4.93) was attained from S_3C_3, whereas the lowest number (2.00, 3.07, 3.67, 4.93, 5.40, 4.20 and 3.47) was observed from S_1C_1.

4.3 Foliage coverage

Different plant spacing varied significantly for foliage coverage of mukhikachu due to at 60, 90, 120, 150, 180, 210 DAP and harvest (Table 5). Data revealed that at 60, 90, 120, 150, 180, 210 DAP and harvest, the maximum foliage coverage (40.11, 58.11, 73.33, 81.00, 84.89, 62.67 and 46.78%) was observed from S_3, again the minimum foliage coverage (34.44, 42.44, 60.22, 70.56, 71.56, 53.22 and 40.56%) was found from S_1. It was revealed that with the increases of spacing foliage coverage showed increasing trend but there after a certain period it decreases with the increases of spacing and optimum spacing produced the highest foliage coverage than wider spacing. In case of closer spacing plant compete for light and with the time being leaf length decreases.

Table 4. Interaction effect of plant spacing and cormel size on number of leaves per plant at different days after planting (DAP) of mukhikachu

Treatments	Number of leaves per plant at						
	60 DAP	90 DAP	120 DAP	150 DAP	180 DAP	210 DAP	Harvest
S_1C_1	2.00 e	3.07 f	3.67 g	4.93 de	5.40 e	4.20 g	3.47 g
S_1C_2	2.33 e	3.27 ef	4.07 f	4.73 e	5.53 e	4.53 e-g	3.93 ef
S_1C_3	2.07 e	3.60 d-f	4.27 ef	5.27 cd	5.60 e	4.40 fg	3.67 fg
S_2C_1	2.47 de	3.67 c-e	4.53 de	6.07 b	6.93 d	4.67 e-g	4.13 de
S_2C_2	3.33 bc	3.80 b-e	4.73 cd	5.07 de	7.40 b-d	5.27 b-d	4.53 bc
S_2C_3	3.87 ab	4.13 a-d	5.00 bc	5.80 b	7.93 ab	5.73 ab	4.67 a-c
S_3C_1	2.67 c-e	3.73 b-e	4.93 bc	6.13 b	7.33 b-d	5.07 c-e	4.40 b-d
S_3C_2	3.33 bc	4.20 a-c	5.27 ab	6.13 b	7.80 a-c	5.60 a-c	4.73 ab
S_3C_3	4.00 a	4.40 a	5.40 a	6.60 a	8.13 a	6.00 a	4.93 a
S_4C_1	3.07 cd	3.60 d-f	4.67 cd	5.67 bc	7.20 cd	4.93 d-f	4.33 cd
S_4C_2	3.27 bc	4.13 a-d	5.00 bc	5.93 b	7.80 a-c	5.60 a-c	4.67 a-c
S_4C_3	3.20 bc	4.27 ab	5.20 ab	5.87 b	7.47 b-d	5.60 a-c	4.73 ab
$LSD_{(0.05)}$	0.627	0.494	0.308	0.445	0.582	0.505	0.303
Level of significance	0.05	0.05	0.05	0.01	0.05	0.05	0.05
CV(%)	12.49	7.62	5.82	4.62	4.88	5.81	6.14

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

S_1: 60 cm × 20 cm

S_2: 60 cm × 30 cm

S_3: 60 cm × 40 cm

S_4: 60 cm × 50 cm

C_1: Small size (5.0-7.5 g)

C_2: Medium size (7.5-10.0 g)

C_3: Large size (10.0-12.5 g)

Table 5. Effect of plant spacing and cormel size on foliage coverage at different days after planting (DAP) of mukhikachu

Treatments	Foliage coverage (%) at						
	60 DAP	90 DAP	120 DAP	150 DAP	180 DAP	210 DAP	Harvest
Plant spacing							
S_1	34.44 b	42.44 d	60.22 c	70.56 b	71.56 c	53.22 c	40.56 c
S_2	38.11 a	49.00 c	68.44 b	77.89 a	80.11 b	57.56 b	43.44 b
S_3	40.11 a	58.11 a	73.33 a	81.00 a	84.89 a	62.67 a	46.78 a
S_4	39.22 a	56.11 b	69.78 b	78.33 a	83.67 ab	60.89 ab	45.00 ab
$LSD_{(0.05)}$	1.982	1.811	2.608	5.666	4.524	3.567	2.424
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Cormel size							
C_1	35.33 b	49.75 b	62.58 b	71.33 b	74.33 b	53.67 b	39.08 b
C_2	39.23 a	51.58 a	69.50 a	78.58 a	81.50 a	60.17 a	45.50 a
C_3	40.92 a	52.92 a	71.75 a	80.92 a	84.33 a	61.92 a	47.25 a
$LSD_{(0.05)}$	1.717	1.568	2.259	4.907	3.918	3.089	2.099
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CV(%)	5.34	6.60	5.93	7.53	5.78	6.23	5.64

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

S_1: 60 cm × 20 cm
S_2: 60 cm × 30 cm
S_3: 60 cm × 40 cm
S_4: 60 cm × 50 cm

C_1: Small size (5.0-7.5 g)
C_2: Medium size (7.5-10.0 g)
C_3: Large size (10.0-12.5 g)

Different cormel size showed significant variation for foliage coverage of mukhikachu at 60, 90, 120, 150, 180, 210 DAP and harvest (Table 5). At 60, 90, 120, 150, 180, 210 DAP and harvest, the maximum foliage coverage (40.92, 52.92, 71.75, 80.92, 84.33, 61.92 and 47.25%) was found from C_3, which was statistically similar (39.23, 51.58, 69.50, 78.58, 81.50, 60.17 and 45.50%) with C_2. On the other hand, the minimum foliage coverage (35.33, 49.75, 62.58, 71.33, 74.33, 53.67 and 39.08%) was observed from C_1. The foliage coverage was higher in larger cormel size because of larger cormel had huge stored food material that support to increase vegetative growth of the plants with the highest foliage coverage.

Foliage coverage of mukhikachu at 60, 90, 120, 150, 180, 210 DAP and harvest showed significant differences due the interaction effect of different levels of plant spacing and cormel size (Table 6). At 60, 90, 120, 150, 180, 210 DAP and harvest, the maximum foliage coverage (44.33, 62.33, 79.33, 89.00, 92.67, 67.00 and 51.67%) was attained from S_3C_3 and the minimum foliage coverage (33.00, 41.00, 55.00, 66.67, 71.00, 49.67 and 36.67%) was recorded from S_1C_1.

4.4 Number of suckers per hill

Significant variation was observed for number of suckers per hill of mukhikachu due to different plant spacing at 60, 90, 120 and 150 DAP (Table 7). At 60, 90, 120 and 150 DAP, the highest number of suckers per hill (1.38, 4.27, 6.13 and 7.89) was recorded from S_3 which was statistically similar with S_4 (1.36, 4.04, 6.11 and 7.71) and S_2 (1.31, 3.73, 5.84 and 7.49), while the lowest number of suckers (1.18, 3.16, 4.89 and 6.11) from S_1. Ira (2004) reported that greater number of suckers was obtained at the wider spacing i.e. 60×65 cm and lesser number of suckers at narrow spacing i.e. 60×35 cm. In case of optimum spacing plant have enough space for vertical and horizontal expansion that leads for production of maximum number of suckers per plant than the closer spacing.

Table 6. Interaction effect of plant spacing and cormel size on foliage coverage at different days after planting (DAP) of mukhikachu

Treatments	Foliage coverage (%) at						
	60 DAP	90 DAP	120 DAP	150 DAP	180 DAP	210 DAP	Harvest
S_1C_1	33.00 e	41.00 g	55.00 g	66.67 d	71.00 d	49.67 g	36.67 f
S_1C_2	34.00 de	44.00 fg	62.67 f	74.67 b-d	70.00 d	53.00 e-g	43.00 cd
S_1C_3	36.33 c-e	42.33 fg	63.00 ef	70.33 cd	73.67 d	57.00 c-f	42.00 de
S_2C_1	33.67 de	45.00 f	61.67 f	70.00 cd	71.00 d	51.00 fg	37.67 ef
S_2C_2	39.00 bc	49.00 e	70.00 b-d	79.67 a-c	83.67 bc	59.00 b-e	44.67 b-d
S_2C_3	41.67 ab	53.00 d	73.67 b	84.00 ab	85.67 a-c	62.67 a-d	48.00 ab
S_3C_1	36.67 c-e	56.33 b-d	67.67 c-e	74.33 b-d	77.33 cd	56.00 d-g	41.00 d-f
S_3C_2	39.33 bc	55.67 b-d	73.00 b	79.67 a-c	84.67 a-c	65.00 ab	47.67 ab
S_3C_3	44.33 a	62.33 a	79.33 a	89.00 a	92.67 a	67.00 a	51.67 a
S_4C_1	37.00 cd	56.67 bc	66.00 d-f	74.33 b-d	78.00 cd	58.00 c-e	41.00 d-f
S_4C_2	39.33 bc	57.67 b	72.33 bc	80.33 a-c	87.67 ab	63.67 a-c	46.67 bc
S_4C_3	41.33 ab	54.00 cd	71.00 bc	80.33 a-c	85.33 a-c	61.00 a-d	47.33 a-c
$LSD_{(0.05)}$	3.433	3.137	4.518	9.814	7.836	6.178	4.199
Level of significance	0.05	0.01	0.05	0.05	0.05	0.05	0.05
CV(%)	5.34	6.60	5.93	7.53	5.78	6.23	5.64

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

S_1: 60 cm × 20 cm

S_2: 60 cm × 30 cm

S_3: 60 cm × 40 cm

S_4: 60 cm × 50 cm

C_1: Small size (5.0-7.5 g)

C_2: Medium size (7.5-10.0 g)

C_3: Large size (10.0-12.5 g)

Table 7. Effect of plant spacing and cormel size on number of suckers/hill at different days after planting (DAP) of mukhikachu

Treatments	Number of suckers/hill at			
	60 DAP	90 DAP	120 DAP	150 DAP
Plant spacing				
S_1	1.18 b	3.16 c	4.89 b	6.11 b
S_2	1.31 a	3.73 b	5.84 a	7.49 a
S_3	1.38 a	4.27 a	6.13 a	7.89 a
S_4	1.36 a	4.04 a	6.11 a	7.71 a
$LSD_{(0.05)}$	0.107	0.231	0.347	0.610
Level of significance	0.01	0.01	0.01	0.01
Cormel size				
C_1	1.18 b	3.37 b	4.80 c	6.45 c
C_2	1.33 a	3.93 a	5.98 b	7.42 b
C_3	1.40 a	4.10 a	6.45 a	8.03 a
$LSD_{(0.05)}$	0.093	0.200	0.301	0.528
Level of significance	0.01	0.01	0.01	0.01
CV(%)	8.29	6.23	6.17	8.54

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

S_1: 60 cm × 20 cm

S_2: 60 cm × 30 cm

S_3: 60 cm × 40 cm

S_4: 60 cm × 50 cm

C_1: Small size (5.0-7.5 g)

C_2: Medium size (7.5-10.0 g)

C_3: Large size (10.0-12.5 g)

Number of suckers per hill of mukhikachu at 60, 90, 120 and 150 DAP showed significant variation for different cormel size (Table 7). At 60, 90, 120 and 150 DAP, the highest number of suckers per hill (1.40, 4.10, 6.45 and 8.03) was found from C_3 and the lowest number of suckers (1.18, 3.37, 4.80 and 6.45) was observed from C_1. The increased number of suckers per hill was obtained from the large cormel might be due to the higher number of potential eyes present in large cormel which led to production of higher sucker per hill.

Significant variation was recorded due to the interaction effect of different levels of plant spacing and cormel size on number of suckers per hill of mukhikachu at 60, 90, 120 and 150 DAP (Table 8). At 60, 90, 120 and 150 DAP, the highest number of suckers per hill (1.53, 4.67, 6.93 and 9.00) was recorded from S_3C_3, whereas the lowest number (1.07, 2.67, 4.20 and 5.33) was found from S_1C_1.

4.5 Weight of individual corm

Statistically significant variation was recorded for weight of individual corm of mukhikachu due to different plant spacing (Figure 4). The highest weight of individual corm (90.30 g) was recorded from S_4 which was statistically similar (89.12 g) with S_3 and closely followed (72.73 g) by S_2, while the lowest weight of individual corm (49.17 g) from S_1. It was revealed that wider plant spacing ensure higher vegetative growth and the ultimate results would be the highest weight of individual corm. Gill *et al*. (2005) reported that plant spacing 45×30 cm resulted in the highest corm weight (29 g) which support the present result.

Different cormel size showed significant variation for weight of individual corm of mukhikachu (Figure 5). The highest weight of individual corm (80.86 g) was observed from C_3, which was statistically similar (79.46 g) with C_2 and the lowest weight of individual corm (65.67 g) was recorded from C_1.

Table 8. Interaction effect of plant spacing and cormel size on number of suckers/hill at different days after planting (DAP) of mukhikachu

Treatments	Number of suckers/hill at			
	60 DAP	90 DAP	120 DAP	150 DAP
S_1C_1	1.07 d	2.67 i	4.20e	5.33 f
S_1C_2	1.20 b-d	3.33 gh	5.13 cd	6.20 ef
S_1C_3	1.27 b-d	3.47 f-h	5.33 c	6.80 c-e
S_2C_1	1.13 cd	3.20 h	4.67 de	6.53 de
S_2C_2	1.40 ab	3.80 d-f	6.00 b	7.60 b-d
S_2C_3	1.40 ab	4.20 b-d	6.87 a	8.33 ab
S_3C_1	1.27 b-d	3.87 c-f	5.00 cd	6.67 de
S_3C_2	1.33 a-c	4.27 a-c	6.47 ab	8.00 ab
S_3C_3	1.53 a	4.67 a	6.93 a	9.00 a
S_4C_1	1.27 b-d	3.73 e-g	5.33 c	7.27 b-e
S_4C_2	1.40 ab	4.33 ab	6.33 ab	7.87 a-c
S_4C_3	1.40 ab	4.07 b-e	6.67 a	8.00 ab
$LSD_{(0.05)}$	0.186	0.401	0.601	1.056
Level of significance	0.05	0.05	0.05	0.05
CV(%)	8.29	6.23	6.17	8.54

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

S_1: 60 cm × 20 cm

S_2: 60 cm × 30 cm

S_3: 60 cm × 40 cm

S_4: 60 cm × 50 cm

C_1: Small size (5.0-7.5 g)

C_2: Medium size (7.5-10.0 g)

C_3: Large size (10.0-12.5 g)

Interaction effect of different levels of plant spacing and cormel size showed significant differences on weight of individual corm of mukhikachu (Figure 6). The highest weight of individual corm (96.28 g) was observed from S_4C_3, whereas the lowest weight of individual corm (43.54 g) was recorded from S_1C_1.

4.6 Yield of corm per plot

Yield of corm per plot of mukhikachu showed statistically significant variation due to different plant spacing (Table 9). The highest yield of corm per plot (2.01 kg) was attained from S_3 which was statistically similar (1.96 kg) with S_4, again the lowest yield corm per plot (1.60 kg) from S_1. Soumik and Sen (2005) reported that corm yield per unit area decreased with increase in spacing.

Statistically significant variation was recorded for different cormel size on yield of corm per plot of mukhikachu (Table 9). The highest yield of corm per plot (2.11 kg) was found from C_3. On the contrary the lowest yield of corm per plot (1.58 kg) was recorded from C_1. The corm yield per plot was lower from smaller size cormel might be due to production of lower number of suckers as well as minimum corm per hill resulting lower corm yield per plot.

Yield of corm per plot of mukhikachu showed significant differences due to the interaction effect of different levels of plant spacing and cormel size (Table 10). The highest yield of corm per plot (2.43 kg) was recorded from S_3C_3 and the lowest yield of corm per plot (1.43 kg) was observed from S_1C_1.

4.7 Yield of corm per hectare

Statistically significant variation was recorded for yield of corm per hectare of mukhikachu due to different plant spacing (Table 9). The highest yield of corm per hectare (5.58 ton) was attained from S_3 which was statistically similar (5.44 ton) with S_4 and closely followed (5.10 ton) by S_2, whereas the lowest corm yield per hectare (4.45 ton) from S_1.

Table 9. Effect of plant spacing and cormel size on yield parameters of mukhikachu

Treatments	Yield of corm (kg/plot)	Yield of corm (t/ha)	Yield of cormel (kg/plot)	Yield of cormel (t/ha)
Plant spacing				
S_1	1.60 c	4.45 c	5.99 d	16.64 d
S_2	1.84 b	5.10 b	8.21 c	22.81 c
S_3	2.01 a	5.58 a	9.41 a	26.15 a
S_4	1.96 a	5.44 a	9.08 b	25.22 b
$LSD_{(0.05)}$	0.112	0.315	0.262	0.727
Level of significance	0.01	0.01	0.01	0.01
Cormel size				
C_1	1.58 c	4.39 c	7.60 c	21.10 c
C_2	1.86 b	5.17 b	8.32 b	23.12 b
C_3	2.11 a	5.87 a	8.60 a	23.89 a
$LSD_{(0.05)}$	0.097	0.273	0.227	0.630
Level of significance	0.01	0.01	0.01	0.01
CV(%)	6.26	6.26	5.27	5.27

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

S_1: 60 cm × 20 cm

S_2: 60 cm × 30 cm

S_3: 60 cm × 40 cm

S_4: 60 cm × 50 cm

C_1: Small size (5.0-7.5 g)

C_2: Medium size (7.5-10.0 g)

C_3: Large size (10.0-12.5 g)

Table 10. Interaction effect of plant spacing and cormel size on yield parameters of mukhikachu

Treatments	Yield of corm (kg/plot)	Yield of corm (t/ha)	Yield of cormel (kg/plot)	Yield of cormel (t/ha)
S_1C_1	1.43 g	3.96 h	5.46 g	15.16 g
S_1C_2	1.59 e-g	4.42 f-h	6.19 f	17.19 f
S_1C_3	1.79 de	4.97 d-f	6.33 f	17.57 f
S_2C_1	1.55 fg	4.31 gh	7.53 e	20.92 e
S_2C_2	1.91 cd	5.31 c-e	8.28 d	22.99 d
S_2C_3	2.05 bc	5.69 bc	8.82 c	24.51 c
S_3C_1	1.59 e-g	4.43 f-h	8.72 cd	24.21 cd
S_3C_2	2.00 bc	5.56 b-d	9.38 b	26.04 b
S_3C_3	2.43 a	6.76 a	10.15 a	28.19 a
S_4C_1	1.75 d-f	4.87 e-g	8.68 cd	24.12 cd
S_4C_2	1.94 cd	5.40 c-e	9.45 b	26.24 b
S_4C_3	2.18 b	6.05 b	9.11bc	25.30 bc
$LSD_{(0.05)}$	0.193	0.546	0.454	1.259
Level of significance	0.05	0.05	0.05	0.05
CV(%)	6.26	6.26	5.27	5.27

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

S_1: 60 cm × 20 cm

S_2: 60 cm × 30 cm

S_3: 60 cm × 40 cm

S_4: 60 cm × 50 cm

C_1: Small size (5.0-7.5 g)

C_2: Medium size (7.5-10.0 g)

C_3: Large size (10.0-12.5 g)

Different cormel size showed significant variation for yield of corm per hectare of mukhikachu (Table 9). The highest yield of corm per hectare (5.87 ton) was found from C_3, which was statistically similar (5.17 ton) with C_2, again the lowest yield of corm per hectare (4.39 ton) was recorded from C_1. It was primarily due to high food reserves in large cormels which ultimately contributed to produce high yield through increase vegetative growth of plants and rapid development of corm. Thititaweesin *et al*. (2010) reported that the largest cormel size (5 cm) gave the highest yield, while the smallest cormel size (1 cm) gave the lowest yield which is similar with present study.

Interaction effect of different levels of plant spacing and cormel size showed significant differences on weight of corm per hectare of mukhikachu (Table 10). The highest weight of corm per hectare (6.76 ton) was recorded from S_3C_3, while the lowest weight of corm per hectare (3.96 ton) was found from S_1C_1.

4.8 Number of cormel per plant

Different plant spacing varied significantly for number of cormel per plant of mukhikachu (Figure 7). The highest number of cormel per plant (26.00) was recorded from S_3 which was closely followed (24.87) by S_4. On the other hand, the lowest number of cormel per plant (12.71) was found from S_1. It is revealed that highest plant spacing ensure highest vegetative growth and the ultimate results would be the highest number of cormel per plant. Sarma and Narzary (1999) reported that 60 × 45 cm was the best with respect to total cormel production. Ira (2004) reported that greater number of cormels was obtained at the wider spacing i.e. 60×65 cm and lesser number at narrow spacing i.e. 60×35 cm.

Different cormel size showed significant variation for number of cormel per plant of mukhikachu (Figure 8). The highest number of cormel per plant (21.82) was observed from C_3, which was statistically similar (21.58) with C_2 and the lowest number of cormel per plant (19.05) was recorded from C_1.

Interaction effect of different levels of plant spacing and cormel size showed significant differences on number of cormel per plant of mukhikachu (Figure 9). The highest number of cormel per plant (27.87) was observed from S_3C_3 again the lowest number of cormel per plant (10.93) was recorded from S_1C_1.

4.9 Yield of cormel per plot

Statistically significant variation was recorded for yield of cormel per plot of mukhikachu due to different plant spacing (Table 9). The highest yield of cormel per plot (9.41 kg) was found from S_3 which closely followed (9.08 kg) by S_4, while the lowest yield cormel per plot (5.99 kg) from S_1 and which was followed (8.21 kg) by S_2. Sarma and Narzary (2000) reported that that the spacing had no effect on quality attributes in *C. esculenta* cultivars.

Different cormel size showed significant variation for yield of cormel per plot of mukhikachu (Table 9). The highest yield of cormel per plot (8.60 kg) was recorded from C_3, which was followed (8.32 kg) by C_2 and the lowest yield of cormel per plot (7.60 kg) was observed from C_1.

Interaction effect of different levels of plant spacing and cormel size showed significant differences on yield of cormel per plot of mukhikachu (Table 10). The highest yield of cormel per plot (10.15 kg) was found from S_3C_3, while the lowest yield of cormel per plot (5.46 kg) was recorded from S_1C_1.

4.10 Yield of cormel per hectare

Significant variation was recorded for yield of cormel per hectare of mukhikachu for different plant spacing (Table 9). The highest yield of cormel per hectare (26.15 ton) was found from S_3 which was closely followed (25.22 ton) by S_4. On the other hand, the lowest yield cormel per hectare (16.64 ton) was obtained from S_1 which was followed (22.81 ton) by S_2. Basak *et al*. (1999) reported that per plant yields were significantly higher in wider spacings but total yields were higher in the closer spacings. Tumuhimbise *et al*. (2009) reported that a moderately wide spacing of 0.75 m × 0.75 m produced an acceptable yield.

Different cormel size showed significant variation for yield of cormel per hectare of mukhikachu (Table 9). The highest yield of cormel per hectare (23.89 ton) was observed from C_3, which was closely followed (23.12 ton) by C_2, while the lowest yield of cormel per hectare (21.10 ton) was attained from C_1. It was primarily due to high food reserves in large cormels which ultimately contributed to produce high yield through increase vegetative growth of plants and rapid development of cormel with higher number. Siddique *et al*. (1988) reported that the weight of cormel greatly influence yield of mukhikachu.

Interaction effect of different levels of plant spacing and cormel size showed significant differences on yield of cormel per hectare of mukhikachu (Table 10). The highest yield of cormel per hectare (28.19 ton) was found from S_3C_3 and the lowest yield of cormel per hectare (15.16 ton) was observed from S_1C_1.

CHAPTER V

SUMMARY AND CONCLUSION

The study was conducted at the Horticultural Farm and Laboratory of Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagar, Dhaka during the period from February 2012 to March 2013 to study the effect of spacing and cormel size on the growth and yield of mukhikachu. Cormels of mukhikachu cv. Bilashi were used for the research work. The experiment consisted of two factors: Factor A: Plant spacing (4 levels) as- S_1: 60 cm × 20 cm, S_2: 60 cm × 30 cm, S_3: 60 cm × 40 cm and S_4: 60 cm × 50 cm; Factor B: Cormel size (3 levels) as- C_1: Small size (5.0-7.5 g), C_2: Medium size (7.5-10.0 g) and C_3: Large size (10.0-12.5 g). The two factors experiment was laid out in Randomized Complete Block Design (RCBD) with three replications.

For plant spacing, at 60, 90, 120, 150, 180, 210 DAP and harvest, the tallest plant (23.78, 32.56, 53.22, 65.80, 68.75, 62.90 and 53.96 cm) was recorded from S_3 and the shortest plant (18.78, 27.83, 46.37, 57.97, 59.79, 58.30 and 49.04 cm) from S_1. At 60, 90, 120, 150, 180, 210 DAP and harvest, the highest number of leaves per plant (3.33, 4.11, 5.20, 6.11, 7.76, 5.56 and 4.69) was observed from S_3, while the lowest number (2.13, 3.31, 4.00, 4.98, 5.51, 4.38 and 3.69) from S_1. At 60, 90, 120, 150, 180, 210 DAP and harvest, the maximum foliage coverage (40.11, 58.11, 73.33, 81.00, 84.89, 62.67 and 46.78%) was observed from S_3, again the minimum (34.44, 42.44, 60.22, 70.56, 71.56, 53.22 and 40.56%) from S_1. At 60, 90, 120 and 150 DAP, the highest number of suckers per hill (1.38, 4.27, 6.13 and 7.89) was recorded from S_3, while the lowest number (1.18, 3.16, 4.89 and 6.11) from S_1. The highest yield of individual corm (90.30 g) was recorded from S_4, while the lowest yield of individual corm (49.17 g) from S_1. The highest yield of corm (2.01 kg/plot and 5.58 t/ha) was attained from S_3, again the lowest yield of corm (1.60 kg/plot and 4.45 t/ha) from S_1. The highest number of cormel per plant (26.00) was recorded from S_3 and the lowest number of cormel per plant (12.71) from S_1. The highest yield of cormel (9.41 kg/plot and 26.15 t/ha) was found from S_3, while the lowest yield of cormel (5.99 kg/plot and 16.64 t/ha) from S_1.

In case of cormel size, at 60, 90, 120, 150, 180, 210 DAP and harvest, the tallest plant (22.95, 31.27, 51.88, 64.50, 67.87, 63.28 and 53.65 cm) was observed from C_3 and the shortest plant (20.24, 29.21, 48.61, 60.28, 63.29, 59.01 and 50.80 cm) from C_1. At 60, 90, 120, 150, 180, 210 DAP and harvest, the highest number of leaves per plant (3.28, 4.10, 4.97, 5.75, 7.28, 5.43 and 4.50) was found from C_3, again the lowest number (2.55, 3.52, 4.45, 5.83, 6.72, 4.72 and 4.08) from C_1. At 60, 90, 120, 150, 180, 210 DAP and harvest, the maximum foliage coverage (40.92, 52.92, 71.75, 80.92, 84.33, 61.92 and 47.25%) was found from C_3 and the minimum foliage coverage (35.33, 49.75, 62.58, 71.33, 74.33, 53.67 and 39.08%) from C_1. At 60, 90, 120 and 150 DAP, the highest number of suckers per hill (1.40, 4.10, 6.45 and 8.03) was found from C_3, and the lowest number of suckers (1.18, 3.37, 4.80 and 6.45) from C_1. The highest weight of individual corm (80.86 g) was observed from C_3, and the lowest weight of individual corm (65.67 g) from C_1. The highest yield of corm (2.11 kg/plot and 5.87 t/ha) was found from C_3, and the lowest yield of corm (1.58 kg/plot and 4.39 t/ha) from C_1. The highest number of cormel per plant (21.82) was observed from C_3, and the lowest number of cormel per plant (19.05) from C_1. The highest yield of cormel (8.60 kg/plot and 23.89 t/ha) was recorded from C_3, and the lowest yield of cormel (7.60 kg/plot and 21.10 t/ha) from C_1.

Due to the interaction effect of different levels of plant spacing and cormel size, at 60, 90, 120, 150, 180, 210 DAP and harvest, the tallest plant (26.04, 33.96, 56.30, 69.07, 73.48, 66.93 and 56.84 cm) was observed from S_3C_3, while the shortest plant (18.20, 27.14, 44.61, 56.77, 59.10, 56.34 and 48.44 cm) from S_1C_1. At 60, 90, 120, 150, 180, 210 DAP and harvest, the highest number of leaves per plant (4.00, 4.40, 5.40, 6.07, 8.13, 6.00 and 4.93) was attained from S_3C_3, whereas the lowest number (2.00, 3.07, 3.67, 4.93, 5.40, 4.20 and 3.47) from S_1C_1. At 60, 90, 120, 150, 180, 210 DAP and harvest, the maximum foliage coverage (44.33, 62.33, 79.33, 89.00, 92.67, 67.00 and 51.67%) was attained from S_3C_3 and the minimum foliage coverage (33.00, 41.00, 55.00, 66.67, 71.00, 49.67 and 36.67%) from S_1C_1. At 60, 90, 120 and 150 DAP, the highest number of suckers per hill (1.53, 4.67, 6.93 and 9.00) was recorded from S_3C_3, whereas the lowest number (1.07, 2.67, 4.20 and 5.33) from S_1C_1. The highest weight of individual corm (96.28 g) was observed from S_4C_3, whereas the lowest weight of individual corm (43.54 g) from S_1C_1. The highest yield of corm (2.43 kg/plot and 6.76 t/ha) was recorded from S_3C_3 and the lowest yield of corm (1.43 kg/plot and 3.96 t/ha) from S_1C_1. The highest number of cormel per plant (27.87) was observed from S_3C_3 again the lowest number of cormel per plant (10.93) from S_1C_1. The highest yield of cormel (10.15 kg/plot and 28.19 t/ha) was found from S_3C_3, while the lowest yield of cormel (5.46 kg/plot and 15.16 t/ha) from S_1C_1.

Considering the findings of the present experiment, it may be concluded that:

1. Spacing S_3 (60 cm × 40 cm) showed significantly better performance in most of the parameter under study such as plant height, leaf number, foliage coverage, number of sucker per hill, individual corm weight, yield per plot as well as per hectare.

2. Large size cormel (10.0-12.5 g) exhibited the potentiality on all yield contributing characters and yield of mukhikachu.

3. The treatment combination of S_3C_3 (spacing 60 cm × 40 cm and size cormel 10.0-12.5 g) showed higher yield of mukhikachu.

4. So, this treatment combination may be used in farmer level for higher yield of mukhikachu after further field trials in different agro-ecological zones (AEZ) of Bangladesh.

Interaction effect of different levels of plant spacing and cormel size showed significant differences on number of cormel per plant of mukhikachu (Figure 9). The highest number of cormel per plant (27.87) was observed from S_3C_3 again the lowest number of cormel per plant (10.93) was recorded from S_1C_1.

4.9 Yield of cormel per plot

Statistically significant variation was recorded for yield of cormel per plot of mukhikachu due to different plant spacing (Table 9). The highest yield of cormel per plot (9.41 kg) was found from S_3 which closely followed (9.08 kg) by S_4, while the lowest yield cormel per plot (5.99 kg) from S_1 and which was followed (8.21 kg) by S_2. Sarma and Narzary (2000) reported that that the spacing had no effect on quality attributes in *C. esculenta* cultivars.

Different cormel size showed significant variation for yield of cormel per plot of mukhikachu (Table 9). The highest yield of cormel per plot (8.60 kg) was recorded from C_3, which was followed (8.32 kg) by C_2 and the lowest yield of cormel per plot (7.60 kg) was observed from C_1.

Interaction effect of different levels of plant spacing and cormel size showed significant differences on yield of cormel per plot of mukhikachu (Table 10). The highest yield of cormel per plot (10.15 kg) was found from S_3C_3, while the lowest yield of cormel per plot (5.46 kg) was recorded from S_1C_1.

4.10 Yield of cormel per hectare

Significant variation was recorded for yield of cormel per hectare of mukhikachu for different plant spacing (Table 9). The highest yield of cormel per hectare (26.15 ton) was found from S_3 which was closely followed (25.22 ton) by S_4. On the other hand, the lowest yield cormel per hectare (16.64 ton) was obtained from S_1 which was followed (22.81 ton) by S_2. Basak *et al*. (1999) reported that per plant yields were significantly higher in wider spacings but total yields were higher in the closer spacings. Tumuhimbise *et al*. (2009) reported that a moderately wide spacing of 0.75 m × 0.75 m produced an acceptable yield.

Different cormel size showed significant variation for yield of cormel per hectare of mukhikachu (Table 9). The highest yield of cormel per hectare (23.89 ton) was observed from C_3, which was closely followed (23.12 ton) by C_2, while the lowest yield of cormel per hectare (21.10 ton) was attained from C_1. It was primarily due to high food reserves in large cormels which ultimately contributed to produce high yield through increase vegetative growth of plants and rapid development of cormel with higher number. Siddique *et al*. (1988) reported that the weight of cormel greatly influence yield of mukhikachu.

Interaction effect of different levels of plant spacing and cormel size showed significant differences on yield of cormel per hectare of mukhikachu (Table 10). The highest yield of cormel per hectare (28.19 ton) was found from S_3C_3 and the lowest yield of cormel per hectare (15.16 ton) was observed from S_1C_1.

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APPENDICES

Appendix I. Characteristics of field soil analyzed in Soil Resources Development Institute (SRDI) laboratory, Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Horticultural Farm, SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained

B. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	27
% Silt	43
% clay	30
Textural class	Silty-clay
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

Source: Soil Resources Development Institute (SRDI)

Appendix II. Monthly record of air temperature, relative humidity, rainfall, and sunshine (average) of the experimental site during the period from February 2012 to March 2013

Month	*Air temperature (^{0}C)		*Relative humidity (%)	*Rainfall (mm)	*Sunshine (hr)
	Maximum	Minimum			
February, 2012	27.1	16.7	67	30	6.7
March, 2012	31.4	19.6	54	11	8.2
April, 2012	34.2	23.4	61	112	8.1
May, 2012	34.7	25.9	70	185	7.8
June, 2102	35.4	22.5	80	577	4.2
July. 2012	36.0	24.6	83	563	3.1
August, 2012	36.0	23.6	81	319	4.0
September, 2012	34.8	24.4	81	279	4.4
October, 2012	26.5	19.4	81	22	6.9
November, 2012	25.8	16.0	78	00	6.8
December, 2012	22.4	13.5	74	00	6.3
January, 2013	24.5	12.4	68	00	5.7
February, 2013	27.1	16.7	67	30	6.7
March, 2013	31.4	19.6	54	11	8.2

* Monthly average,

Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka – 1212

Appendix III. Analysis of variance of the data on plant height at different days after planting (DAP) of mukhikachu as influenced by different plant spacing and cormel size

Source of variation	Degrees of freedom	Mean square						
		Plant height (cm) at						
		60 DAP	90 DAP	120 DAP	150 DAP	180 DAP	210 DAP	Harvest
Replication	2	0.378	0.528	4.025	3.175	6.097	0.213	2.599
Plant spacing (A)	3	39.579**	35.807**	83.936**	104.547**	154.681**	38.147**	42.710**
Cormel size (B)	2	22.171**	14.775**	35.452**	60.852**	67.825**	55.353**	24.440**
Interaction (A×B)	6	2.645*	4.180*	8.738*	11.484*	20.950*	14.546*	5.040*
Error	22	1.454	1.748	4.386	6.184	9.699	6.649	4.941

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix IV. Analysis of variance of the data on number of leaves per plant at different days after planting (DAP) of mukhikachu as influenced by different plant spacing and cormel size

Source of variation	Degrees of freedom	Mean square						
		Number of leaves per plant at						
		60 DAP	90 DAP	120 DAP	150 DAP	180 DAP	210 DAP	Harvest
Replication	2	0.010	0.001	0.028	0.013	0.058	0.223	0.030
Plant spacing (A)	3	2.816**	1.135**	2.416**	2.158**	9.591**	2.450**	1.838**
Cormel size (B)	2	1.703**	1.028**	0.814**	0.443**	1.034**	1.664**	0.643**
Interaction (A×B)	6	0.417*	1.029**	0.607*	0.534*	0.168*	0.127*	0.036*
Error	22	0.137	0.085	0.033	0.069	0.118	0.089	0.032

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix V. Analysis of variance of the data on foliage coverage at different days after planting (DAP) of mukhikachu as influenced by different plant spacing and cormel size

Source of variation	Degrees of freedom	Mean square						
		Foliage coverage (%) at						
		60 DAP	90 DAP	120 DAP	150 DAP	180 DAP	210 DAP	Harvest
Replication	2	0.444	5.250	2.694	28.528	2.111	31.583	3.694
Plant spacing (A)	3	55.806**	459.583**	276.852**	180.259**	325.963**	155.361**	6.630**
Cormel size (B)	2	94.362**	30.333**	273.861**	299.694**	318.778**	226.750**	221.861**
Interaction (A×B)	6	7.917*	25.222**	12.269*	34.620*	44.852*	15.861*	6.602*
Error	22	4.111	3.432	7.119	33.588	21.414	13.311	6.149

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix VI. Analysis of variance of the data on number of suckers/hill at different days after planting (DAP) of mukhikachu as influenced by different plant spacing and cormel size

Source of variation	Degrees of freedom	Mean square			
		Number of suckers/hill at			
		60 DAP	90 DAP	120 DAP	150 DAP
Replication	2	0.004	0.023	0.298	0.250
Plant spacing (A)	3	0.072**	2.092**	3.083**	5.894**
Cormel size (B)	2	0.148**	1.773**	8.681**	7.640**
Interaction (A×B)	6	0.510*	0.096*	0.200*	0.739*
Error	22	0.012	0.056	0.126	0.389

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix VII. Analysis of variance of the data on yield parameter of mukhikachu as influenced by different plant spacing and cormel size

Source of variation	Degrees of freedom	Mean square					
		Weight of individual corm (g)	Weight of corm (kg/plot)	Weight of corm (t/ha)	Number of cormel/plant	Weight of cormel (kg/plot)	Weight of cormel (t/ha)
Replication	2	0.607	0.001	0.006	0.263	0.004	0.033
Plant spacing (A)	3	3316.080**	0.296**	2.285**	330.719**	21.383**	164.990**
Cormel size (B)	2	845.459**	0.850**	6.560**	28.252**	3.222**	24.863**
Interaction (A×B)	6	31.054*	0.038*	0.294*	3.052*	0.223*	1.724*
Error	22	11.375	0.013	0.104	1.172	0.072	0.553

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability