EFFECT OF SPACING AND COWDUNG ON THE GROWTH AND YIELD OF RADISH *(Raphanus sativus* L.)

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By

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This is to certify that the thesis entitled "EFFECT OF SPACING AND COWDANG ON THE GROWTH AND YIELD OF RADISH" submitted to the Faculty of Agriculture, 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 MOHAMMAD MANZUR HOSSAIN, Reg. No.-26201/00493 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 sources of information, as has been availed of during the course of this investigation have been duly acknowledged.

Dated
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Dedicated to

My

Parents and

Prof. Mahtabuddin

LIST OF ABBREVIATED TERMS

Agro-Ecological Zone	AEZ
And others	*et al.*
Centimeter	cm
Days after sowing	DAS
Etcetera	etc
Food and Agricultural Organization	FAO
Gram	g
Hectare	ha
Kilogram	kg
Meter	m
Number	no.
Percent	%
Pei-	/
Randomized Complete Block Design	RCBD
Sher-e-Bangla Agricultural University	SAU
Ton	t

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Place: Dhaka **The Author**

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ABSTRACT

An experiment was conducted at the Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka during the period from October 2006 to December 2006 to study the effect of different spacing viz. 40cm x 20cm, 40cm x 30cm and 40cm x 40cm and different levels of cow-dung viz. control i.e. no cow-dung (Mi), 20 t/ha (M;), 40 t/ha (M_3) and 60 t/ha (M_4) on the growth and yield of radish. The experiment was conducted in the Randomized Complete Block Design (RCBD) with three replications. Different spacing significantly influences the growth and yield of radish. Closer spacing (40cm x 20cm) resulted the highest root yield (37.06 t/ha) where the highest (337.13g) individual root weight was found in wider spacing (40cm x 40cm) at 75 days alter sowing (DAS). The highest root yield (31.07 t/ha at 75 DAS) was recorded from those plot where 60 t/ha cow-dung was applied which was statistically identical with 40 t/ha cow-dung, while the lowest (6.46 t/ha at 45 DAS) was recorded from control treatment. The combined effect of spacing and cow-dung were also found significant incase of radish production. The use of 60 t/ha cow-dung with 40cm x 20cm spacing produced the highest root yield (40.25 t/ha) at 75 DAS. The lowest root yield (5.40 t/ha) was recorded from 40cm x 40cm spacing with no cow-dung at 45 DAS. The benefit cost ratio (BCR) was the maximum (3.06) in the treatment combination of the closest spacing with no cow-dung at 75 DAS, whereas, the minimum (-0.29) in the treatment combination of the widest spacing with 60 t/ha cow-dung at 45 DAS. To obtain a profitable yield root should be harvested from 60 to 75 DAS.

Introduction

Radish *(Raphanus sativus* L.) is a vegetable crop under the family Cruciferae. The chromosome number of this crop is nine pair. It is a herbaceous plant. Its root is called underground-modified root, which is fusiform in shape. The stem is short at vegetative stage but elongated at the reproductive stage, leaves are generally lyrate and leaf blade is simple. Flower may be white or sometimes-pink Fruit is called pod, which is 3-8 cm long containing 6-12 seeds (Rashid, 1999).

Radish *(Raphanus sativus* L.) is a popular and important vegetable crop in Bangladesh. It is mainly a winter vegetable crop but available in the markets from early September to May. Now a days it can be grown any time of the year in Bangladesh (Rashid, 1983).

This crop can withstand so diversified climate that the crop is grown in tropical, subtropical and even in temperate countries. There are many opinions among the scientists regarding to its place of origin. China and India was the native lands of radish (Katyal and Chandha,1985).

The crop is becoming popular day by day among all classes of people, poor or rich, urban or rural. This is one of the top ranking vegetables in Japan, in respect of acreage under cultivation and its consumption (Rashid, 1983). Radish is cultivated everywhere in Bangladesh and is grown mainly as a kitchen garden crop for home consumption. Now a days it grows commercially in our country.

The fleshy root and young leaves are edible portion and nutritionally not so poor as commonly believed. Rashid (1976) mentioned that a hundred gram of edible root contains l% protein, 4% carbohydrate, little fat, 15 calories, negligible vitamin A, 0.03 mg thiamine, 0.03mg riboflavin, 0.30mg niacine, 25mg vitamin C, 30mg calcium and .00mg iron. The leaves are also nutritionally rich. One hundred gram of edible leaf contains 18660 IU vitamin A, 103 mg vitamin C and 310 mg calcium. The Japanese use the fleshy roots as pickle or boiled slices (Katyal and Chadha, 1985). In Bangladesh the root is eaten mainly in curries or as salad.

Red radish contains 39.3 to 185mg anthocyanin/l00g in skin and 12.2 to 53mg anthocyanin/l00g root (Giusti, *at al.* 1998). Otsuki, F. *at al.* (2002) isolated twelve acylated anthocyanins from red radish. Six of them were identified as petargonidin based.

Radish has a cooling effect on human body and is suitable for patients suffering from Piles, liver troubles, enlarged splin and jaundice (Katyal and Chadha, 1985).

It may be possible to reap a reasonable radish harvest using organic manure alone as plant food. Anonymous (1983) recommended a fairly high dose of chemical fertilizers in radish. Use of chemical fertilizers in crop production is one of the important causes of environmental pollution. Now a days, there is growing awareness among the scientists in various parts of the world regarding the problems of environmental pollution through the use of chemicals in crop production. As an alternative to chemicals, scientists in the developed nations are trying to develop various bio-fertilizers for reducing environmental pollution and for obtaining pollution free crop production, especially vegetables. Use of organic manure in crop production has many advantages over chemical fertilizers. Whitefield (1963) mentioned that organic manure saves the crop plants from adverse environment. Organic matter reduces soil erosion, increasing water holding capacity and physio-chemical and biological conditions of the soil.

The recommended plant-to-plant spacing of BARI mula-2 (Pinky) (Rashid, 1999) is 50cm x 30cm.At this plant spacing this radish produces very large roots. Such big roots may not always be desirable to the consumers. Some buyers always prefer medium sized or even small roots for their small families. By using closer spacing than recommended it may be possible to obtain higher yield, sacrificing root size to some extent.

A few investigation has been reported on the influences of spacing and using organic manure alone on radish yield in Bangladesh. Therefore the present investigation is undertaken to assess the performance of the newly developed radish variety as influenced by spacing and application of cow-dung.

i) to fiend out the appropriate spacing of radish.

ii) to determine the approximate dose of cow-dung for obtaining better growth and higher yield of radish.

A lot of information has been accumulated on the effect of spacing and productivity of different annual crop in different parts of the world. A considerable amount of such research works have been reported on vegetable crops but regarding reports on radish is meager. Experimental reports on the influence of manure on soil condition and crop productivity are also available to a considerable extent but such report on radish is lacking. However, some of the available literatures related to the present investigation have been presented below.

2.1. Effect of Spacing on the growth and yield of radish

Experimental results regarding the influence of spacing on yield of radish is meager in generally and BARI Mula-2 in particularly. There are, however some recommendations on spacing of radish in general, has been cited in this chapter.

An experiment was conducted at UNESP, Jaboticabal-SP, by Resende *el al.* (2006), with the objective of evaluating the productivity of the cultivation of lettuce and radishes as a function of spacing between plants and of the time of establishment of intercropping. The experimental design was a completely randomized blocks and four replications. The 14 treatments consisted of combinations of spacing between lines (0.30 and 0.40 m), cultivation systems (intercropping and monoculture), and time of sowing of radish seeds to establish intercropping (0, 7 and 14 days after transplant of lettuce). The cultivars of lettuce and radish were, ‘Taina’ and ‘Crimson Gigante’, respectively. A greater yield of commercial radish roots was obtained with intercropping cultivation. The fresh mass of lettuce in monoculture did not differ from that produced with intercropping. These results suggest that intercropping cultivation between these species is advantageous.

An experiment was conducted by Ara *et al.* (1999) to study the effects of different spacings and different fertilizer levels on radish seed yield and quality. Days to flowering and pod maturity of radish were greatly influenced by different fertilizer levels and spacing. The highest seed yield (1.16 t/ha) was obtained when 10 ton/ha cowdung, 175 kg/ha nitrogen, 100 kg/ha phosphorus. 125 kg/ha potash and 100 kg/ha gypsum were used at a plant spacing of 30 x 20 cm which was closely followed by 0 t/ha cowdung, 200 kg/ha nitrogen, 125 kg/ha phosphorus, 150 kg/ha potash and 125 kg/ha gypsum fertilizer level with a spacing of 45 x 20 cm (1.11 t/ha). The germination percentage was significantly affected by different fertilizer levels and spacing.

A study was earned out by Lee and Nichols (1998) to investigate the effect of plant density, plant arrangement, seed size and time of harvest on the weight frequency distribution of radish, and to explore ways of describing population variability. The coefficient of variation was found to be a useful means of describing population variability, as it measures variability independent of the size of the mean. Variability was found to increase with high density and high rectangularity, with a significant interaction between plant density and harvest date, with variability being independent of harvest date at low density, but increasing with time at high plant density. The development of positive skewness was enhanced by high rectangularities and high densities, but the effect of harvest date on skewness varied with the grade of seed used.

Minami *et al.*(1998) observed that inter-row spacings did not affect any of the analysed variables. On the other hand, the larger intra-row spacing (10 cm) increased root yield and reduced total shoot yield, resulting in a higher root/shoot ratio, compared with the 5-cm treatment.

Sirkar *et al.* (1998) conclude that Root diameter, fresh weight, dry weight, leaf area ratio, net assimilation rate, reducing sugar, non-reducing sugar and total sugar content of the radish roots decreased as plant density increased. Root length increased as plant density increased.

Jandial *et al.* (1997) found that spacing had a significant effect on seed yield, plant weight, number of branches per plant, number of pods per plant and 1000-seed weight. The results suggest that to obtain high seed yields, 1/2 the roots of stecklings should be trimmed off before planting at 30 cm X 30 cm.

Anonymous (1983) recommended a spacing of 60cm between rows and 30cm within row for radish. It is mentioned that although radish is normally broadcasted, it is better to sow the seeds per unit ground area and for facilitating easy intercultural operations.

Rashid (1976) recommended a spacing of 37.5 to 45.0cm between lines depending on variety. He did not mention any interplant spacing in a line, rather suggested a continuous sowing and 2-3 tomes thinning of seedlings in such away that a space between plants in a row is finally kept to avoid sever interplant competition. He postulated that with big rooted cultivars yield as high as 27.7 t/ha is not difficult to obtain.

The usual distance between radish lines, as mentioned by Thompson and Kelly (1972), is 37.5cm. They mentioned that the seeds arc sown in line in such a way that there arc 30-45 plants per 30cm of row and then the plants are thinned keeping them 5- 10cm apart in a row.

Eleven years of yield measurements by Kelly *et al.*(2005) comparing in-row plant spacings of 15.2, 30.5, 45.7 and 61.0 cm resulted in a significantly higher yield at the 15.2-cm spacing. Differences among the wider spacings were minor. The elosest spacing yielded a slightly smaller harvest of large spears, and the average spear weight was slightly lower. The smaller size minimally affected marketable yield. Economic analysis indicated that the increased returns, needed to compensate for the added cost of the high- density planting compared to the standard 30.5-cm spacing, would be realized early in the third year of harvest. The cumulative increased net return after 11 years of harvest would be approximately SI2,500 per hectare.

Gebologlu and Saglam (2005) Conducted an experiment to determine the effects of different plant spacings within row and mulching materials on the yield and quality of pickling cucumber in Tokat / Turkey during summer and autumn seasons of 1998 - 1999.
In this study, pickling cucumber (cv. Levina Fi) seedlings were planted in 20, 30 and 40 cm within row and 75 cm between rows spicing. Also, transparent PE, black PE, and straw were used as mulching material. Plants were trained in single stem pole system. The use of mulching materials raised the fruit yield compared to the control. In addition, transparent polyethylene (PE) mulching materials showed the highest performance. On the other hand, the highest fruit yield was obtained from the 20 cm within row spacing. Transparent PE mulching materials and 20 cm plant spacing within row combination resulted in the highest yield.

The effect of plant spacing within rows on growth and yield of vegetable amaranth *(Amaranthus spp.*) was studied by Mortley *et al.* (2004). Spacing treatments were 10 cm, 20 cm, 30 cm, and 40 cm corresponding to approximately 161000, 80000, 54000 and 40000 plants ha, respectively, in a randomized complete block design with three replications. Plants were harvested four times over three months and fresh weight yield on per plant and unit area basis were determined. Measurement of stem diameter was done two weeks after transplanting and continued up to the first harvest. Fresh weight yield per plant increased linearly at each successive harvest as spacing increased from 10 to 40 cm, and with each harvest up to the third, but declined at the fourth harvest. Total fresh weight yield per plant across all four harvests increased linearly as spacing increased. By contrast, when fresh weight yield was evaluated on a per unit area basis, yield increased linearly per harvest and across all harvests as spacing between plants decreased from 40 to 10 cm. Stem diameter increased linearly as spacing between plants increased from 10 cm to 40 cm, respectively. These results indicate that vegetable amaranth can be grown successfully in Alabama, harvested more than once, and that fresh weight yields are highest at closer within-row spacing.

Albayral *et al.* (2004) conducted an experiment to find out the effect of four row spacing (20, 30, 40 and 50cm) on root and leaf yields and yield components of forage turnips. The root yield, root dry matter yield, root crude protein yield, root diameter, root length, leaf dry matter yield and leaf crude protein yield were determined. Row spacing significantly affected most the yield components determined on forage turnip cultivars. Root and leaf yield and their components increased along with increase of row spacing. The highest root and leaf dry matter yields were obtained from the 40cm row spacing.

Seif and Ali (2003) conducted an experiment to study the effects of in-row spacing at 20, 40 and 60 cm on yield and some quality attributes of tomato. Direct-seeded tomatoes significantly responded to in-row spacing. Reducing the in-row plant spacing from 60 to 40 cm resulted in a total yield increase of 24% in the first season and 38% in the second season. Further reduction in spacing from 60 to 20 cm resulted in a total yield increase of 43% in the first season and 75% in the second season. Closer spacing of 20 cm also reduced the numbers of sun-scalded fruits compared to 60 cm spacing. Other fruit quality aspects such as TSS and cracked fruits were not significantly affected by the in-row plant spacing.

The effects of four row spacing (17.5, 35.0, 52.5 and 70 cm) and live seeding rate on seed yield and some yield components of forage turnip were evaluated under rainfed condition by Bilgili *et al.* (2003). Plant height, stem diameter, pods/terminal raceme, total pods/plant, seeds/pod and primary branches/plant were measured individually. The number of plants per unit area was counted and the lodging arte of the plots was scored. The seed yield and 1000-seed weight were also determined. Row spacing and seeding rate significantly affected most yield components measured. The number of plants per unit area increased with increasing seeding rate and decreasing row spacing. Plant height was not greatly influenced by row spacing and seeding rate. Also, the number of pods/main stem was affected by either the row spacing or the seeding rate. In contrast, the number of pods per plant clearly increase with increasing row spacing, but decreased with increasing seeding rate. The plots seeded at narrow row spacing and st high seeding rates were more sensitive to lodging. Seeding rate had no significant effect on seed yield. However, row spacing was associated with seed yield.

Whitwell and Senior (2003) conducted an experiment with ten varieties of autumn cauliflowers were grown at three spacings, 640 mm, 440 mm and 240 mm down the row in rows 600 mm apart, for production of heads for curd removal and floretting. Plana, Revito, Linas, Cervina and Vernon were good varieties for both yield and quality. Two varieties, Channel Reef and Elby, gave low yields of grade A florets in both years. The distribution of cutting dates and length of cut was unaffected by crop spacing, head size, curd depth and quality were reduced at the closest spacing, although there were some varietal exceptions. Linas, Cervina, Revito and Plana not only increased yield at elose spacing but also maintained crop quality whereas a variety such as Elby increased yield substantially at close spacing but at the expense of quality. Both Plana and Elby have a vigorous growth habit. When the extra costs of materials and labour incurred by growing plants at the close spacing were deducted from the value of the extra yield of grade A and grade B florets achieved, it was clear that all the extra net income was achieved at a spacing of 600 mm x 440 mm and no extra benefit was obtained from closer spacing. The best varieties for curd yield and floret quality, i.e. Plana, Revito, Vernon, Linas and Cervina, are best grown at a spacing of 600 mm x 440 mm, 3.8 plants /m^2 and at this plant population give optimum monetary advantage.

An experiment was conducted by Whish *et al.* (2002) on the adoption of no-till farming and the desire to maintain stubble cover when sowing legumes in Australia had resulted in an increasing in commercial row spacing for chickpea. That paper examines the effects of increasing crop row spacing on weed competition in chickpea crops. In those experiments, weed free fields were higher when chickpea was sown in 32cm rows compared with 64 cm rows, but weeds caused no greater loss in crop yield with the wider row spacing. The result of that work showed that the use of wide rows had minimum impact on weed competition in northern chickpea crops.

Two experiments were conducted by Kogbe (2001)on the effect of spacing on the yields of two species of egg plant. The spacing treatments compared were 90 x 120cm, 90 x 60cm, 45 x 60cm and 45 x 45cm. In the local species, total fruit yield, number of fruits per plant and number of fruits per square metre increased with increase in spacing up to the widest spacing used but at this spacing response of total fruit yield was not significant. Average fruit weight was not affected by spacing. In the exotic species, total fruit yield increased up to 90 x 60cm spacing and then declined. Mean number of fruits per plant increased with spacing. In both species, fruit size and quality were not significantly affected by spacing. It is recommended that both the local and exotic species be planted at a spacing of 90 x 60cm.

In a field experiment in Peshawar, Pakistan, turnip stecklings 2, 3 or 4 months old of 2.5, 5.0 or 7.5 cm were planted at spacing of 45x15, 30 of 45 cm. Ahmad *et al.* (1999) conclude that three month old stecklings of 7.5 cm at 45x 15 cm spacing gave the best seed yields.

Osei Bonsu (1992) concluded that close spacing of Sesamum indicum var. Dulce S 49 (7.5 x 60 cm and 15.0 x 60 cm) increased the leaf area index, crop growth rate and shoot dry matter production but not plant height and final seed yield. The number of branches per plant, the number of podding nodes per plant, the number of pods per plant and the number of mature seeds per pod decreased with close planting (7.5 x 60 cm and 15.0 x 60 cm), whereas wider spaced plants (22.5 x 60 cm and 30 x 60 cm) produced their first pods at lower heights. The 1000-seed weight was not affected by spacing.

An experiment was conducted by Kepka *et al.* (1992) on the effects of different plant density and spacing patterns of carrots on yield. In small-scale field experiment the following row spacings were compared: 10, 15, 22, 5, 30 and 45 cm, with 2, 3, 4 and 6 cm within the rows. In addition, 30 and 45 cm row spacings were compared with twin rows or a band 8 cm wide. The density of plants/m^2 ranged from 37 up to 500. Total and ware (roots 2-6 cm diam) yields of carrots increased as the distance between rows decreased from 45 to 10 cm and as the distance between plants in row was decreased from 6 to 2 cm. A population of 111 or 222 plant/m^2, gave the highest and most uniform ware yield, and the highest yields of roots suitable for pre-packing (2 - 4 cm). Greening of the crowns was least when carrots were sown in bands 45 cm apart. In large-scale field experiments band sowing systems (30 and 45 cm apart) gave more uniform crops of carrots and a higher proportion of roots suitable for prepacking (2 - 4 cm), than a row system of culture (15, 30 and 45 cm apart).

With an increase in plant population from 59,200 to 88,800/ha of maize hybrids Reddy *et al.* (1987) found that Cob length, shelling percentage, 100-grain weight and grain yield/cob decreased from 17.98 to 17.26 cm, 75.47 to 74.56,292.2 to271.3 g and 87.23 to 62.91 g, respectively.

Using row spacings of 15, 20, 25 and 30 cm Ahmed and Haque (1986) reported that with decreasing row spacing the yield of Black cumin per unit area was increased to a considerable extent.

In a trial with panikachu Hussain *et al.* (1985) found significant effect of spacing on yield. With every reduction in spacing the yield was heavily increased while the yield per plant was significantly reduced. The crop produced the lowest yield of 6.05 t/ha at the widest spacing of 120 ^{x} 90 cm while highest yield of 28.4 t/ha was obtained from the closest spacing of 45 x 45 cm. Splittstoesser (1984) recommended a spacing between rows is 30cm and the plants are then allowed to stand 2.5cni apart in a row after thinning. Line to line spacing of 45cm has been recommended by Yawallcer (1985). He did not mention about plant to plant distance in a line. Since no more literature regarding spacing on radish could be made available similar information on other crops have been presented below.

It was reported by Absar and Siddique (1982) that with increasing plant density plant height and yield of okra was greatly increased. The number of leaves and yield per plant was however, greatly decreased using 4, 8 or 15 plants per square meter they found that the crops producted yields of 9.6, 12.4 and 18.6 t/ha respectively and every increase in plant density was associated with a significant decrease in yield per plant.

Badruddin and Haque (1977) used three interplant spacings of 10, 15 and 20 cm apart and found that with increase in spacing of onion, plant height was increased but yield per unit area was decreased significantly. Leaf number, bulb diameret and bulb weight was not much influenced

2.2. Effect of cowdung on the growth and yield of radish

In three test years the Jubilantka pepper cultivar was grown in twelve variants of fertilization by Valsikova (2000). One of the objectives of study was the determination of the effect of dung on the quality of fruits. The studied quality characteristics included dry matter content, ascorbic acid content, size and weight parameters, fruit respiration and market value. The results indicated the need of applying dung to sweet pepper to improve the yields as well the quality of fruits.

Huang *et al.* (1993) found that radish yield wasl2.3-15.5 % lower, respectively, in the organic farming system than in the conventional system. Appearance of organic products was poor but eating quality was superior to conventional crops. Net income was lower in the organic system due to higher costs of organic fertilizers and labour. They concluded that yields and pest control in organic farming were unsatisfactory, and that an intermediate system (organic plus limited inputs of chemical fertilizers and pesticides) should be used as the first stage of transition from conventional to organic farming.

Srivastava and Singh (1992) carried an experiment on residual effect of organic mulches and conclude that the residual effect of mulches had not significantly influenced the performance of radish.

Conducting an experiment during 1977-84 with farmyard manure and dhaincha it was found by Sharma *et al.* (1988) that the yield of potato tubers was increased by 55 and 51q/ha respectively in the absence of nitrogenous fertilizer.

Using 15 t/ha of farmyard manure in absence of any fertilizers Nimje and Seth (1987) found that the grain yield of soybean was significantly increased by 15.3% in 1982 and 19.3% in 1983 over the control plots.

Katyal and chandha (1985) recommend 40 t/ha of FYM for radish besides a high dose of fertilizers.

Working with potatoes, Shahota (1983) found that application of FYM significantly increase the plant height, number of leaves per plant and yield of tubers. The total tuber yields at 0, 20 and 40 t/ha of manure were 18.4, 22.6 and 22.8 t/ha respectively indicating the optimum manure dose to be 20 t/ha.

Anonymous (1977) reported that application of compost to the soil increases water holding capacity, reduces soil erosion and improves the physio-chemical and biological condition of the soil, besides providing with plant nutrients.

Edmond *et al.* (1977) reported that organic matter increases the pore space of the soil and thus improve the rate of gas exchange in the soil.

Russell (1966) emphasized the widely accepted opinion that organic matter plays a positive role on soil productivity and this effect was attributed mainly to the release of nutrients of the organic matter during decomposition to the improvement of soil physio-chemical condition.

Bunting (1963) compared the results of 113 experiments, which conducted on 56 sites in England for eight years. Those experiments studied the composition and agronomic effects of farmyard manure, sewage, sludge etc. He staled that where organic manure was incorporated in to the soil its effects on yield can generally be ascribed simply to the increases in the total amount of plant nutrients supplied.

It was stated by Shaw and Rabinson (1960) that the benefit of the soil from organic materials was due to their effect on increase microbial activity followed by increase humus content and increased supply of available nutrients, particularly NPK.

From the literature cited above it can be concluded that organic manures have great capacity to improve soil status and can significantly increase yield of crops through release of plant nutrients and improving soil conditions; and the yield of crops per unit area increase and yield per plant decreases with reduction in spacing.

MATERIALS AND METHODS

3.1. Experimental Site

The experiment was conducted at Horticulture farm of Sher-e-Bangla Agricultural University, Dhaka-1207. The experimental area was situated at 23° 74' N latitude and $90^{()}$35' E longitude at an elevation of 8.2 meter from sea level (Anon 1989).

3.2. Climate

The area had sub tropical climate. It was characterized by high temperature(28°-32°C) accompanied by moderately high rainfall during Kharif (April-September) season and low temperature(15°-20°C) in the Rabi (October-March) season. The weather data of experimental site was collected during the period of experiment from the Bangladesh Meteorological Department (Climate Division), Agargonj, Dhaka and have been presented in Appendix-I

3.3. Soil

The soil was belongs to the “Modhupur Tract”, AEZ-28 (FAO, 1988). Top soils were clay loam in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH ranges from 5.4-5.6 and have organic carbon 0.82%. The chemical analysis of the soil of the experimental field were determined in the SRDI, soil Testing Laboratory, Khamarbari, Dhaka and have been presented in Appendix-U.

3.4. Plant Materials Used

BARI Mula-2 (popular name Pinky) was selected for investigation. Seeds of BARI Mula-1 (Pinky) was obtained from the Horticulture Research Center, Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.

3.5. Land Preparation :

The land was ploughed and cross-ploughed quite a few times by tractor, followed by harrowing and laddering until a good tilth was achieved. In order to get good experimental plot spade was used in the corner of the plot. Almost all the big clods were broken into pieces. Weeds and stubbles were removed as far as possible. The land was laid out according to the design of the experiment.

3.6. Experimental Design

The experiment was laid-out in two factorial randomize completely block design (RCBD) with three replications.

Factor A: Cow dung Level: 4

M_1 = Control/ no cowdung

M_2= 20t/ha

M3 = 40t/ha

M4 = 60t/ha

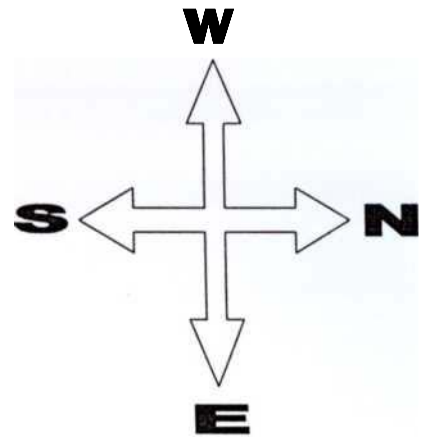
Factor **B:** Spacing
Level 3

s,=	40cm x 20 cm
s_2 =	40cm x 30 cm
s_3=	40cm x 40 cm

The treatment combinations (Spacing x Cow-dung) were as follows:

1.	S|M,	-	40cm x 20 cm spacing with no cow-dung
2.	s,m_2	-	40cm x 20 cm spacing with 20t/ha cow-dung
3.	s,m_3	-	40cm x 20 cm spacing with 40t/ha cow-dung
4.	s,m_4	-	40cm x 20 cm spacing with 60 t/ha cow-dung
5.	s_2m,	-	40cm x 30 cm spacing with no cow-dung
6.	S2M2	-	40cm x 30 cm spacing with 20t/ha cow-dung
7.	S2M3	-	40cm x 30 cm spacing with 40t/ha cow-dung
8.	S2M4	-	40cm x 30 cm spacing with 60 t/ha cow-dung
9.	S_3M,	-	40cm x 40 cm spacing with no cow-dung
10.	s_3m_2	-	40cm x 40 cm spacing with 20t/ha cow-dung
11.	S3M3	-	40cm x 40 cm spacing with 40t/ha cow-dung
12.	S3M4	-	40cm x 40 cm spacing with 60 t/ha cow-dung

s,m_3	S_3M_4	s_2m_2
s_3m_2	$S,M,$	s_3m_3
s_2m_4	s_3m_2	$S,M,$
$S,M,$	s_2m_4	$s_3m,$
S_2M_3	s,m_4	s_2m_2
S_3M_4	s_2m_3	s,m_3
$s_2m,$	s,m_2	s_3m_4
S_3M_3	$s_2m,$	s,m_2
S,M_2	s_3m_3	$s_2m,$
$s_3m,$	s,m_3	s_3m_3
s_2m_2	$s_3m,$	s,m_4
S,M_4	s_2m_2	S_2M_4



Plot size: 2.4m x 2.0m
Plot spacing: 0.5m
Between replication: lm

Si = 40 x 20cm
S_2= 40 x 30cm
S3= 40 x 40cm

M| = No cow-dung
20 t/ha cow-dung
M_3= 40t/ha cow-dung
M_4 = 60t/ha cow-dung

Fig. I. Field layout of the two factors experiment in the Randomized Complete Block Design (RCBD)

Plot Size: 2.4m x 2.0m = 4.8m^2
Total No. of **Plot:** 36

Plot-to-Plot Distance: 0.5m

Replication-to-Replication Distance: 1.0m

Total Area: 30.0m x 10.2m = 306.0 m^2

3.7. Date of sowing:

The seed was sown on 9 October 2006.

3.8. Chemical Fertilizer:

Chemical fertilizers were not used in this experiment.

3.9. Irrigation:

At dry season radish need regular irrigation and considering this fact irrigation was done at ten (10) days interval.

3.10. Weeding:

Weeding was done three times, first on at the 7days after sowing, second on at 25days after sowing and third on at 35 days after sowing.

3.11. Pesticide Application:

There was no incidence of insects and diseases.

3.12. Harvesting:

Randomly selected five plants were harvested from each plot for data collection for three times. First harvest was done at 45 DAS (Days After Sowing) and second at 60 DAS and finally at 75 DAS. The soil adhering to the roots after harvest was rubbed of and the roots were cleaned before weighting. The leaves were separated from the plants by a sharp knife and weight of leaves and roots was taken separately.

3.13. Duration of the experiment:

The experiment was continued from 9 October, 2006 to 23 December, 2006.

3.14. Data Collection (Parameter):

Data were recorded on the following parameters from the sample plants during 1 lie course of experiment. Ten (10) plants were sampled randomly from each unit plot for the collection of data. The plants in the outer rows and at the extreme end of the middle rows were excluded from the random selection to avoid the border effect.

3.14.1. Plant height (cm)

Plant height of ten randomly selected plants were measured in centimeter (cm) by a meter scale at 45, 60 and 75 days after sowing (DAS) from the bottom of root to the tip of the longest leaf.

3.14.2. Number of leaves per plant:

Numbers of leaves of ten randomly selected plants were counted at 45, 60 and 75 DAS. All the leaves of each plant were counted separately. Only the smallest young leaves at the growing point of the plant were excluded from counting. The average number of leaves of ten plants gave the number of leaves per plant.

3.14.3. Largest Leaf size (cm)

Length and width of the biggest leaf of ten randomly selected plants were measured in centimeter at 45, 60 and 75 DAS by a meter scale. The average length and width of leaf of ten plants gave the biggest leaf size per plant in centimeter (cm).

3.14.4. Weight of Leaves per Plant (g)

Ten randomly selected plants were cut at the crown point by a sharp knife and weight of leaves was taken by a triple beam balance at 45, 60 and 75 DAS. The average weight of leaves of ten plants gave the weight of leaves per plant in gram (g).

3.14.5. Root length (cm)

Root length of ten randomly selected plants was measured in centimeter at 45, 60 and 75 DAS by a triple beam balance. The average length of roots often plants gave the length of roots per plant in centimeter (cm).

3.14.6. Root Diameter (cm)

Root diameter of ten randomly selected plants was measured in centimeter at 45, 60 and 75 DAS by a virnear scale. The average diameter of roots often plants gave the root diameter per plant in centimeter (cm).

3.14.7. Weight of root (g)

Ten randomly selected plants were cut at the crown point by a sharp knife and weight of roots was taken by a triple beam balance at 45, 60 and 75 DAS. The average weight of roots of ten plants gave the weight of root per plant in gram (g).

3.14.8. Root Yield (t/ha)

The yield of roots per hectare was calculated in ton by converting the total yield of roots per plot.

3.15. Qualitative Characters

The data of the qualitative characters were recorded from each plot

3.15.1 Dry matter estimation

From each plot leaf and root of ten plant sample previously cut into thin pieces were sun dried after that samples were placed in envelope, were weighted and placed in oven maintained at 70° C for 72 hours. The sample then was transferred into a desiccator and allowed to cool down to the room temperature. The dry weight of the sample was taken. The average dry weight of roots and leaves of ten plants gave the dry matter of root and leaves per plant in gram (g).

3.16. Statistical Analysis:

The data were analyzed statistically to find out whether there is any significant difference among the treatment means. The analysis of variance for most of the characters was accomplished by ‘F variance test’. The significant of difference between pair of means was tested by the Least Significant Difference (LSD) test at 5% and 1% level of probability (Gomez and Gomez, 1984)

RESULTS AND DISCUSSION

The results have been presented in table 1 to 9 and figure 1 to 22. The results of the present study have been presented and discussed in this chapter under following headings.

4.1. **Plant height:**

The plant height was recorded at different stages of growth i.e. 45, 60 and 75 days after sowing (DAS). The plant height varied significantly due to different spacing. During the period of plant growth the maximum plant height (59.78cm) was observed in the widest spacing (S3) at 75DAS and the minimum plant height (40.47cm) was observed in the closest spacing (Si) at 45 DAS. In general the plant height increase gradually in the early stages and became sloth at the later stages of the plant growth (Fig. 1).

The plant height varied significantly due to the application of different cow-dung treatment. The maximum plant height (59.97cm) was observed in M_4 treatment at 75 DAS and the minimum plant height (39.12cm) was observed in M| treatment at 45 DAS. At 45 and 60 DAS there were no significant differences between Mi to M_2, M_2 to M3 and M3 to M_4. But M_3 and M_4 were superior to Mi and M2 respectively. At 75 DAS, the increment of plant height failed to reach the level of significance until 40 t/ha cow-dung was applied. In other words the treatment of Mi and M2 showed identical difference between the treatments of M3 and M_4 (Fig. 2).

The plant height was significantly influenced by the interaction effect of cow-dung and spacing. The combined effect of cow-dung and spacing at different days after sowing was also significant (Appendix III). The maximum vegetative growth was recorded at 75 DAS. The highest plant height of 63.55 cm was found from the widest spacing along with 60 t/ha cow-dung application at 75 DAS and the shortest (35.98 cm) from the control treatment of cow-dung with the closest spacing at 45 DAS (Table 1).

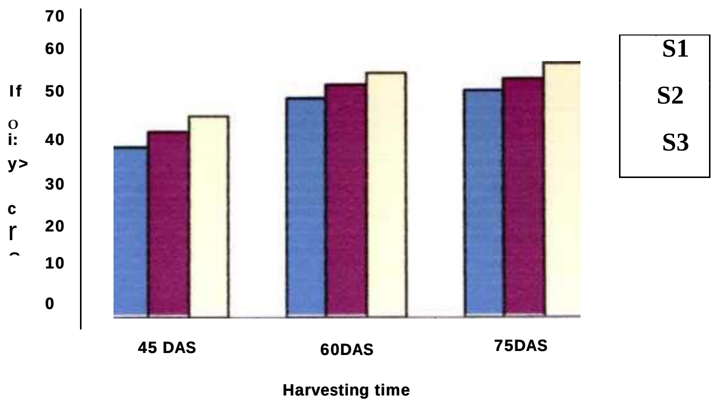


Fig. 1. Effect of spacing on the plant height of radish

51 = 40cm x 20cm
52 = 40cm x 30cm
53 = 40cm x 40cm

DAS= Days after sowing

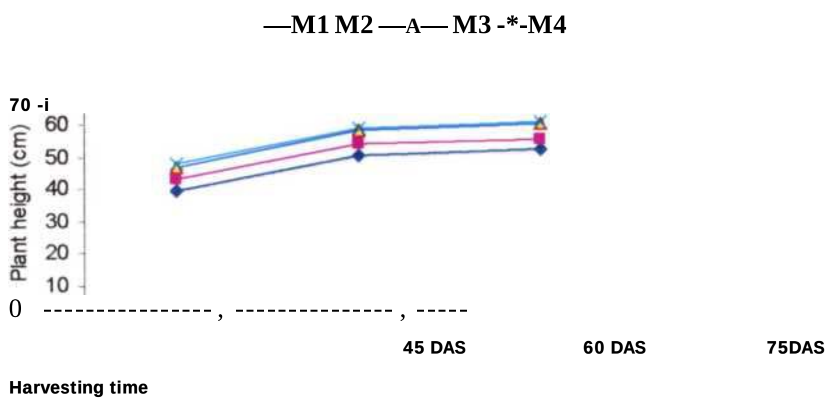


Fig. 2. Effect of cowdung on the plant height of radish

Mi = No cow-dung

M_2 = 20 t/ha cow-dung

M_3 = 40 t/ha cow-dung

M_4 = 60 t/ha cow-dung

DAS = Days after sowing

Table 1. Combined effect of spacing and cow-dung on plant height of radish

Treatment combinations	Plant height (cm) at different days after sowing (DAS)		
	45 DAS	60DAS	75DAS
S,M,	35.98	46.39	48.95
s,m_2	38.50	50.49	52.20
s,m_3	42.50	54.49	56.11
s,m_4	44.88	55.35	56.56
s_2m,	39.62	50.87	51.53
S2M2	43.00	53.53	54.25
S2M3	45.73	57.79	59.23
S_2M_4	46.93	58.17	59.80
S_3 M|	41.77	52.35	54.14
S3M2	46.36	56.20	58.25
S_3M_3	50.50	60.79	63.17
S_3M_4	51.09	61.19	63.55
LSD 5%	7.62	7.89	7.69
LSD 1%	10.36	10.72	10.41
CV%	10.25	8.50	8.01

S_1= 40cm x 20cm
S_2= 40cm x 3Qcm
S_3= 40cm x 40cm

M_1 = No cow-dung
M_2 = 20 t/ha cow-dung
M_3 = 40 t/ha cow-dung
M_4 = 60 t/ha cow-dung

4.2. **Average number of leaves per plant:**

Number of leaves per plant was recorded at different stage of growth i.e. 45, 60 and 75 days after sowing (DAS). The variation among the spacing in respect of average number of leaves per plant was statistically significant. In case of 45 DAS the maximum number of leaves per plant (17.21) was produced by the widest spacing (S3) and the minimum (12.59) was found in closest spacing (S|). Similar trend was found in 60 and 75 DAS (Fig.3). In this experiment it was reveled that the average numbers of leaves per plant was increased in the increased in spacing which was in agreement with Absar and Siddique (19S2).

Significant variation was found in case of production of leaves per plant due to the effect of cow-dung (Fig. 4). The highest number of leaves (21.67) were produced at 75 DAS when 60 t/ha cow-dung applied which was identical will) treatment M_3 (40 t/ha cow-dung). The control treatment gives minimum number of leaves per plant (13.01) at 45 DAS. In line with the present experimental results Shahota (1983) reported an increase in the number of potato leaves with increasing amount of farmyard manure.

The number of leaves per plant was also significantly influenced by the interaction effect of fertilizer and spacing (Appendix III). Maximum number of leaves (23.42) obtained from the treatment combination of the widest spacing and 60t/ha cow- dung application (S3M4) treatment at 75 DAS. The lowest number of leaves (10.18) was observed from the control treatment where no cow-dung was used and the closest spacing at 45 DAS (Table 2).

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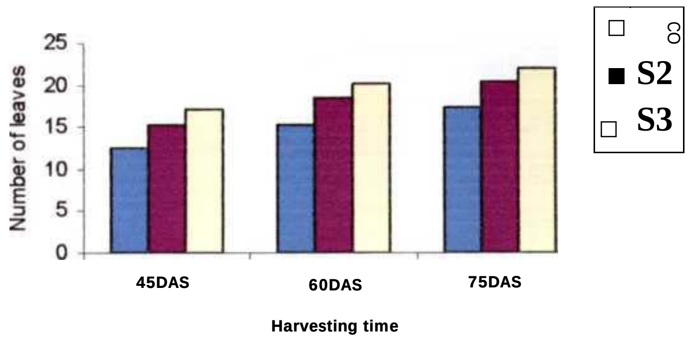


Fig. 3. Effect of spacing on the leaves number of radish

> 0 V6

51 = 40cm x 20cm
52 — 40cm x 30cm
S? — 40cm x 40cm

DAS- Days after sowing

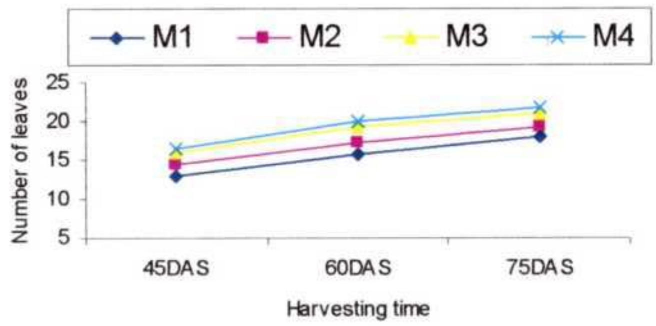


Fig. 4. Effect of cowdung on the leaves number of radish

M_1 = No cow-dung
M_2 = 20 t/ha cow-dung
M_3 = 40 t/ha cow-dung
M_4 = 60 t/ha cow-dung

DAS = Days after sowing

Table 2. Combined effect of spacing and cow-dung on the number of leaves per plant of radish

Treatment combinations	Number of leaves per plant (g) at different days after sowing (DAS)		
	45 DAS	60DAS	75DAS
S,M,	10.18	13.27	15.17
S,M_2	12.5	14.42	16.33
s,m_3	13.33	16.17	18.67
s,m_4	14.33	17.33	19.42
s_2m,	13.58	16.00	18.33
s_2m_2	14.92	17.58	19.58
s_2m_3	16.18	20.25	21.50
s_2m_4	16.5	20.67	22.17
s_3m,	15.27	18.00	20.33
S3M2	16.33	16.50	21.58
S3M3	18.50	21.25	22.92
S3M4	18.75	21.75	23.42
LSD 5%	2.32	2.3	3.79
LSD 1%	3.16	3.13	5.15
CV%	9.13	7.55	11.21

S_1 = 40cm x 20cm
S_2= 40cm x 30cm
S_3= 40cm x 40cm

M_1= No cow-dung
M_2 = 20 t/ha cow-dung
M3 = 40 t/ha cow-dung
M4 = 60 t/ha cow-dung

4.3. **Leaf size**

4.3.i. **Leaf length:**

Plant spacing had a significant influence in leaf length. Although the length of leaves increased progressively with the increase of spacing, the difference between Si and S2 at 45 and 75 DAS and S_2 and S3 at 60 DAS was not significant (Fig. 5). However widest spacing gave the longest leaf (38.52cm) at 75 DAS and the narrowest leaf (28.84cm) was produced from the closest spacing at 45 DAS.

There was a progressive increase in leaf length with the increase of cow-dung application (Fig. 6). The increase of leaf length due to application of 20 t/ha cow-dung was 1.41cm at 45 DAS, 1,20cm at 60 DAS and 1.00 at 75 DAS over the control plots and the difference was not significant. M3 and M_4 produced significantly longer leaves than control. The highest dose of cow-dung produced the longest leaf (37.26cm) at 75 DAS and the smallest leaf (29.11cm) was produced by control treatment at 45 DAS.

There were interacting effect on leaf length of plant due to spacing and application of cow-dung (Appendix III). Cow-dung at the rate of 60 t/ha along with widest spacing gave the longest leaves (39.80cm) at 75 DAS which was statistically similar with interaction of cow-dung at 40 t/ha and widest spacing. The smallest leaf (27.70cm) was found from the interaction of control treatment of cow-dung and closest spacing at 45 DAS (Table 3).

4.3.ii. **Leaf width:**

The leaf width varied significantly due to the application of different spacing treatments. In this experiment it was reveled that the width of leaves increased in the increased in spacing (Fig. 7). The widest leaves (9.61 cm) was produced from the widest spacing at 75 DAS and the narrowest leaf (6.82 cm) was found from the closest spacing at 45 DAS.

Significant variation was found in ease of leaf width due to the effect of cow-dung (Fig. 8). At every harvest the narrowest leaves were found in control treatment. There was no significant difference between the control and M2 (20 t/ha cow-dung). However, the widest leaves (9.69 cm) were found due to the application of 60 t/ha cow- dung at 75 DAS and the narrowest leaves (7.19cm) were found in M| treatment al 45 DAS.

There were significant variation on leaf width of plant due to spacing and application of cow-dung. The narrowest leaf (6.29cm) was produced from the treatment combination of the closest spacing with no cow-dung at 45 DAS and the widest leaf (10.60cni) was produced from the interaction of widest spacing with 60 t/ha cow-dung application at 75 DAS.

The size of leaves (length and breadth) as a whole was increased with increasing spacing as well as cow-dung doses. Ambroziak-Galaj and Woyke (1965) also reported that wider spacing produced bigger leaves. It is a well established fact that the size of leaf is increased through increases in cell number and cell size. The number and size of cells in turn, are geared up through the availability of higher amount of plant food or resources. The size of leaf, therefore, increased with increasing amount of manure and spacing mainly because of availability of higher amount of resources per plant.

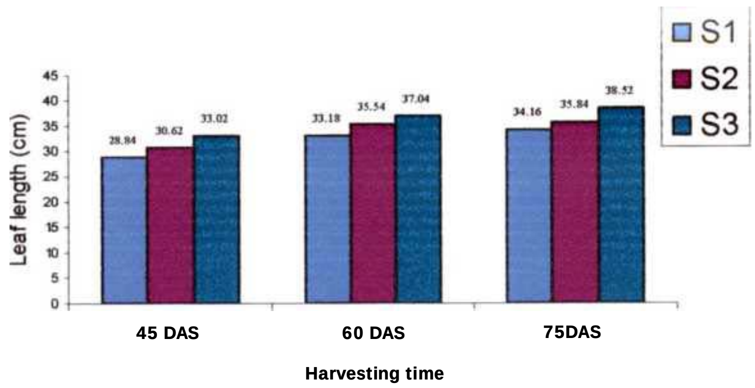


Fig. 5. Effect of spacing on the leaf length of radish

51 = 40cm x 20cm
52 — 40cm x 30cm
53 — 40cm x 40cm

DAS= Days after sowing

M1 **M2** **M3**

40
30
20
10
0

S

45 DAS **60DAS** **75DAS**

Harvesting time

Fig. 6. Effect of cowdung on the leaf length of radish

Mi = No cow-dung
M2 = 20 t/ha cow-dung
M_3 = 40 t/ha cow-dung
M4 = 60 t/ha cow-dung

DAS = Days after sowing

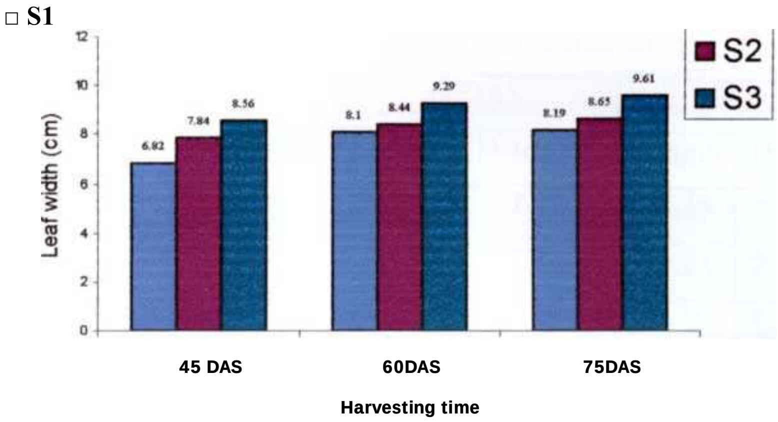


Fig. 7. Effect of spacing on the leaf width of radish

51 = 40cm x 20cm
52 — 40cm x 30cm
53 — 40cm x 40cm

DAS= Days after sowing

12
10
8
6
4
2
0

45DAS 60DAS 75DAS

Harvesting time

Fig. 8. Effect of cowdung on the leaf width of radish

Mi = No cow-dung M_2 =
20 t/ha cow-dung M_3 = 40
t/ha cow-dung M* = 60
t/ha cow-dung

DAS = Days after sowing

Table 3. Combined effect of spacing and cow-dung on largest leaf size of radish

Treatment combinations	Largest leaf size (cm) at different days after sowing (DAS)					
	45 DAS		60DAS		75DAS	
	Length	Diameter	Length	Diameter	Length	Diameter
S_1M_1	27.70	6.29	31.17	7.47	33.25	7.61
S,M:	28.25	6.70	32.74	7.74	33.93	7.80
Si M_3	29.00	7.03	34.20	8.29	34.69	8.39
S,M_4	30.42	7.27	34.61	8.92	34.78	8.96
S_2M.	29.12	7.11	34.17	7.78	34.33	7.89
S_2M_2	30.62	7.50	34.78	8.04	35.12	8.21
s_2m_3	31.03	8.23	36.50	8.72	36.70	8.99
S_2M_4	31.70	8.50	36.70	9.25	37.19	9.50
S3 Ml	30.50	8.18	35.08	8.13	36.54	8.42
S3M2	32.69	8.50	36.50	8.86	38.08	9.13
S3M3	34.25	8.74	38.17	9.82	39.67	10.28
S3M4	34.63	8.83	38.42	10.34	39.80	10.60
LSD 5%	3.82	3.95	3.85	0.76	0.96	0.83
LSD 1%	5.19	5.37	5.23	1.03	1.3	1.4
CV%	7.31	5.80	6.62	6.58	6.28	5.60

S_1 = 40cm x 20cm
S_2= 40cm x 30cm
S_3= 40cm x 40cm

M_1 = No cow-dung
M_2 = 20 t/ha cow-dung
M_3 = 40 t/ha cow-dung
M_4 = 60 t/ha cow-dung

4.4. **Weight of leaves per plant:**

This is one of the most important yield contributing parameters that gives an indication of leafage of the plant. The leafage in turn, indicates the size of the photosynthetic system. Every increase in spacing significantly increased the total weight of leaves per plant (Fig. 9). The highest weight (150.90g) of leaves was recorded from the widest spacing at 75 DAS and the lowest weight (58.66g) was produced from the closest spacing at 45 DAS. Previous reports of Absar and Siddique (1982), and Rahman and Haque (1982) indicate that the number of leaves per plant is increased in the increased in spacing and these reports indirectly support the present finding in respect of leaf weight.

The manorial treatments had a marked influence on weight of leaves per plant. Every increase in the amount of cow-dung significantly increased the leaf weight with the exception that 60 and 40 t/ha were identical (Fig. 10). The highest rate of increase in leaf weight was found when the rate of manure was increased from 20 to 40 t/ha. The highest weights(151.81 g) were produced from M4 treatment at 75 DAS and the lowest leaves weight (62.78g) was recorded with the control plots at 45 DAS. Shahota (1983) reported that the increase in applied manure was associated with increase in the number of leaves per plant. The present findings were indirectly in agreement with shahota, because the increase in number of leaves might be associated with increase in leaf weight per plant.

Variation in interaction of spacing and cow-dung application showed significant effect on fresh weight of leaves per plant (Appendix III). The highest leaves weight (167.75g) was found from the highest level of cow-dung interacting with the widest spacing at 75 DAS and the lowest weight (46.08g) was found from the closest spacing interacting with 0 t/ha cow-dung at 45 DAS (Table 4). Like other plant character viz. number of leaves, leaf size and plant height, weights of leaves were found highest at 75 DAS which were statistically identical with the weights of leaves at 60 DAS.

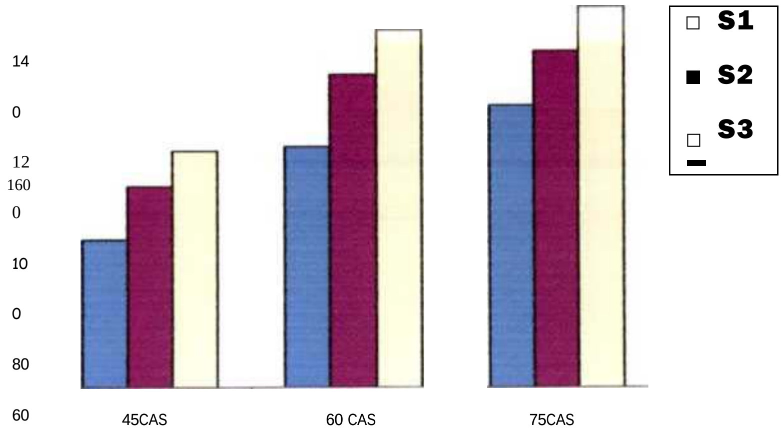


Fig. 9. Effect of spacing on the leaves weight of radish

DAS= Days after sowing

S1 = 40cm x 20cm
S2= 40cm x 30cm
S3= 40cm x 40cm

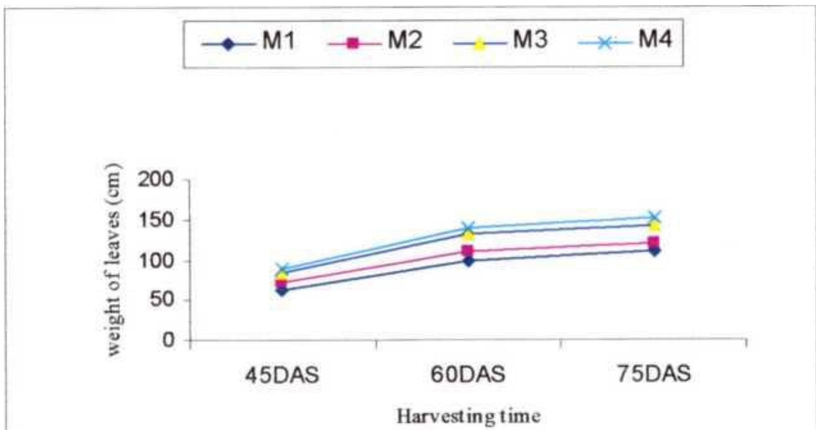


Fig.10. Effect of cowdung on the weight of leaves

1= No cow-dung
= 20 t/ha cow-dung
= 40 t/ha cow-dung
= 60 t/ha cow-dung

DAS = Days after sowing

Table 4. Combined effect of spacing and cow-dung on leaf weight per plant of radish

Treatment combinations	Leaf weight per plant (g) at different days after sowing (DAS)		
	45 DAS	60DAS	75DAS
S,M,	46.08	73.25	84.42
S,M_2	54.58	83.08	102.50
s,m_3	61.90	106.58	124.73
s,m_4	72.08	118.08	134.67
s_2m,	64.25	102.62	115.67
S2M2	73.17	113.17	120.92
S2M3	88.50	137.50	143.25
S2M4	91.75	141.42	153.00
s_3m,	78.02	121.83	133.83
S3M2	85.67	133.17	140.83
S3M3	102.58	153.00	161.17
S3M4	106.67	156.75	167.75
LSD 5%	10.58	17.29	15.65
LSD 1%	14.39	23.5	21.28
CV%	2.42	8.51	7.01

51 = 40cm x 20cm
52 = 40cm x 30cm
53 = 40cm x 40cm

Mi = No cow-dung
M_2 = 20 t/ha cow-dung
M3 = 40 t/ha cow-dung
M4 = 60 t/ha cow-dung

4.5. **Root size:**

i. **Root Length:**

The root length varied significantly due to the application of different spacing treatments. In this experiment it was reveled that root length of radish significantly increased in the increased in spacing (Fig. 11). The longest root (21.25 cm) was produced from the widest spacing at 75 DAS and the shortest root (11.62 cm) was found from the closest spacing at 45 DAS.

The cow-dung treatments had a marked influence on root length of radish. Every increase in the amount of cow-dung significantly increased the root length with the exception that M3 and M_4 were identical. The longest root (22.76cm) was produced by applying 60 t/ha cow-dung at 75 DAS and the control treatments produced the shortest root (10.02cm) at 45 DAS. Figure 12 showed that root length was gradually increased at the early stage of growth but at the later stage it became slower.

Significant variation in root length was observed with the interaction effect of spacing and cow-dung application (Appendix III). The longest root (23.74cm) was produced from the interaction of widest spacing with 60 t/ha cow-dung at 75 DAS. The shortest root (8.28cm) was produced from the 0t/ha cow-dung and closest spacing at 45 DAS. At early stage root length increased gradually but it became slower at later stage. The root length had no significant difference between 60 DAS and 75 DAS (Table 6).

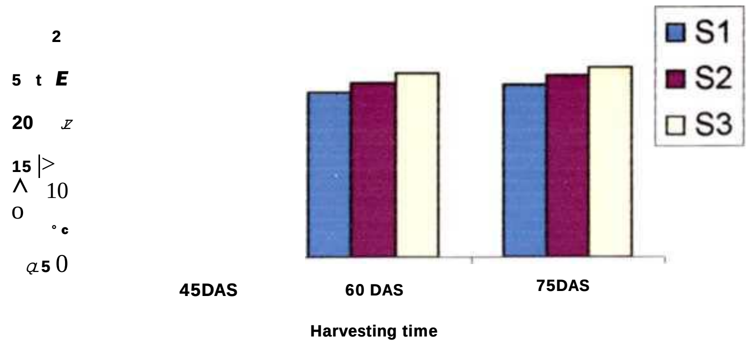


Fig. 11. Effect of spacing on the root length of radish

51 = 40cm x 20cm

52 = 40cm x 30cm

53 = 40cm x 40cm

DAS= Days after sowing

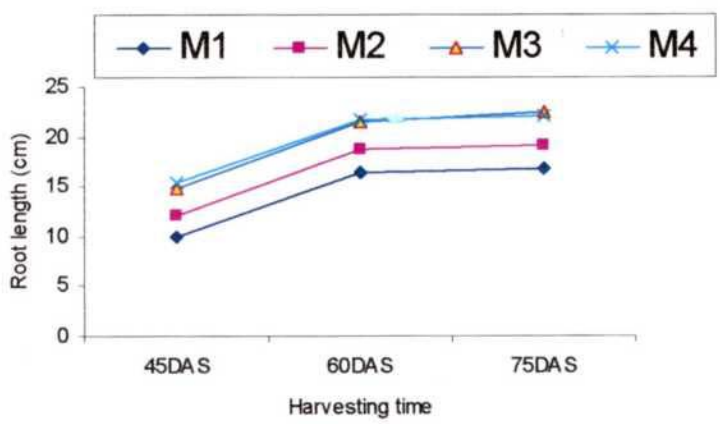


Fig.12. Effect of cowdung on the root length of radish

Mi = No cow-dung

M2 = 20 t/ha cow-dung

M3 = 40 t/ha cow-dung

M4 = 60 t/ha cow-dung

DAS = Days after sowing

ii. **Root diameter:**

The diameter was increased significantly with every increase in planting distance at every harvest (Fig. 15). The widest root (5.66cm) was produced from the widest spacing at 75 DAS and the narrowest root (3.30cm) was produced from the closest spacing at 45 DAS. Similar results were also reported by Hussain *et al.* (1985) with panikachu.

As with root length, the diameter of root was also increased with increasing cow-dung doses (Fig. 16). There was no statistical difference between the plants of the control plots and those receiving cow-dung at 20 t/ha. The widest root (5.72cm) was produced from M_4 treatment at 75 DAS and the narrowest root (3.30cm) was produced from Mi treatment at 45 DAS.

The root diameter was significantly influenced by the interaction effect of spacing and cow-dung. The widest root (6.10cm) was produced from the interaction of the widest spacing with 60 t/ha cow-dung at 75 DAS and the narrowest root (3.12cm) was produced from the combined effect of closest spacing with 0t/ha cow-dung at 45 DAS (Table 6).

Deep and loose soil is essential for proper expansion of edible roots both across and downwards. The reasons of increasing root size (length and diameter) with increasing amount of cow-dung may possible be that the physical, chemical and biological condition of the soil were improved facilitating better growth and development of the roots.

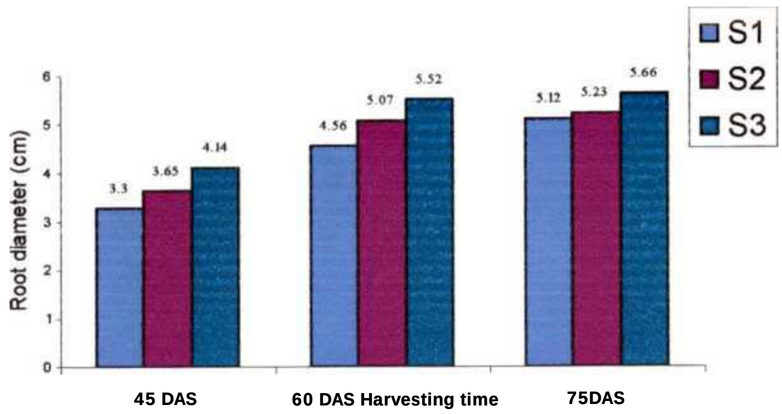


Fig. 13. Effect of spacing on the root diameter of radish

S_1= 40cm x 20cm

S_2= 40cm x 30cm

S_3= 40cm x 40cm

DAS=" Days after sowing

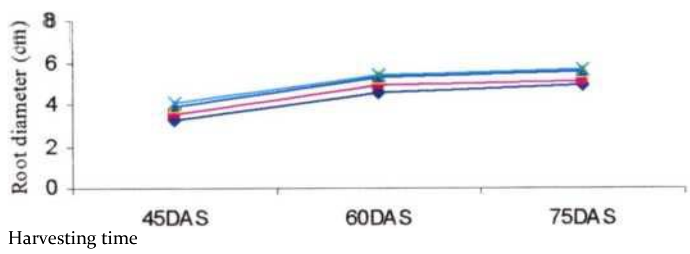


Fig. 14. Effect of cowdung on the root diameter of radish

M_1 = No cow-dung

M_2 = 20 t/ha cow-dung

M_3 = 40 t/ha cow-dung

M_4 = 60 t/ha cow-dung

DAS = Days after sowing

Table 5. Combined effect of spacing and cow-dung on root size of radish

Treatment combinations	Root size (cm) at different days after sowing (DAS)					
	45 DAS		60DAS		75DAS	
	Length T	Diameter	Length	Diameter	Length	Diameter
S,M,	8.28	3.12	15.23	4.11	15.70	4.63
i S,M:	10.25	3.23	17.75	4.43	18.27	4.97
Si M_3	13.5	3.33	20.29	4.82	21.42	5.42
S1M4	14.47	3.53	20.74	8.49	21.78	5.45
S_2M,	10.5	3.24	16.70	4.48	17.03	4.98
S2M2	12.38	3.43	18.75	5.03	19.13	5.05
S2M3	14.69	3.91	21.29	5.35	22.527	5.42
S:M_4	15.23	4.01	21.47	5.43	22.74	5.63
S3 M,	11.27	3.55	17.27	5.07	17.60	5.27
S3M2	13.67	3.93	19.70	5.26	20.17	5.32
S3M3	16.25	4.46	22.63	5.8	23.50	5.90
S3M4	16.46	4.62	22.77	5.95	23.74	6.10
LSD 5%	1.51	2.42	2.29	0.66	0.81	0.79
LSD 1%	2.05	3.28	3.12	0.90	1.11	1.08
CV%	6.82	10.63	7.31	9.51	6.67	8.79

S_1 = 40cm x 20cm
S_2= 40cm x 30cm
S_3= 40cm x 40cm

M_1 = No cow-dung
M_2 = 20 t/ha cow-dung
M_3 = 40 t/ha cow-dung
M_4 = 60 t/ha cow-dung

4.6. **Root weight:**

As was the case with other plant characters studied, the spacing showed a significant influence on weight of individual roots. The weight was significantly increased with every increase in spacing (Fig. 15). The highest weight of root (337.13g) was produced from the widest spacing at 75 DAS and the lowest weight (98.55g) was found from closest spacing at 45 DAS.

Root weight varied significantly due to the application of different cow-dung application. The weight of root had progressively increased with increasing amount of cow-dung (Fig. 16). The highest weight of root (349.75g) was produced from M_4 treatment at 75 DAS and the lowest weight (74.1 lg) was found from Mi treatment at 45 DAS.

Variation in interaction of spacing and cow-dung application showed significant effect on weight of root per plant (Appendix III). The highest root weight (367.25 g) was found from the highest level of cow-dung (60 t/ha) interacting with widest spacing at 75 DAS and the lowest root weight (64.17g) was found from the closest spacing interacting with Ot/ha cow-dung at 45 DAS. Comparing the weight of root at different treatment combination it was observed that root weight increased almost triple from 45 DAS to 75 DAS, but the root weight at 75 DAS and 60 DAS showed identical result (Table 7).

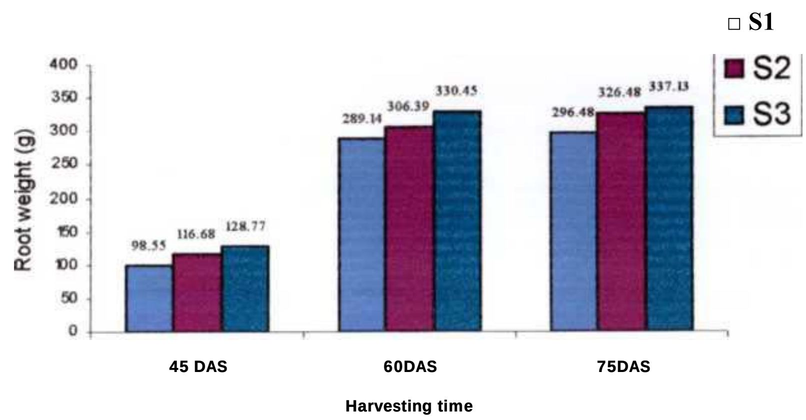


Fig. 15. Effect of spacing on the root wight of radish

S1= 40cm x 20cm

S2= 40cm x 30cm

S3= 40cm x 40cm

DAS= Days after sowing

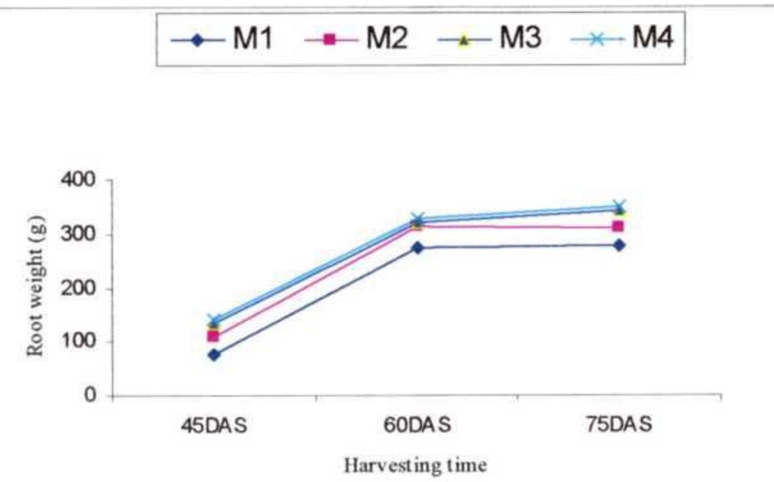


Fig. 16. Effect of cowdung on the root weight of radish

Mi = No cow-dung

M2 = 20 t/ha cow-dung

M_3 = 40 t/ha cow-dung

M_4 = 60 t/ha cow-dung

DAS = Days after sowing

Table 6. Combined effect of spacing and cow-dung on root weight per plant of radish

T reatment combinations	Root weight per plant (g) at different days after sowing (DAS)		
	45 DAS	60DAS	75DAS
S,M,	64.17	256.08	262.00
S,M_2	97.92	284.58	283.17
s,m_3	111.23	304.92	318.75
S1M4	120.92	310.98	322.00
S:M,	71.75	273.37	273.20
S2M2	106.05	329.62	321.73
S2M3	141.25	307.42	351.00
S2M4	147.65	315.17	360.00
s_3m,	86.42	293.83	294.92
S3M2	125.25	327.83	327.92
S3M3	148.83	346.67	358.42
S3M4	154.58	353.45	367.25
LSD 5%	16.20	29.53	23.62
LSD 1%	22.01	40.14	32.10
CV%	8.34	5.65	4.36

S| = 40cm x 20cm
52 = 40cm x 30cm
53 = 40cm x 40cm

M_1 = No cow-dung
M2 = 20 t/ha cow-dung
M3 = 40 t/ha cow-dung
M4 = 60 t/ha cow-dung

4.7. Dry matter:

4.7.i. Dry matter of leaves:

Dry matter of leaves per plant increased significantly with the increase of spacing. The dry matter of radish leaves per plant was recorded to be the highest (11.28g) at 75 DAS from the widest spacing. The lowest dry matter (4.40g) of leaves per plant was obtained from the closest spacing at 45 DAS (Fig. 17).

From fig. 18 and appendix 111 it reveals that different cow-dung doses had significant effect on dry matter of radish leaves per plant. Dry matter of leaves per plant was increased in the increased in cow-dung doses with the exception that the doses of 40 t/ha and 60 t/ha gave identical result. The highest dry matter of leaves (11.03) per plant was recorded at 75 DAS where 60 t/ha cow-dung was applied and the lowest dry matter of leaves (4.38g) was recorded at 45 DAS where 0 t/ha cow-dung was applied.

Variation in interaction of spacing and cow-dung application showed significant effect on dry matter of leaves per plant (Appendix III). The highest dry matter of leaves per plant (13.20g) was found from the highest level of cow-dung (60t/ha) interacting with widest spacing at 75 DAS. At every harvest S3M4 and S3M3 gave the highest dry matter of leaves per plant which were statistically similar and S1M1 gave the lowest dry matter (3.55g) of leaves per plant at 45 DAS (Table 7).

4.7.ii. Dry matter of root:

Dry matter of root per plant varied significantly due to the effect of spacing. Dry matter of root was increased in the increased in spacing and the highest root dry matter (13.39g) was found in the widest spacing at 75 DAS and the lowest dry matter (3.34g) of root per plant was obtained from the closest spacing at 45 DAS (Fig. 19).

Significant variation was found in case of dry matter of root due to the effect of cow-dung. The highest dry matter of radish root (14.10g) per plant was recorded at 75 DAS where 60 t/ha cow-dung applied and the lowest root dry matter (3.52g) per plant was observed in control plot at 45 DAS.

There were interaction effect on dry matter of root per plant due to spacing and application of cow-dung (Appendix III). The highest dry matter of root per plant (15.08g) was found from the highest level of cow-dung (60t/ha) interacting with the widest spacing at 75 DAS. The lowest root dry matter (2.85g) per plant was found from the interaction between the closest spacing and 0 t/ha cow-dung application at 45 DAS. The root dry matter per plant was increased gradually from 45 DAS to 60 DAS and become slower at 75 DAS (Table 9).

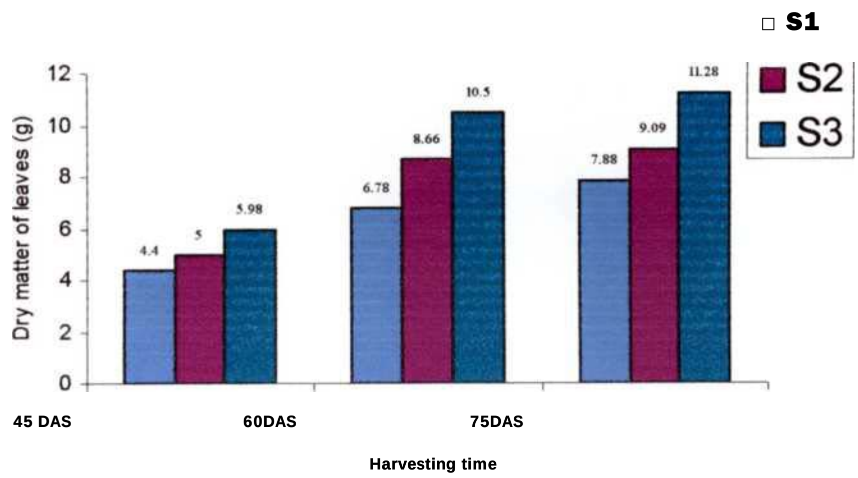


Fig. 17. Effect of spacing on the dry matter of leaves

S1= 40cm x 20cm

S2= 40cm x 30cm

S3= 40cm x 40cm

DAS= Days after sowing

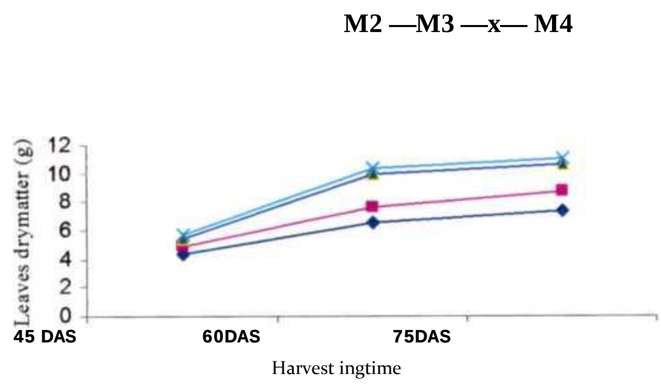


Fig. 18. Effect of cowdung on the dry matter of leaves

Mi = No cow-dung

M2 = 20 t/ha cow-dung

M_3 = 40 t/ha cow-dung

M4 = 60 t/ha cow-dung

DAS = Days after sowing

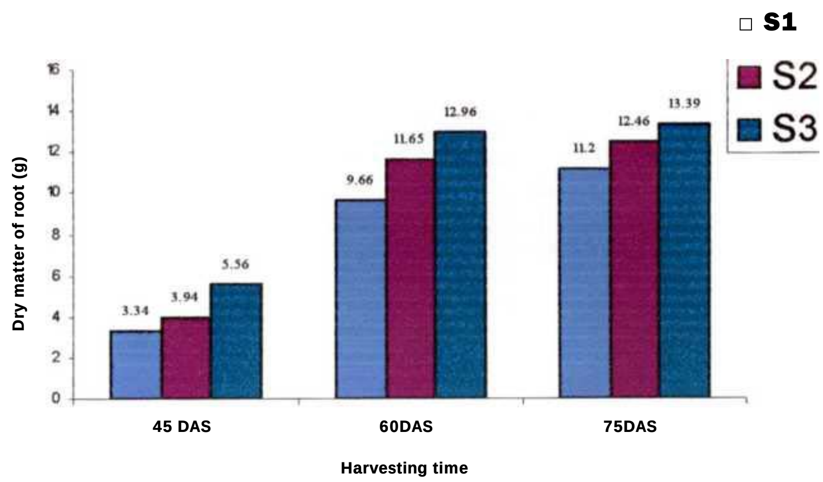


Fig. 19. Effect of spacing on the dry matter of root

S1= 40cm x 20cm DAS= Days after sowing

S2=40cm x 30cm

S3= 40cm x 40cm

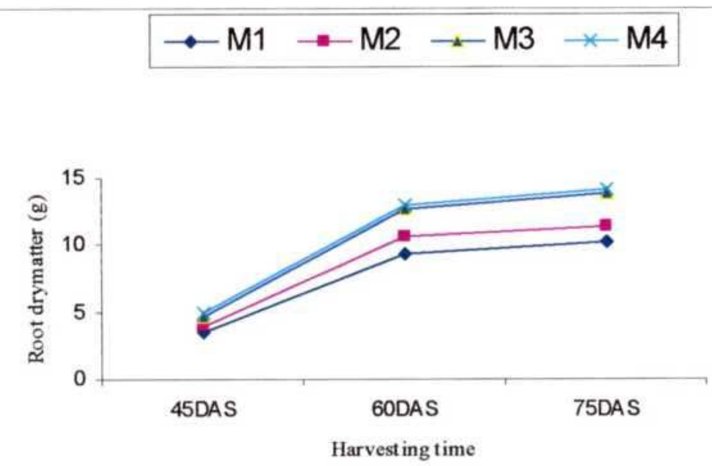


Fig. 20. Effect of cowdung on the dry matter of root

M_1 = No cow-dung DAS = Days after sowing

M_2 = 20 t/ha cow-dung

M_3 = 40 t/ha cow-dung

M4 = 60 t/ha cow-dung

Table 7. Combined effect of spacing and cow-dung on Dry mater of radish

Treatment combinations	Root dry mater (g) at different days after sowing (DAS)					
	45 DAS		60DAS		75DAS	
	Leaf	Root	Leaf	Root	Leaf	Root
S_1M_1	3.55	2.85	5.30	7.77	6.60	9.46
S_1M_2	4.33	3.15	6.18	8.85	7.12	10.29
S_1M_3	4.83	3.62	7.46	10.76	8.72	12.38
S_1M_4	4.88	3.74	8.18	11.28	9.10	12.68
S_2M_1	4.40	3.24	6.38	9.62	6.83	9.80
S_2M_2	4.79	3.42	7.69	10.83	8.23	11.40
S_2M_3	5.28	4.39	10.18	13.02	10.51	14.12
S_2M_4	5.52	4.69	10.38	13.12	10.78	14.53
S_3M_1	5.20	4.46	8.12	10.47	8.58	11.20
S_3M_2	5.79	5.28	9.24	12.28	10.65	12.47
S_3M_3	6.23	5.99	12.18	14.38	12.70	14.83
S_3M_4	6.68	6.50	12.47	14.69	13.20	15.08
LSD 5%	0.74	0.77	0.83	0.38	1.32	1.62
LSD 1%	1.00	1.04	1.13	0.51	0.79	2.20
CV%	8.89	5.29	5.25	6.48	5.23	7.77

S_1 = 40cm x 20cm M1= No cow-dung
S_2 = 40cm x 30cm M2 = 20 t/ha cow-dung
S_3 = 40cm x 40cm M3 = 40 t/ha cow-dung
M4 = 60 t/ha cow-dung

4.8. **Root yield:**

A significant variation was observed on root yield due to the different spacing treatment (Fig. 21). The highest yield (37.06 t/ha) was found in the closest spacing at 75 DAS and the lowest yield (8.05 t/ha) was found in the widest spacing at 45 DAS. The leaf size, leaf weight, root size and individual root weight decreased with decreasing spacing but the root yield per unit area increased significantly because of accommodating higher number of plants at the closest spacing. In other words the reduced weight of individual root due to higher interplant competition was more than compensated by the higher number of plants accommodated per unit area leading to higher yield at the closest spacing. The results of this study are in accord with the finding of many workers (Badruddin and Haque, 1977; Absar and Siddique, 1982 and Ahmed and Haque, 1986).

Like all the yield contributing characters studied, the root yield was increased with increasing amount of cow-dung. The trend in the increase in root yield was in line with weight of leaves per plant and weight of individual root. The root yield was significantly increased with every increase in cow-dung dose with the exception that the doses of 40 t/ha and 60 t/ha produced identical yield at every stages of harvest (Fig. 22). At 75 DAS root yields were higher (31.07 t/ha) than any other harvesting time at every increased of cow-dung treatment, which were showed identical result with 60 DAS. The root yield at final harvest showed almost triple than that of early harvest (Fig. 24). The lowest yield (6.46 t/ha) was found at the control plot at 45 DAS which was significantly out yielded by all the other cow-dung treatments. The last significant increase in yield was found when cow-dung was increased from 20 t/ha to 40 t/ha and beyond 40 t/ha of cow-dung application there was no further significant increase in yield. This indicate that the optimum level of applied cow-dung was 40 t/ha. The increase in yield per unit area with the increase in applied cow-dung was in agreement with Nimzi and Seth (1987), Sharma *ct al.* (1988) and Shahota (1983).

Significant variation in root yield was observed with the interaction effect of spacing and cow-dung (Appendix III). The highest root yield (40.25 t/ha) was observed from the highest level of cow-dung (60 t/ha) with the closest spacing at 75 DAS and the lowest yield (5.40 t/ha) was found from the combined effect of the widest spacing with Ot/ha cow-dung application at 45 DAS (Table 8).

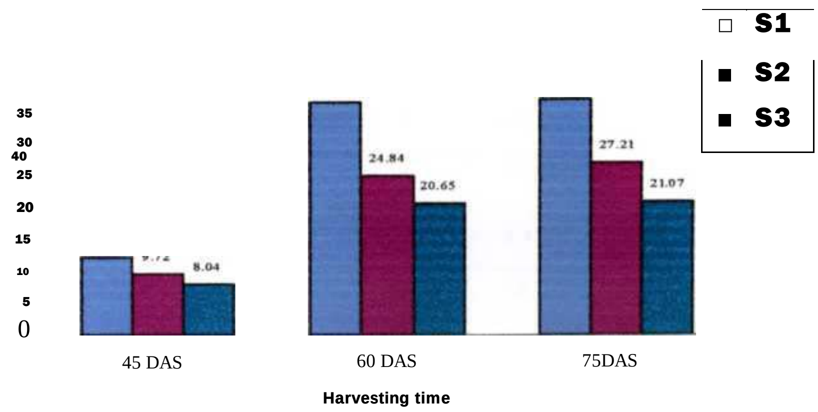


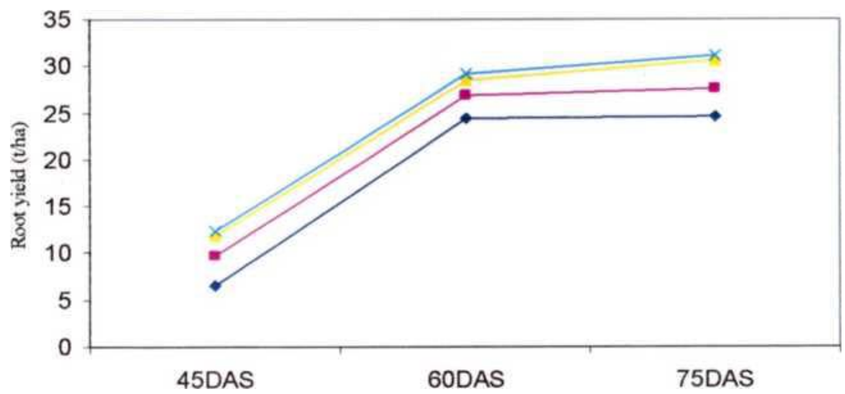
Fig. 21. Effect of spacing on the root yield of radish

51 = 40cm x 20cm
52 = 40cm x 30cm

DAS= Days after sowing

M
O

M
1



53 - 40cm x 40cm

M2 M3
DAS = Days after sowing

Mi = No cow-dung
M_2 = 20 t/ha cow-dung
M_3 = 40 t/ha cow-dung
M_4 = 60 t/ha cow-dung

Harvesting time

Fig. 22. Effect of cow-dung on the mot yield of radish

Table 8. Combined effect of spacing and cow-dung on root yield of r

T reatment combinations	Root yield (t/ha) at different days after sowing (DAS)		
	45 DAS	60DAS	75DAS
S,M,	8.01	25.01	26.25
S|M_2	12.24	35.57	35.40
SiM_3	14.32	38.12	39.84
S|M_4	15.11	38.87	40.25
s_2M,	5.98	22.78	22.77
S2M2	8.83	24.69	26.81
S2M3	11.77	25.62	29.25
S2M4	12.30	26.26	30.12
S3M,	5.40	18.37	18.43
S3M2	7.83	20.49	20.50
S3M3	9.30	21.67	22.41
S3M4	9.66	22.09	22.95
LSD 5%	1.52	4.09	3.09
LSD 1%	2.06	5.56	4.20
CV%	8.90	8.88	6.44

S i = 40cm x 20cm
52 = 40cm x 30cm
53 = 40cm x 40cm

M1=- No cow-dung
M2 = 20 t/ha cow-dung
M3 = 40 t/ha cow-dung
M_4 = 60 t/ha cow-dung

4.9. Cost and Return Analysis

Materials, non-materials and overhead costs were recorded for all the treatments of unit plot and were calculated per hectare basis (marketable yield). The price of radish root at the local market was also noted. The cost and return analysis were done and have been presented in table 9 and appendix IV.

The total cost of production ranges between Tk. 68529 and Tk. 32295 per ha among the different treatment combination. The variation was due to different dose of cow-dung. The highest cost of production Tk. 68529 per ha was involved in the treatment combination of the widest spacing with 60 t/ha cow-dung, while the lowest cost of production Tk. 32295 per ha was involved in the treatment combination of the closest spacing with no cow-dung.

The highest gross return (Tk.201250) was obtained from the treatment combination of the closest spacing with 60 t/ha cow-dung at 75 DAS and the lowest gross return (Tk.27000) was obtained from the treatment combination of the widest spacing with no cow-dung at 45 DAS. On the other hand, the highest net-return (Tk. 142749) was obtained from the treatment combination of the closest spacing with 40 t/ha cow-dung at 75 DAS and the lowest net-return (Tk.-20229) was obtained from the treatment combination of the widest spacing with 60 t/ha cow-dung at 45 DAS.

The benefit cost ratio (BCR) was found to be the highest (3.06) in the treatment combination of the closest spacing with no cow-dung at 75 DAS and the lowest BCR (-0.29) was recorded from the treatment combination of the widest spacing with 60 t/ha cow-dung at 45 DAS.

Table 9. Cost and return of Radish due to spacing and cowdung treatments

T reatment Combination	Yield (t/ha)			Gross return (Tk/ha)			Total Cost of production (Tk/ha)	Net return (Tk/ha)			Benefit cost ratio (BCR)		
	45DAS	60DAS	75DAS	45DAS	60DAS	75DAS		45DAS	60DAS	75 DAS	45DAS	60DAS	75 DAS
S,M,	8.01	25.01	26.25	40050	125050	131250	32295	7755	92755	98955	0.24	2.87	3.06
S,M_2	12.24	35.57	35.40	61200	177850	177000	44373	16827	133477	132627	0.38	3.00	2.98
s,m_3	14.32	38.12	39.84	71600	190600	199200	56451	15149	134149	142749	0.27	2.37	2.52
s,m_4	15.11	38.87	40.25	75550	194350	201250	68529	7021	125821	132721	0.10	1.83	1.93
s_2m.	5.98	22.78	22.77	29900	113850	113850	32295	-2395	81605	81555	-0.07	2.52	2.52
S2M,	8.83	24.69	26.81	44150	123450	134050	44373	-223	79077	89677	-0.01	1.78	2.02
S2M3	11.77	25.62	29.25	58850	128100	146250	56451	2395	71649	89799	0.04	1.26	1.59
S_2M_4	12.30	26.26	30.12	61500	131300	150600	68529	-7029	62771	82071	-0.10	0.91	1.19
s_3m,	5.40	18.37	18.43	27000	91850	92150	32295	-5295	59555	59855	-0.16	1.84	1.85
s_3m_2	7.83	20.49	20.50	39150	102450	102500	44373	-5223	58077	58127	-0.12	1.31	1.31
S3M3	9.30	21.67	22.41	46500	108350	112050	56451	-9951	51899	55599	-0.18	0.91	0.98
s_3m_4	9.66	22.09	22.95	48300	110450	114750	68529	-20229	41921	49221	-0.29	0.61	0.67

Sale of Radish @ Tk. 4500/t

S1= 40cm x 20cm

S2= 40cm x 30cm

S3= 40cm x 40cm

M_1= No cow-dung

M_2 = 20 t/ha cow-dung

M3 = 40 t/ha cow-dung

M_4 = 60 t/ha cow-dung

Summary and Conclusion

An experiment was conducted at the Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka, to evaluate the effects of spacing and cow-dung on the yield of radish during the period of October 2006 to December 2006. The experiment consisted of three levels of spacing viz. 40 cm x 20 cm, 40 cm x30 cm and 40 cm x 40 cm and four levels of cow-dung viz. control, 20 t/ha, 40 t/ha and 60 t/ha.

The factorial experiment was laid in Randomized Complete Block Design (RCBD) with three replications. There were all together twelve treatment combinations in this experiment. Each unit plot size was 2.4m x 2.0m where 1.0 m and 0.5 m gap between blocks and plots respectively were maintained. The experiments plots were fertilized with cow-dung. All levels of cow-dung were applied during final land preparation. The radish seeds of cv. BARI-Mulla-2 (Pinky) were sown on 9th October 2006 and harvested on 45, 60 and 75 days after sowing (DAS). All the intercultural operations were done as and when needed. Data of growth and yield parameters were collected and analyzed statistically. The mean differences were adjusted by least significant different (lsd) test.

Different spacing management practices significantly influenced all the parameters. 40 cm x 40 cm spacing gave maximum plant height (59.78cm), number of leaves (22.06), fresh weight of leaves (150.90g), weight of individual root (337.13g), biggest leaf (38.52cm long and 9.61cm width), longest root (21.25cm long and 5.66cm in diameter) at 75 days after sowing. But the maximum root yield (37.06 t/ha) was recorded from 40 cm x 20 cm spacing at 75 DAS. Beside the minimum plant height (40.47 cm), Number of leaves (12.59) per plant, leaf size (28.84 cm long and 6.82 cm width), weight of leaves per plant (58.66g), root size (11.62cm long and 3.30 cm in diameter), individual root weight (98.55g) were recorded from 40 cm x 20 cm spacing at 45 DAS and minimum root yield (8.05 t/ha) was recorded from 40 cm x 40 cm spacing at 45 DAS.

Cow-dung treatment also showed a significant difference on plant height, number of leaves per plant, leaf size, leaves weight per plant, root size, dry matter content, individual root weight and root yield per hectare. All these parameters showed to its maximum values in those plot where 60 t/ha cow-dung was applied. The yield and yield contributing characters were increase progressively and significantly with every increase in the rate of cow-dung up to the application of 40t/ha. A further increase in the rate of cow-dung slightly increased the yield. The maximum values of plants height (59.97 cm), number of leaves per plant (21.67), leaf size (37.26 cm long and 9.69cm width), leaves weight per plant (151.81 g), root size (22.76cm long and 5.72cm in diameter), individual root weight (349.75 g), root yield (31.07 t/ha), dry matter (11.03g in leaves and 14.10g in root) were found from 60 t/ha cow-dung application at 75 DAS. On the other hand the minimum plant height (39.12cm), number of leaves per plant (13.01), leaf size (29.11 cm long and 7.19cm width), leaves weight per plant (62.78g), root size (10.02cm long and 3.30cm in diameter), individual root weight (74.11 g), root yield (6.46 t/ha), dry matter (4.38 g in leaves and 3.52g in root) were recorded from control treatment of cow-dung at 45 DAS.

The benefit cost ratio (BCR) was found to be the highest (3.06) in the treatment combination of the closest spacing with no cow-dung at 75 DAS and the lowest BCR (-0.29) was recorded from the treatment combination of the widest spacing with 60 t/ha cow-dung at 45 DAS.

Conclusion:

It can be concluded that a reasonable good yield can be reaped with cow-dung application alone and avoiding chemical fertilizers and cow-dung at the rate of 40t/ha was found to be the optimum dose. Instead of using 50cm x 30 cm spacing as recommended earlier (Rashid 1999), the spacing of 40cm x 20cm may be used for obtaining maximum root yield but with sacrificing the root size to some extent. The root should be harvested from 60 to 75 days after sowing to obtain a good yield.

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Appendix I. Monthly recorded of year temperature, rainfall, relative humidity, soil temperature and Sunshine hour of the experimental site during the period from October to December,2006

year	* month	Air Tem. (0C)			RH	Rainfall
		Max	Min	mean	(%)	(mm)
2006	Oct	30.97	23.31	27.14	75.25	208
	Nov	29.45	18.63	24.04	69.52	00
	Dec	26.85	16.23	21.54	70.61	00

*Monthly average

Source: Bangladesh Meteorological Department (Climate division) Agargong,

Dhaka-1212.

Appendix-11. Characteristics of Horticulture Farm soil is analyzed by soil Resource Development Institute (SRDI), Khamar Bari, Farmgate, Dhaka.

A. Morphological characteristics of the experimental field

Morphological feature	Characteristics
Location	Horticulture garden. SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land Type	Medium high land
Soil series	Tejgaon

B. Physical and Chemical properties of the initial soil

Characteristics	Value
Partical size analysis	
% Sand	27
% Silt	43
% clay	30
Textural class	Silty Clay
P"	5.6
Organic Carbon %	0.45
Organic matter%	0.78
Total N%	0.03
Available P (ppm)	20.00
Exchangeable K (me/lOOg Soil)	0.10
Available S (ppm)	45

Source: SRDI

Appendix III. Analysis of variance of different characters of Radish

Source of variation	Degree of Freedom	Mean Square								th)
		Number of leaves			Leaf size (length)			Leaf size (wid		
		45 DAS	60 DAS	75 DAS	45 DAS	60DAS	75DAS	45DAS	60DAS	75 DAS
Replication	2	10.85	9.57	21.05	23.58	20.99	17.12	1.88	1.37	2.49
Spacing	2	64.821	73.31**	67.11**	52.70**	45.46**	58.09**	9.18**	4.43**	6.25**
Cow-dung	3	22.42**	32.35**	26.23**	16.31**	18.98**	12.74**	1.82**	5 19**	5.47**
Spacing x cowdung	6	4.38*	3.51*	3.08*	9.98**	1.81**	6.04**	1.01**	] 41**	1.70**
Error	22	1.88	1.85	1.99	1.57	0.54	0.52	0.20	0.32	0.24

** Significance at 1% level * Significance at 5% level

Appendix III. Continued

Source of variation	Degree of Freedom	Mean Square								
		Plant height			Weight of leaves per plant			Leaves yielc		
		45 DAS	60 DAS	75 DAS	45 DAS	60DAS	75DAS	45DAS	60DAS	75DAS
Replication	2	93.44	79.52	70.66	84.93	317.80	246.61	1.61	3.47	2.42
Spacing	2	145.58**	106.94**	120.59**	3633.55**	6449.84**	4652.93**	6.08**	28.50**	62.56**
Cow-dung	3	131.65**	139.22**	144.61**	1390.44**	3118.60**	3163.75**	10.74**	26.71**	27.07**
Spacing x cowdung	6	18.00**	12.27**	74.90**	17.71**	218.24**	479.09**	3.21**	j9 37**	2.78*
Error	22	2.25	2.17	14.45	3.47	10.42	85.46	0.21	1.05	0.84

1 Significance at 1% level
* Significance at 5% level

Appendix III. Continued

Source of variation	Degree of Freedom	Mean Square								
		Root size (length)			Root size (Diameter)			Weight of root per plant		
		45 DAS	60 DAS	75 DAS	45 DAS	60DAS	75DAS	45DAS	60DAS	75 DAS
Replication	2	5.10	6.79	6.51	1.26	1.80	0.96	679.14	308.58	629.43
Spacing	2	23.472	13.08**	11.56**	2.13**	2.75**	1.35**	2775.44**	5164.399**	5331.15**
Cow-dung	3	56.00**	55.46**	73.34**	1.04**	1 44**	I]7**	8189.77**	4923.24**	10073.61**
Spacing x cowdung	6	4.89**	12.70**	10.04**	0.98**	1.02**	1.01**	1115.68**	3820.25**	1265.10**
Error	22	0.79	2.04	1.83	0.15	0.23	0.22	91.47	304.11	194.59

** Significance at 1% level * Significance at 5% level

Appendix III. Continued

Source of variation	Degree of Freedom	Mean Square								
		Root yield			Dry matter (leaves)			Dry matter (root)		
		45 DAS	60 DAS	75 DAS	45 DAS	60DAS	75DAS	45DAS	60DAS	75DAS
Replication	2	5.35	20.93	11.15	1.26	1.59	7.32	0.65	3.22	3.18
Spacing	2	58.42**	770.69**	780.41**	7.59**	41.51**	35.67**	15.80**	32.96**	14.50**
Cow-dung	3	64.28**	39.38**	78.93**	3.01**	28.88**	26.92**	3.99**	28.30**	32.49**
Spacing x cowdung	6	14.79**	23.18**	24.54**	1.46**	7.18**	7 79**	0.20*	5.12**	3.64*
Error	22	0.80	5.84	3.35	0.18	0.20	0.24	0.05	0.611	0.92

2 Significance at 1% level
* Significance at 5% level

Appendix IV. Production Cost of Radish per hectare.

A) Material Cost (Tk./ha)

Treatment combination	Seed (Tk/ha)	Cowdung (Tk/ha)	Irrigation (Tk/ha)	Sub-Total (Tk/ha) (A)
S,M,	1800	0	1000	2800
SiM$_2$	1800	12000	1000	14800
s,m$_3$	1800	24000	1000	26800
s,m$_4$	1800	36000	1000	38800
s$_2$m,	1800	0	1000	2800
s$_2$m$_2$	1800	12000	1000	14800
S2M3	1800	24000	1000	26800
s$_2$m$_4$	1800	36000	1000	38800
s$_3$m,	1800	0	1000	2800
S3M2	1800	12000	1000	14800
S3M3	1800	24000	1000	26800
S$_3$M$_4$	1800	36000	1000	38800

Radish Seed @ Tk. 600/Kg.
Cowdung @ Tk. 6000/t

S1= 40cm ^{x} 20cm
S2= 40cm x 30cm
S3= 40cm x 40cm

Mi = No cow-dung
M2 = 20 t/ha cow-dung
M3 = 40 t/ha cow-dung
M4 = 60 t/ha cow-dung

Appendix IV. Continued.

B) Non-material Cost (Tk./ha)

Treatment Combination	Land Preparation	Cowdung Application	Seed Sowing	Interculture Operation	Harvesting	Sub Total (B)	Total Input (A+B)
S|M,	7000	420	2800	10000	7000	27220	30020
s,m_2	7000	420	2800	10000	7000	27220	42020
Si M_3	7000	420	2800	10000	7000	27220	54020
S1M4	7000	420	2800	10000	7000	27220	66020
S_2M|	7000	420	2800	10000	7000	27220	30020
S_2M_2	7000	420	2800	10000	7000	27220	42020
S2M3	7000	420	2800	10000	7000	27220	54020
S2M4	7000	420	2800	10000	7000	27220	66020
s_3m.	7000	420	2800	10000	7000	27220	30020
S3M2	7000	420	2800	10000	7000	27220	42020
S3M3	7000	420	2800	10000	7000	27220	54020
S3M4	7000	420	2800	10000	7000	27220	66020

Labour Cost @ Tk. 70/day

S1= 40cm x 20cm
S2= 40cm x 30cm
S3= 40cm x 40cm

Mi = No cow-dung
M2 = 20 t/ha cow-dung
M_3 = 40 t/ha cow-dung
M4 = 60 t/ha cow-dung

Appendix IV. Continued. C)

Overhead Cost (Tk./ha)

Treatment Combination	Cost of lease of land	Miscellaneous Cost (5% of Total input cost)	Interast on running capital for 6 month (13% of the total input cost)	Overhead Cost	Total cost of Production (Total input cost + Overhead cost)
S,M|	16000	1501	17501	2275	32295
s,m_2	16000	2101	18101	2353	44373
Si M3	16000	2701	18701	2431	56451
s,m_4	16000	3301	19301	2509	68529
$s_2m,$	16000	1501	17501	2275	32295
s_2m_2	16000	2101	18101	2353	44373
s_2m_3	16000	2701	18701	2431	56451
s_2m_4	16000	3301	19301	2509	68529
$s_3m,$	16000	1501	17501	2275	32295
S3M2	16000	2101	18101	2353	44373
S3M3	16000	2701	18701	2431	56451
s_3m_4	16000	3301	19301	2509	68529

S1= 40cm * 20cm
S2= 40cm x 30cm
S3= 40cm x 40cm

Mi = No cow-dung
M_2 = 20 t/ha cow-dung
M3 = 40 t/ha cow-dung
M_4 = 60 t/ha cow-dung