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EFFECT OF SPACING AND FERTILIZER MANAGEMENT ON THE YIELD AND YIELD ATTRIBUTES OF MUKHIKACHU (*Colocasia esculenta* Schott.)

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Abstract

Field experiments were carried out in the Agronomy field of BARI, Joydebpur, RARS, Jamalpur and RARS, Ishurdi during two consecutive *kharif* seasons of 2012 and 2013 to determine the suitable plant spacing and optimum fertilizer dose for higher yield of mukhikachu. Three levels of spacing viz., 60 cm x 60 cm, 60 cm x 45 cm and 60 cm x 30 cm and three levels of fertilizer dose viz., recommended dose (3000-96-27-81-18 kg ha^{-1} of CD-N-P-K-S), 25% less than the recommended dose and 25% higher than the recommended dose were used as treatment variables. The experiments were laid out in factorial randomized complete block design with three replications. Results revealed that the closer spacing (60 cm x 30 cm) in combination with 25% higher than the recommended fertilizer dose gave the maximum edible yield of mukhikachu (two years average) at all locations (20.04 t ha^{-1}, 20.75 t ha^{-1} and 16.63 t ha^{-1} at Joydebpur, Jamalpur and Ishurdi, respectively). The wider spacing (60 cm x 60 cm) coupled with 25% less than the recommended fertilizer dose produced the lowest yield (two years average). The maximum benefit- cost ratio (two years average) was obtained from the combination of the recommended fertilizer dose and 60 cm x 30 cm spacing, that were 2.93 at Joydebpur and 3.42 at Ishurdi, while at Jamalpur the maximum benefit-cost ratio (two years average) was found maximum from 60 cm x 30 cm spacing with 25% higher than the recommended fertilizer dose (3.12).

Keywords: Mukhikachu, spacing, fertilizer, yield, benefit-cost ratio, *Colocasia esculenta* schott

Introduction

Mukhikachu (*Colocasia esculenta* Schott) is an important tuber crop vegetable grown in *kharif* season in Bangladesh. It belongs to the family Araceae and is well known as taro. It is a carbohydrate, protein and iron and vitamin 'A' rich vegetable which is generally grown during February/March to September/October (Salam, 2003). It is considered as an important vegetable, particularly in the month of August-October when the supply of other vegetables is scarce in the market (Siddique *et al*., 1988; Basak and Maleque, 1992). The area and gross annual production of mukhikachu in Bangladesh is increasing year after year, but its yield

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per unit area is low (9.76 tha^{-1}) (BBS, 2011) as compared with China (17.05 t ha^{-1}) and Japan (11.59 t ha^{-1}) (FAO, 1999). Too low or wider spacing and unbalanced fertilizer might be two important factors for this low yield of mukhikachu. It is reported that its yield usually varied with different plant densities (Atikuzzaman, 2008; Suminarti *et al*., 2016; Sikder *et al*., 2014). Suitable plant spacing can lead to optimum yield whereas too high or too low plant spacing could result in relatively low yield and quality. Application of fertilizer has great impact on growth and yield of crop plants. The requirement of fertilizer for any crop varies with cultivars, plant population and soil type in AEZs (Mitra *et al*., 1990). The tendency of the Bangladeshi farmers is to use closer spacing and high amount of nitrogenous fertilizer because they think that more the plant population with vigorus vegetative growth due to N fertilization and more the yield of mukhikachu. Mukhikachu requires a high dose of nitrogen and potassium (Rashid, 1999; Bose and Som, 1986; Mohankumar *et al*., 1991) because nitrogen is essential for growth and potassium for starch formation and potassium exerts a blanching effect on both N and P and consequently important in mixed fertilizer. Potassium is very important for tuber formation because it is known to be essential for the synthesis and translocation of carbohydrate (Bose and Som, 1986). The present experiment was therefore, carried out to find out suitable plant spacing and optimum fertilizer dose for higher yield and maximum economic return in different AEZs.

Materials and Method

Field experiments were carried out in the Agronomy field of BARI, Joydebpur, Regional Agricultural Research Station (RARS), Jamalpur and RARS, Ishurdi of BARI during two consecutive *Kharif* seasons of 2012 and 2013. In 2012, during experimentation the average temperature of Gazipur, Ishurdi and Jamalpur was 29.04^{o}C, 27.30^{o}C and 24.22^{o}C, respectively whereas, in 2013 that were 28.60^{o}C, 28.25^{o}C and 28.60^{o}C, respectively. In 2012, the total rainfall of Gazipur, Ishurdi and Jamalpur was 1104.80, 948.89 and 1552.30 mm, respectively, while in 2013, the total rainfall of Gazipur, Ishurdi and Jamalpur was 1583.60, 1172.72 and 1453.75 mm, respectively. The initial soil analyses of Joydebpur, Ishurdi and Jamalpur are given in Table 1. At all locations the status of total N was very low and P was below critical level. At Ishurdi and Jamalpur, the amount of K was below the critical level whereas at Joydebpur the status of K was just above the critical level. At all locations the amount of S was just above the critical level. Three levels of spacing i.e. S_1= 60 cm x 60 cm, S_2= 60 cm x 45 cm and S_3= 60 cm x 30 cm and three levels of fertilizer dose i.e. F_1= recommended dose (3000-96-27-81-18 kg ha^{-1} of CD-N-P-K-S, FRG, 2005), F_2= 25 % less than the recommended dose and F_3= 25% higher than the recommended dose were used as treatment variables in the present study.

The experiments were conducted in a factorial randomized complete block design with three replications. The unit plot size was 3.6 m x 3.6 m. The variety used in the experiment was ‘Bilashi’. The crop was fertilized with as per treatment.

Table 1. The initial soil analyses of Joydebpur, Ishurdi and Jamalpur before experimentation

Location	PH	OM (%)	Total N %	P (ppm)	K (meq./ 100 g soil)	S (ppm)
Joydebpur	6.25	0.62	0.10	8.64	0.23	17.30
Ishurdi	7.3	1.32	0.053	11	0.12	15
Jamalpur	5.6	1.79	0.094	5.60	0.10	17.0
Critical level	-	-	-	14	0.2	14

The entire amount of phosphorous (P), potassium (K) and sulphur (S) was applied as basal. N was applied at 15-20 and 40-45 days after planting. Cormel was planted in line. In the first year (2012), seed cormels of mukhikachu were planted on 11 March at Jamalpur, 12 March at Joydebpur and 30 March at Ishurdi and harvested on 12 December at Jamalpur, 30 August at Joydebpur and 9 December at Ishurdi and in the second year (2013), seed cormels of mukhikachu were planted on 23 March at Jamalpur, 21 March at Joydebpur and 16 March at Ishurdi and harvested at 4 November at Jamalpur, 30 October at Joydebpur and 28 November at Ishurdi. Intercultural operations were done as and when required. Ten plants were randomly selected from each plot for recording yield contributing characters. The yield data was recorded from an area of 12.96 m^2 in each plot and per hectare yield was calculated. Secondary corms and cormels were considered to calculate yield data which were mentioned as edible yield. All the collected data were analyzed statistically and mean separation was done by the Least Significant Difference (LSD) at 5% level of probability (Gomez and Gomez, 1984).

Results and Discussion

Number of secondary corms plant^{-1}: Different spacing in combination with fertilizer showed significant effect on number of secondary corms plant^{-1} at all locations except Jamalpur (Tables 2, 3 & 4). At Joydebpur number of corms plant^{-1} in different treatments were found identical in 2012 while that varied significantly in 2013 (Table 2). In 2012, number of corms plant^{-1} ranged from 4.07 (S_3F_2) to 5.13 (S_2F_3). In 2013, the highest number of corms plant^{-1} recorded in S_1F_1 (5.13) which was significantly higher than S_2F_2 but statistically similar with all other treatments. The lowest number of corms plant^{-1} was obtained from S_2F_2 (3.53) combination. At Jamalpur, number of corms plant^{-1} was not significantly varied in different treatments (Table 3). However, number of corms plant^{-1} ranged from 3.40 (S_1F_2) to 5.40 (S_1F_1) in 2012 and in 2013, number of corms plant^{-1} ranged from 6.0 (S_1F_2) to 8.13 (S_1F_1). At Ishurdi, number of corms plant^{-1} varied significantly in different treatments during both the years (2012 & 2013) (Table 4). In 2012, the highest number of corms plant^{-1} was recorded in

S_1F_3 (5.20) which were identical to all other treatments except S_3F_2. The lowest number of secondary corms plant^{-1} was obtained from S_3F_2 (3.70) combination. In 2013, the highest number of corms plant^{-1} was recorded in S_1F_3 (5.86) which was closely followed by all other treatments except S_3F_1 and S_3F_2. The lowest number of secondary corms plant^{-1} was obtained from S_3F_2 combination in both the years. Suminarti *et al.* (2016) reported that application of 125 kg N ha^{-1} and 62 kg K ha^{-1} gave the highest yield of mukhikachu (16.45 t/ha) and number of corms plant^{-1} decreased with the increase of plant population.

Weight of secondary corms plant^{-1} (g): Combination of spacing and fertilizer put significant effect on weight of secondary corms plant^{-1} at all the locations (Tables 2, 3 & 4). At Joydebpur, different treatments did not differ significantly in respect of weight of secondary corms plant^{-1} in 2012 while that varied significantly in 2013 (Table 2). In 2012, weight of secondary corms plant^{-1} ranged from 233.30 g (S_3F_1) to 274 g (S_1F_3) in different treatments. In 2013, the maximum weight of secondary corms plant^{-1} was recorded in S_1F_3 (232.90 g) which was closely followed by S_1F_1, S_1F_2, S_2F_1 and S_2F_3. The lowest weight of secondary corms plant^{-1} was obtained from S_3F_1 (198.30 g) combination in 2013. At Jamalpur, weight of secondary corms plant^{-1} varied significantly in different treatments during both the years (2012 & 2013) (Table 3). In 2012, the maximum weight of secondary corms plant^{-1} was recorded in S_1F_3 (393.30 g) closely followed by S_1F_1 and S_2F_3 and the lowest weight of secondary corms plant^{-1} was obtained from S_3F_1 (206.70 g) treatment. In 2013, the highest weight of secondary corms plant^{-1} was recorded in S_1F_3 (456.60 g) which was statistically similar with S_1F_2 and S_2F_1 combinations and the lowest weight of secondary corms plant^{-1} was obtained from S_3F_1 (246.60 g) combination. At Ishurdi, different combinations had significant effect on weight of secondary corms plant^{-1} in both the years (2012 & 2013) (Table 4). In 2012, the highest weight of secondary corms plant^{-1} was recorded in S_1F_3 (135.50 g) which was identical with S_2F_3. The lowest weight of secondary corms plant^{-1} was obtained from S_3F_2 (95 g) combination. In 2013, the highest weight of secondary corms plant^{-1} was recorded in S_1F_3 (155.72 g) which was identical with S_2F_3 and the lowest weight of secondary corms plant^{-1} was obtained in S_3F_2 (115.24 g) treatment. Weight of corms plant^{-1} increased at wider spacing might be due to less competition for nutrients, moisture and light among the plants. Suminarti *et al.* (2016) obtained the highest yield of corms and cormels plant^{-1} from 60 cm x 40 cm spacing. Sikder *et al*. (2014) also got the maximum and minimum individual corm from 60 cm x 50 cm and 60 x 20 cm spacing, respectively.

Number of cormels plant^{-1}: Different spacing coupled with fertilizer treatment showed significant effect on number of cormels plant^{-1} at all locations (Tables 2, 3 & 4). At Joydebpur, number of cormels plant^{-1} was found identical in different treatments in 2012 while that varied significantly in 2013 (Table 2). In 2012,

number of cormels plant^{-1} ranged from 24.53 (S_3F_2) to 28.4 (S_1F_3) while in 2013, the highest number of cormels plant^{-1} was recorded in S_3F_1 (14.93) which was statistically similar with all other treatments except S_3F_2 and the lowest number of cormels plant^{-1} was obtained from S_3F_2 (10.07) treatment in 2013. At Jamalpur, number of cormels plant^{-1} was found identical in different treatments in 2012 while that varied significantly in 2013 (Table 3). In 2012, number of cormels plant^{-1} ranged from 6.60 (S_3F_2) to 9.90 (S_2F_1) but in 2013, the highest number of cormels plant^{-1} was recorded in S_1F_1 (17.80) and the lowest number of cormels plant^{-1} was obtained from S_3F_2 (9.50) treatment. At Ishurdi, different treatments varied significantly in terms of number of cormels plant^{-1} in both the years (2012 & 2013) (Table 4). In 2012, the highest number of cormels plant^{-1} was recorded in S_1F_3 (16.88) which was statistically similar with S_1F_1 and the lowest number of cormels plant^{-1} was obtained from S_3F_2 (13.90) treatment. In 2013, the highest number of cormels plant^{-1} was recorded in S_1F_3 (17.46) which was identical with S_1F_1 and the lowest weight of number of cormels plant^{-1} was obtained from S_3F_2 (14.48) treatment.

Weight of cormels plant^{-1}: Different spacing in combination with fertilizer treatments exerts significant effect on weight of cormels plant^{-1} at all locations (Tables 2, 3 & 4). At Joydebpur, weight of cormels plant^{-1} varied significantly in 2012 while did not vary significantly in 2013 (Table 2). In 2012, the highest weight of cormels plant^{-1} was recorded in S_1F_3 (594 g) which was statistically similar with S_2F_1 and S_2F_2 treatments and the lowest weight of cormels plant^{-1} was obtained from S_2F_2 (534 g) treatment. In 2013, weight of cormels plant^{-1} ranged from 400.50 g (S_2F_2) to 445.50 g (S_1F_3). At Jamalpur, weight of cormels plant^{-1} varied statistically due to different treatments in both years (2012 & 2013) (Table 3). In 2012, the maximum weight of cormels plant^{-1} was recorded in S_2F_1 (124.70 g) which was statistically similar with S_1F_1 and S_1F_3 and the lowest weight of cormels plant^{-1} was obtained from S_3F_2 (64 g) treatment. In 2013, the highest weight of cormels plant^{-1} was recorded in S_2F_1 (200 g) which was statistically similar with the S_1F_2 and the lowest weight of number of cormels plant^{-1} was obtained from S_3F_2 (83.3 g) treatment. At Ishurdi, weight of cormels plant^{-1} in different treatments varied significantly in both the years (2012 & 2013) (Table 4). In 2012, the maximum weight of cormels plant^{-1} was recorded in S_1F_3 (245 g) which was statistically similar with the treatment of S_2F_3 and the lowest weight of cormels plant^{-1} was obtained from S_3F_2 (187.50 g) treatment. In 2013, the highest weight of cormels plant^{-1} was recorded in S_1F_3 (268.47 g) which was identical with S_2F_3 and the lowest weight of cormels plant^{-1} was obtained from S_3F_2 (210.97 g) treatment. The results revealed that wider spacing (60 cm x 60 cm) gave the maximum weight of cormels plant^{-1}and closer spacing (60 cm x 30 cm) gave the lowest weight. This is in agreement with the results of Mannan *et al.* (1988) and Dhar (1989).

Table 2. Combined effect of spacing and fertilizer on yield contributing characters of mukhikachu at Joydebpur in *kharif* 2012 and 2013

Treatment	No. of secondary corms plant^{-1}		Weight of secondary corms plant^{-1}(g)		No. of cormels plant^{-1}		Weight of cormels plant^{-1} (g)	
	2012	2013	2012	2013	2012	2013	2012	2013
S_1F_1	4.50	5.13	270.6	230.1	27.80	13.53	576.6	432.5
S_1F_2	4.47	3.80	259.3	220.4	28.07	13.07	585.3	439.0
S_1F_3	4.80	3.60	274.0	232.9	28.40	12.20	594.0	445.5
S_2F_1	4.80	3.87	244.6	208.0	26.27	13.27	540.0	405.0
S_2F_2	4.43	3.53	242.6	206.3	25.67	12.47	534.0	400.5
S_2F_3	5.13	4.13	256.0	217.6	26.73	14.60	547.0	410.3
S_3F_1	5.00	3.73	233.3	198.3	24.80	14.93	593.3	445.0
S_3F_2	4.07	4.00	234.6	199.5	24.53	10.07	574.6	431.0
S_3F_3	4.73	4.00	240.6	204.6	26.67	13	572.0	429.0
LSD (0.05)	NS	1.54	NS	25.27	NS	2.98	48.46	NS
CV (%)	8.90	9.91	7.2	8.2	5.80	5.90	10.9	5.12

S_1=60 cm x 60 cm, S_2=60 cm x 45 cm, S_3= 60 cm x 30 cm, F_1 = Recommended fertilizer dose (3000-97-27-81-18 kg ha^{-1} of CD- NPKS), F_2 = 25% less than recommended dose and F_3 = 25% higher than recommended dose

Table 3. Combined effect of spacing and fertilizer on yield contributing characters of mukhikachu at Jamalpur in *kharif* 2012 and 2013

Treatment	No. of secondary Corms plant^{-1}		Weight of secondary Corms plant^{-1} (g)		No. of cormels plant^{-1}		Weight of cormel plant^{-1} (g)	
	2012	2013	2012	2013	2012	2013	2012	2013
S_1F_1	5.40	8.13	353.30	373.3	8.50	17.80	123.30	106.60
S_1F_2	3.40	6.00	246.70	453.3	7.13	11.50	67.30	193.30
S_1F_3	4.33	6.93	393.30	456.6	8.90	13.90	118	163.30
S_2F_1	4.60	8.00	320.0	426.6	9.90	14.90	124.70	200
S_2F_2	3.60	6.93	330.0	316.6	7.30	12.40	75.30	120
S_2F_3	5.13	7.70	386.70	356.6	7.50	10.90	77.30	118
S_3F_1	4.0	6.10	206.70	246.6	7.50	9.90	91.30	103.30
S_3F_2	4.80	6.66	290.0	336.6	6.60	9.50	64.0	83.30
S_3F_3	4.20	6.63	300.0	333.3	6.90	10.40	78	116.60
LSD (0.05)	NS	NS	56.90	53.3	NS	2.18	22.70	28.30
CV (%)	8.01	12.40	10.20	8.24	12.20	0.94	14.0	11.87

S_1=60 cm x 60 cm, S_2=60 cm x 45 cm, S_3= 60 cm x 30 cm, F_1 = Recommended fertilizer dose (3000-97-27-81-18 kg ha^{-1} of CD- N-P-K-S), F_2 = 25% less than recommended dose and F_3 = 25% higher than recommended dose

Table 4. Combined effect of spacing and fertilizer on yield contributing characters of mukhikachu at Ishurdi in *kharif* 2012 and 2013

Treatment	No. of Secondary corms plant^{-1}		Weight of secondary corms plant^{-1} (g)		No. of cormels plant^{-1}		Weight of cormels plant^{-1} (g)	
	2012	2013	2012	2013	2012	2013	2012	2013
S_1F_1	5.10	5.75	123.50	143.73	15.70	16.27	230.50	253.96
S_1F_2	4.80	5.45	119.50	139.72	14.80	15.37	212.00	235.47
S_1F_3	5.20	5.86	135.50	155.72	16.88	17.46	245.00	268.47
S_2F_1	4.80	5.45	115.50	135.71	14.90	15.48	219.50	242.99
S_2F_2	4.70	5.35	110.50	130.74	14.76	15.34	209.00	232.49
S_2F_3	5.0	5.65	135.00	155.21	15.10	15.68	236.00	259.46
S_3F_1	5.0	5.31	111.00	130.72	14.00	14.88	212.80	236.29
S_3F_2	3.70	4.35	95.00	115.24	13.90	14.48	187.50	210.97
S_3F_3	4.90	5.56	112.00	132.22	14.70	15.30	223.00	246.48
LSD (0.05)	0.55	0.54	6.50	1.84	1.49	1.50	13.60	13.61
CV (%)	6.63	5.80	3.20	2.73	5.72	5.54	3.50	3.24

S_1=60 cm x 60 cm, S_2=60 cm x 45 cm, S_3= 60 cm x 30 cm, F_1 = Recommended fertilizer dose (3000-97-27-81-18 kg ha^{-1} of CD-N-P-K-S), F_2 = 25% less than recommended dose and F_3 = 25% higher than recommended dose

Edible yield of mukhikachu

The combination of spacing and fertilizer treatments put significant effect on edible yield of mukhikachu at all locations (Table 5). At Joydebpur, different treatments varied significantly in respect of edible yield in both the years (2012 & 2013). In 2012, the maximum edible yield was recorded in S_3F_3 (19.87 t ha^{-1}) closely followed by S_3F_1 (16.23 t ha^{-1}) and the lowest edible yield was obtained in S_1F_2 (14.94 t ha^{-1}) treatment. In 2013, the highest edible yield was recorded in S_3F_3 (20.21 t ha^{-1}) which was identical with S_3F_1 (19.92 t ha^{-1}) and the lowest edible yield was obtained from S_1F_2 (9.54 t ha^{-1}) treatment. Maximum edible yield (two years average) was obtained from S_3F_3 (20.04 t ha^{-1}) closely followed by S_3F_1 (19.58 t ha^{-1}) and the lowest (average of two years) from S_1F_2 (12.24 t ha^{-1}) treatment. At Jamalpur, the highest edible yield was recorded in S_3F_3 (21.60 t ha^{-1} in 2012 and 19.90 t ha^{-1} in 2013) which was identical with the treatments S_2F_2, S_3F_1 and S_3F_2 in 2012 and S_3F_1 and S_3F_2 in 2013. The lowest edible yield was obtained from S_1F_2 treatment (11.80 t ha^{-1} in 2012 and 15.30 t ha^{-1} in 2013). From the two years average data, it was revealed that the maximum edible yield was recorded in S_3F_3 (20.75 t ha^{-1}) closely followed by S_3F_2 (19.05 tha^{-1}) and the lowest was found in S_1F_2 (14.30 t ha^{-1}) treatment. At Ishurdi location, the highest

edible yield was found in S_3F_3 (15.94 and 17.32 tha^{-1} in 2012 and 2013, respectively) closely followed by S_2F_3 and S_3F_1 treatments. The lowest edible yield was obtained from S_1F_2 (12.09 t ha^{-1} in 2012 and 13.47 t ha^{-1} in 2013). On the basis of two years average data, the maximum edible yield was recorded in S_3F_3 (16.63 t ha^{-1}) which was identical with S_3F_1 (16.49 t ha^{-1}) and the lowest was found in S_1F_2 (12.78 t ha^{-1}) treatment. As the soil nutrient content of Jamalpur was comparatively poor compared to Joydepur and Ishurdi (Table 1), it required 25% higher than the recommended dose for maximum yield of mukhikachu. Edible yield increased at closer spacing over wider spacing may solely be ascribed on the function of the highest plant density per unit area of land.

Table 5. Combined effect of spacing and fertilizer on edible yield of mukhikachu at Joydebpur, Jamalpur and Ishurdi locations

Treatment	Edible yield (t ha^{-1})								
	Joydebpur			Jamalpur			Ishurdi		
	2012	2013	Average	2012	2013	Average	2012	2013	Average
S_1F_1	15.30	11.52	13.41	15.90	15.30	15.60	13.13	14.52	13.83
S_1F_2	14.94	9.54	12.24	11.80	16.80	14.30	12.09	13.47	12.78
S_1F_3	15.25	11.43	13.34	14.20	15.70	14.95	13.42	14.81	14.12
S_2F_1	17.23	11.51	14.37	15.40	17.10	16.25	14.29	15.67	14.98
S_2F_2	15.20	10.62	12.91	19.00	15.40	17.20	12.76	14.14	13.45
S_2F_3	16.82	14.41	15.62	17.60	15.60	16.60	14.88	16.25	15.57
S_3F_1	19.23	19.92	19.58	19.90	17.60	18.75	15.80	17.18	16.49
S_3F_2	18.49	13.32	15.91	19.20	18.90	19.05	14.08	15.47	14.78
S_3F_3	19.87	20.21	20.04	21.60	19.90	20.75	15.94	17.32	16.63
LSD (0.05)	0.90	1.34	1.21	2.77	2.91	1.82	1.67	1.66	1.32
CV (%)	3.10	10.12	11.20	9.08	7.79	10.15	6.85	6.23	9.56

S_1=60 cm x 60 cm, S_2=60 cm x 45 cm, S_3= 60 cm x 30 cm, F_1 = Recommended fertilizer dose (3000-97-27-81-18 kg ha^{-1} of CD-N-P-K-S), F_2 = 25% less than recommended dose and F_3 = 25% higher than recommended dose

It revealed that at all three locations, the maximum edible yield were recorded in S_3F_3 treatment. Imran *et al.* (2010) obtained the maximum yield of cormels (37.29 t ha^{-1}) by fertilizing Compost, Urea, TSP and MoP @ 15000, 62.5, 62.5 and 50 kg ha^{-1}. Gill *et al.* (2005) got the highest yield of mukhikachu at closer spacing than at wider spacing. This is also in agreement with the findings of Basak *et al.* (1999) who evaluated multi location trial of *Colocasia esculenta* under different spacing and fertilizer level and found that per plant yield was higher in wider spacing but total yield was higher in the closer spacing. Atiquzzanman (2008) obtained the maximum yield of corms and cormel (edible

yield) (20.24 t ha^{-1}) at 60 x 25 cm spacing whereas Sikder (2014) got maximum yield (31.8 t ha^{-1} from 60cm x 40 cm spacing. Oglbonna *et al.* (2015) stated that closest spacing gave the highest yield of taro.

Table 6. Economic analysis of mukhikachu under variable spacing and fertilizer management at different locations (two years average)

Treatment	Gross return (Tk ha^{-1})			Cultivation cost (Tk ha^{-1})			Benefit Cost Ratio		
	Joydebpur	Ishurdi	Jamalpur	Joydebpur	Ishurdi	Jamalpur	Joydebpur	Ishurdi	Jamalpur
S_1F_1	201150	207375	234000	92364	68465	88456	2.18	3.03	2.64
S_1F_2	183600	191700	214500	89780	65337	86314	2.05	2.94	2.48
S_1F_3	200100	211725	224250	94940	71594	91594	2.11	2.96	2.45
S_2F_1	215550	224700	243750	96864	70465	92031	2.23	3.19	2.65
S_2F_2	193650	201750	258000	94280	67337	88889	2.06	3.00	2.90
S_2F_3	234225	233475	249000	99440	73594	95169	2.36	3.17	2.62
S_3F_1	293625	247350	281250	100204	72465	94268	2.93	3.42	2.98
S_3F_2	238575	221625	285750	99780	69337	94014	2.39	3.20	3.03
S_3F_3	300600	249450	311250	104940	75594	99794	2.69	3.30	3.12

S_1=60 cm x 60 cm, S_2=60 cm x 45 cm, S^3= 60 cm x 30 cm, F_1 = Recommended fertilizer dose (3000-97-27-81-18 kg ha^{-1} of CD-N-P-K-S) , F_2 = 25% less than recommended dose and F_3 = 25% higher than recommended dose and Produce price = Tk. 15 kg^{-1}

Economic analysis

The maximum gross return was found in 25% higher than the recommended fertilizer dose (96-27-81-18 kg ha^{-1} of NPKS) with 60 cm x 30 cm spacing (Tk. 300600, Tk. 249450 and Tk. 311250 at Joydebpur, Ishurdi and Jamalpur, respectively) and the lowest gross return was found in 25% less than the recommended dose with 60 cm x 45 cm spacing (Tk. 201150, Tk. 207375 and Tk. 234000 at Joydebpur, Ishurdi and Jamalpur, respectively) (Table 6). The highest cultivation cost was found in 25% higher than the recommended dose with 60 cm x 30 cm spacing (Tk. 104940, Tk. 75594 and Tk. 99794 at Joydebpur, Ishurdi and Jamalpur, respectively) and the lowest cultivation cost was found in 25% less than the recommended dose with 60 cm x 45 cm spacing (Tk. 89780, Tk. 65337 and Tk. 86314 at Joydebpur, Ishurdi and Jamalpur, respectively). The maximum benefit-cost ratio was recorded from the

recommended fertilizer dose with 60 cm x 30 cm spacing at Joydebpur (2.93) and Ishurdi (3.42), while at Jamalpur the maximum benefit-cost ratio was observed from 25% higher than the recommended fertilizer dose with 60 cm x 30 cm spacing (3.12).

Conclusion

The results of the experiment led to the conclusion that the farmers of Jodebpur and Ishurdi region might be suggested to use the recommended fertilizer dose of 3000-96-27-81-18 kg ha^{-1} of CD-N-P-K-S in combination with 60 cm x 30 cm spacing while the farmers of Jamalpur region suggested to cultivate mukhikachu by using 25% higher than the recommended fertilizer dose at 60 cm x 30 cm spacing.

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