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PERFORMANCES OF DIFFERENT HYBRID MAIZE *(Zea mays* L.) VARIETIES UNDER INTERCROPPING SYSTEMS WITH GROUNDNUT *(Arachis hypogaea* L.)

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Abstract

The experiment was carried out at Regional Agricultural Research Station, Bangladesh Agricultural Research Institute (BARI), Jessore to evaluate the performance of different varieties of hybrid maize under intercropping systems with groundnut in *rabi* seasons to find out the suitable intercropping system in increasing crop productivity and profitability of consecutive two years (2004 and 2005). Four sole crops of hybrid maize varieties (BHM-1, BHM-3, Pacific-11 and Pacific-984), one sole crop of groundnut (var. Jhingabadam) and eight intercropping systems of maize + groundnut under two planting methods viz., normal and paired row made 13 treatments were used. Treatments were arranged in a randomized complete block design with four replications. Among the intercropped treatments, four rows groundnut in between paired rows of hybrid maize var. Pacific-11 showed higher maize equivalent yield (13.56 t/ha in 2003-04 and 15.34 t/ha in 2004-05), groundnut equivalent yield (4.34 t/ha in 2003-04 and 4.91 t/ha in 2004-05), land equivalent ratio (1.54 in 2003-04 and 1.66 in 2004-05) as compared to other treatments.

Kew Words : Hybrid maize varieties, intercropping systems, groundnut.

Introduction

Maize *(Zea mays* L.) is one of the important cereal crops in the world. It has a good potential as a cereal crop side by side with rice and wheat in Bangladesh. As food, it can be consumed directly as green cob, roasted cob or popped grain. Its grain can be used as corn meal, fried grain and flour. It is the highest yielding grain crop having multiple uses, such as food, feed and fodder for human, poultry and livestock, respectively. In Bangladesh, the condition of maize has been gaining popularity in recent years. It is now becoming an important cereal crop for its high productivity and diversity. Maize area, production and demands are changing rapidly. In 1992-93, the area, production and yields were 2834 ha, 3000 metric tons and 1.06 t/ha, respectively (BBS, 2002). By 2004-2005, the area increased 24 times (66,802 ha), production 119 times (356000 metric tons) and yield more than *5* times (BBS, 2005). An estimate shows that at the present rate of consumption, the country would need more than one million tons of maize by

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2012 (Mian *et al.,* 2001). The agro-climatic condition of Bangladesh is favourable for its cultivation round the year. However, the average yield of maize in the country is considerably low. The national average yield is only 5.33 t/ha (BBS, 2005), whereas the newly released varieties have the potential to produce more than 8.0 t/ha. For fulfillment of the requirement of maize in Bangladesh, Bangladesh Agricultural Research Institute (BARI) has already released hybrid maize varieties, such as BHM-1, BHM-2 and BHM-3, which are higher yielder with yield potential of about 9-10 t/ha.

Groundnut *(Arachis hypogaea* L.) is the third most important legume crop in Bangladesh which is grown on 27073 ha with a production of 34240 metric tons in 2002-2003 (BBS, 2005). It is used as edible oil, to make cake, biscuit and bakery in the food industries. Recently the area of groundnut is being decreased due to the competition with *rabi* crops like wheat, potato, *boro* rice and mustard (Biswas *et al.,* 1997). Moreover, most of the char areas of Bangladesh become inundated in the *kharf* season which causes the decline of groundnut area. In *kharf* season, only some high lands are used for groundnut cultivation.

The temporal way of increasing food production includes adoption of modern varieties, practicing of improved cultural techniques and following the appropriate cropping systems. Intercropping system is one of the important approach of cropping systems, emerged as an important tool for increasing crop production. Better intercrop production could be achieved with the choice of appropriate crops (Santalla *et al.,* 2001), population density and planting geometry of component species/crops (Myaka, 1995). Combination of groundnut (Jhinghabadam) and hybrid maize in intercropping systems may increase the production and fulfill the demand for maize and groundnut. In this context, the experiment was conducted to find out the performances of different varieties of hybrid maize under intercropping systems with groundnut for higher productivity and profitability.

Materials and Method

The experiment was conducted at the Regional Agricultural Research Station, Bangladesh Agricultural Research Institute (BARI), Jessore during two consecutive *rabi* seasons of 2003-04 and 2004-05. The soil of the experimental site was silty clay loam having pH 7.2. There were 13 treatments of which 4 sole crops of hybrid maize viz. var. BHM-1, BHM-3, Pacific-11, and Pacific-984, one sole crop of groundnut viz. var. Jhingabadam and 8 intercropping systems of maize + groundnut under two planting systems viz., normal and paired row. The treatments were as follows:

T_1 = Two rows of groundnut in between normal rows of hybrid maize (var. BHM-1)

T_2 = Two rows of groundnut in between normal rows of hybrid maize (var. BHM-3)
T_3 = Two rows of groundnut in between normal rows of hybrid maize (var. Pacific-11)
T_4= Two rows of groundnut in between normal rows of hybrid maize (var. Pacific-984)
T_5= Four rows of groundnut in between paired rows of hybrid maize (var. BHM-1)
T_6 = Four rows of groundnut in between paired rows of hybrid maize (var. BHM-3)
T_7 = Four rows of groundnut in between paired rows of hybrid maize (var. Pacific-11)
T_8 = Four rows of groundnut in between paired rows of hybrid maize (var. Pacific-984)
T_9 = Sole hybrid maize (var. BHM-1)
T_{10}= Sole hybrid maize (var. BHM-3)
T_{11} = Sole hybrid maize (var. Pacific-11)
T_{12} = Sole hybrid maize (var. Pacific-984)
T_{13} = Sole groundnut (var. Jhingabadam).

The experiment was laid out in a randomized complete block design with four replications. The unit plot size was 4.5m × 6.0 m. Maize was sown in 75 cm apart rows with 25 cm between the plants both in sole (T_9, T_{10}, T_{11} and T_{12}) and intercrop situation in normal row of maize (T_1, T_2, T_3 and T_4). On the other hand, maize was sown in paired 37.5 cm apart rows and 150 cm between two pairs with 25 cm between the plants (T_5, T_6, T_7 and T_8). The spacing maintained for sole groundnut was 30 cm × 10 cm. In case of intercrop situation, the population density of maize remained same as that of sole plot of maize, but it varied for groundnut. Germination of the seeds of both the crops was 95 percent in both the years. Sowing of both the crops was done on 13 November in 2003 and 2004. Fertilizer was applied for maize at the rate of 250-120-120-40-5 and 2 kg of N, P_20_5, K_20, S, Zn and B/ha, respectively, from urea, triple superphosphate, muriate of potash, gypsum, zinc sulphate and boric acid, respectively. Half amount of N and full dose of other fertilizers were incorporated into the soil at the time of final land preparation. The remaining urea was top dressed in two equal installments at 35 and 65 days after sowing. For groundnut sole crop, fertilizer was applied at the rate of 12-32-43-31-4-2 kg of N, P_20_5, K_20, S, Zn and B/ha, respectively, from urea, TSP, MP, gypsum, zinc sulphate and boric acid. Half amount of urea and full amount of other fertilizers were applied at the time of final land preparation. Additional fertilizers were not applied for groundnut in intercrop situation. Remaining Urea was top dressed as band placement in maize rows only. Three irrigations were applied at 30, 60 and 90 days after sowing. Mulching and hand weedings were done as and when necessary to keep the field

reasonably weed free. Dasban was sprayed at 20-day intervals as precautionary measure against insects attack. Dithane M-45 was sprayed at 15-day intervals at the later stages of groundnut as precautionary measure from prevalence of tikka disease. An effective area of 3.0 m × 4.5 m was harvested from each plot. Grain, pod and straw yields at harvest were converted into t/ha after proper drying.

Maize was harvested at physiological maturity at 15% grain moisture content, threshed and winnowed to determine the grain yield. Ten maize plants were selected randomly for recording data on yield attributes. Groundnut was also harvested at physiological maturity, threshed and dried properly to determine the pod yield. Ten groundnut plants were selected randomly for the yield components. Harvest index was calculated as per following equation:

$$\text{HI (\%)} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

Yield of individual crop was converted into equivalent yield on the basis of the prevailing market price of individual crop (Bandyopadhyay, 1984).

Maize equivalent yield = Ysm + (Yig × Pg)/Pm
Groundnut equivalent yield = Ysg + (Yim × Pm)/Pg

Where,

Ysm = Yield of sole maize (t/ha)
Ysg = Yield of sole groundnut (t/ha)
Yim = Yield of intercrop maize (t/ha)
Yig = Yield of intercrop groundnut (t/ha)
Pm = Selling price of maize
Pg = Selling price of groundnut.

In intercropping systems, relative yield is quantified by (Jokinen, 1991).

RY of maize (RYm) : (Yim/Ysm)
RY of groundnut (RYg) : (Yig/Ysg)
Relative yield total (RYT) : RYm + RYg

Where,

Ysm = Yield of sole maize
Yim = Yield of intercrop maize
Ysg = Yield of sole groundnut
Yig Yield of intercrop groundnut

LER was calculated (Mead and Willey, 1980) according to the following formula

$$\text{LER} = \frac{\text{Yim}}{\text{Ym}} + \frac{\text{Yig}}{\text{Yg}}$$

Where,

Yim = Yield of intercrop maize
Ym = Yield of sole maize
Yig = Yield of intercrop groundnut
Yg = Yield of sole groundnut

Table 1. Grain yield, yield components and harvest index of different varieties of hybrid maize in maize+groundnut intercropping systems in 2003-04 and 2004-05.

Treatment	Cobs/ plant (no.)	Cob length (cm)	Cob[1] diameter (cm)	Grains/ cob (no.)	100-grain wt (g)	Grain yield (t/ha)	Harvest index (%)
	2003-04						
T_1	1.16 b	18.03 cd	4.63 b	460 c	289.50 ef	7.98 bc	50
T_2	1.13 be	17.90 cd	4.65 b	504 bc	302.48cde	8.28 be	43
T_3	1.16 b	17.40 d	4.85 ab	477 be	321.68 a	9.05 ab	50
T_4	1.03d	19.40ab	4.70ab	561a	303.l0cd	8.83ab	47
T_5	1.16 b	17.85 cd	4.60 b	460c	287.95 f	7.62 c	50
T_6	1.13 bc	18.45 bcd	4.64 b	501 bc	299.40cdef	8.13 bc	45
T_7	1.l8ab	17.45d	4.83ab	473bc	316.85ab	8.97ab	50
T_8	1.03 d	19.25 ab	4.65 b	560a	301.93 cde	8.53 abc	49
T_9	1.l8ab	18.58 abc	4.68ab	482bc	292.33 def	8.15 be	49
T_{10}	1.l8ab	18.80 abc	4.78ab	512b	303.38cd	8.61 abc	43
T_{11}	1.26 a	18.00 ed	4.93 a	480 bc	327.85 a	9.39 a	49
T_{12}	1.04 cd	19.53 a	4.85 ab	566a	307.00 bc	8.99 ab	47
F-test	**	**	**	**	**	**	-
CV(%)	3.74	2.63	2.57	4.11	2.07	5.84	-
	2004-05						
T_1	1.l8abc	17.43de	4.74c	477e	351.87ab	9.42cd	50
T_2	1.l4abc	19.30abc	4.79bc	514c	362.62ab	10.28abc	46
T_3	1.24a	17.57de	5.03ab	508c	378.00a	10.89a	50
T_4	1.03c	20.30a	4.98abc	579ab	373.l9ab	10.82a	48
T_5	1.l8abc	17.17e	4.71c	476c	348.40b	8.57d	50
T_6	1.l4abc	19.36abc	4.86abc	510c	358.22ab	10.l8abc	46
T_7	1.24a	17.37de	5.lla	505c	374.65ab	10.68ab	50
T_8	1.03c	20.37a	4.99abc	577ab	371.99ab	10.62abc	50
T_9	1.20ab	18.73bcd	4.77bc	497c	357.l5ab	9.47bcd	50
T_{10}	1.l7abc	19.79ab	4.93abc	521bc	64.48ab	10.57abc	46
T_{11}	1.26a	18.l3cde	5.13a	510c	379.75a	1l.31a	50
T_{12}	1.05bc	20.40a	5.00abc	592a	373.42ab	11.28a	48
F-test	**	**	**	**	**	**	-
CV(%)	5.41	2.91	2.22	4.90	2.87	4.60	-

Mean values in a column having the dissimilar letter/letters indicate significant differences at 0.05 (*) and 0.01 (**) levels of significance (DMRT)

The data recorded for different characters were compiled and tabulated *in* proper way for statistical analysis. Data were statistically analyzed using Analysis of Variance technique with the help of computer package MSTAT-C and Duncan Multiple Range test was used to determine the significant differences among the treatment means.

Results and Discussion

Maize : All yield and yield attributes of hybrid maize were significantly influenced by maize + groundnut intercropping systems in both the years (Table 1). Grain yield of maize showed almost similar pattern to its yield contributing characters observed in sole and at different intercropping systems. Higher grain yield was observed in T_{11} (sole maize var. Pacific-11), which was at par with T_3, T_4, T_7, T_8, T_{10} and T_{12} in 2003-04 and T_2, T_3, T_4, T_6 T_7, T_8, T_{10} and T_{12} in 2004-05. It showed that Pacific-II variety of hybrid maize was higher yielder in monoculture (T_{11}**)** and its respective intercrops which occurred due to more number of cobs/plant and higher 1000-grain weight and cumulative effect of yield attributes. Lower yield was obtained from T_5 which was statistically identical with T_1, T_2, T_6, T_8, T_9 and T_{10} in 2003-04 and T_1 and T_9 in 2004-05. It was noted that BARI Hybrid Maize-1 (BHM-1) was lower yielder in monoculture (T_9) and its respective intercrops (T_1 and T_5) compared to the other varieties tested in the experiment. The lower grain yield might be due to lower yield attributes. Higher yield of maize was observed in monoculture compared to their yield in intercropping situation might be due to no intercrop competition for light, nutrients, moisture, and space. This corroborates with the findings of Quayyum and Maniruzzaman (1995), Nag *et al.* (1996) and Uddin *et al.* (2003). The maize yield under intereropping treatment (both normal and paired row) was lower than that of respective monoculture, though the population of maize was constant regardless of treatment. The reduction of maize yield was probably due to intercrop competition between maize and groundnut. However, additional yield from groundnut not only compensated the deficit but also gave extra income. In intercropping situation, grain yield was reduced compared to sole maize. This finding is in conformity with Quayyum and Maniruzzaman (1995), Uddin *et al.* (2003) and Pandey *et al.* (2003). The yield reduction of maize was more when intercropped in paired row system (4.47-6.50% in 2003-04 and 3.69-9.50% in 2004-05) than normal row system (1.78-3.83% in 2003-04 and 0.53-4.08% in (2004-05) which might be due to more interplant competition for growth resources. Similar results were also reported by Karim *et al.* (1990). The lowest grain yield of maize was recorded in T_5 (4 rows of groundnut in between 2 paired rows of hybrid maize var. BHM-1) in both the years due to more interplant competition for growth resources as well as the low yield potential of BHM-1. The harvest index (HI) of maize did not differ by the intereropping

systems. Harvest index of maize had higher value in T_1, T_3, T_5 and T_7 in 2003-04 and T_1, T_3, T_5, T_8, T_9 and T_{11} in 2004-05 (Table 1.1).

Groundnut

The yield and yield components of groundnut were significantly influenced by maize + groundnut intercropping system in both the years (Table 2). Pod yield of groundnut was significantly affected by maize + groundnut intercropping systems in both the years. The highest pod yield was recorded in T_{13} (monoculture groundnut). These pod yield differences were mainly due to the highest number of plants/m^2, number of pods/plant and 100-pod weight of groundnut. The pod yield of groundnut in intercropping situation was considerably reduced. This corroborates with the findings of Sarkar and Pal (2004) and Razzaque *et al.* (2007). The reduction of pod yield might be due to shading effect of maize on the groundnut. Similar results were reported by Karim *et al.* (1990) and Razzaque *et al.* (2007). It reveals that paired row planting system of maize favoured the growth of intercropped groundnut. Similar findings were observed by Islam *et al.* (2006). Among the intercropping treatments, T_7 (4 rows of groundnut in between 2 paired rows of hybrid maize var. Pacific-11) had higher pod yield. It might be due to paired rows planting system and maize var. Pacific-II which favoured the growth of intercropped groundnut and judicious use of growth resources compared to other intercrop combinations. The results are in conformity with the findings of Islam *et al.* (2006). Higher harvest index of groundnut was observed in T_7 (four rows of groundnut in between paired rows of hybrid maize var. Pacific-11) in both the years possibly owing to use of more assimilates to the reproductive organs (Table 2).

Equivalent yield and relative yield

The performance of maize + groundnut intercropping system was also evaluated on the basis of equivalent yield (Bandyopadhyay, 1984). The equivalent yield of maize and groundnut was influenced markedly in response to their different varieties of hybrid maize and different planting systems. The result showed that all the intercropping systems gave higher maize and groundnut equivalent yield than that of their corresponding sole crop yield in both the years (Table 3). The highest maize equivalent yield as well as groundnut equivalent yield were recorded in T_7 (four rows of groundnut in between paired rows of hybrid maize var. Pacific-11) which covered the yield advantages of 44.41% in 2003-04 and 35.63% in 2004-05 and 72.22% in 2003-04 and 138.35% in 2004-05 over the respective sole crops. Other authors (Karim *et al.,* 1990; Patra *et al.,* 2000 and Islam *et al.,* 2006a) also made similar observations in different intercropping systems. Higher maize and groundnut equivalent yield was recorded from all the intercropping treatments than their respective monoculture. Such yield

advantages could be due to combined yield of both the crops. Similar trend was observed in both the years.

Table 2. Pod yield, yield components and harvest index of groundnut in maize + groundnut intercropping systems in 2003-04 and 2004-05.

Treatment	2003-04					
	Plants/m^2 (at harvest)	Branches/ plant (no.)	Pods/plant (no.)	100-pod wt (g)	Pod yield (t/ha)	Harvest index (%)
T_1	17.58 b	4.48 b	10.08 d	94.73 c	0.91 d	27
T_2	18.48 b	4.58 ab	11.40 bcd	107.53 d	1.23 bc	27
T_3	18.83b	4.60ab	11.93bcd	115.40c	1.34b	28
T_4	18.05 b	4.55 ab	10.80 ed	99.30 e	1.07 cd	27
T_5	14.05 c	4.75 ab	12.43 abc	122.25 b	1.23 bc	32
T_6	15.53c	4.95ab	13.l0ab	126.60ab	1.40b	33
T_7	14.88 c	4.98 ab	14.18 ab	127.78 ab	1.47 b	34
T_8	14.50c	4.73ab	13.30ab	123.05b	1.28bc	33
T_{13}	25.35 a	5.18 a	14.93 a	129.95 a	2.52 a	33
F-test	**	*	**	**	**	-
CV(%)	4.35	6.45	7.93	2.37	9.01	-
	2004-05					
T_1	18.l5abe	4.57b	7.33b	108.04d	0.82f	23
T_2	18.80ab	5.03ab	7.77b	123.29c	1.11de	23
T_3	17.85a-d	5.50ab	7.97b	141.31b	1.23cde	25
T_4	18.63ab	4.87ab	7.53b	139.51b	1.04ef	24
T_5	14.26d	4.67b	10.07a	125.23c	1.20cde	30
T_6	14.56cd	5.30ab	10.73a	141.17b	1.43bc	31
T_7	15.26bcd	5.53ab	11.20a	148.lla	1.49b	32
T_8	14.59cd	5.27ab	10.l0a	139.27b	1.32bcd	31
T_{13}	21.34a	5.93a	11.30a	149.17a	2.06a	31
F-test	**	**	**	**	**	-
CV (%)	8.62	7.79	6.43	1.86	7.44	-

Mean values in a column having the dissimilar letter/letters indicate significant differences at 0.05 (*) and 0.01 (**) levels of significance (DMRT).

In this experiment, maize (all varieties) 100% and groundnut 67% (T_1, T_2, T_3 and T_4), and 53% (T_5, T_6, T_7 and T_8) population was accommodated in intercropping system expressing expected relative yield (RY) of maize varieties as 1.00 and that of groundnut as 0.67 and 0.53 over the respective intercropping systems. The relative yields of intercropped maize varied from 0.93 to 0.98 in 2003-04 and 0.94 to 0.99 in 2004-05 depending upon the different planting systems of maize and groundnut (Table 3). Similarly, relative yields of intercropped groundnut ranged from 0.36 to 0.58 in 2003-04 and 0.40 to 0.72 in 2004-05 in response to different planting systems (Table 3). Maize yield was slightly reduced (2 to 5%) among the intercropping system but groundnut yield was drastically reduced (42 to 74%). The groundnut yield was reduced (53 to

67%) due to lower plant population. The result showed that T_7 treatment is well accommodative in competitiveness in maize + groundnut intercropping system (Table 3).

Table 3. Maize and groundnut equivalent yield, relative yield and land equivalent ratio of different treatments in maize+groundnut intercropping systems in 2003-04 and 2004-05.

Treatment	Maize equivalent yield (t/ha)	Groundnut equivalent yield (t/ha)	Relative yield (t/ha)		land equivalent ratio (LER)
			Maize	Groundnut	
		2003-04			
T_1	10.82	3.46	0.98	0.36	1.34
T_2	12.12	3.88	0.96	0.49	1.45
T_3	13.24	4.24	0.96	0.53	1.49
T_4	12.17	3.90	0.98	0.42	1.42
T_5	11.46	3.67	0.93	0.49	1.42
T_6	12.51	4.00	0.94	0.56	1.50
T_7	13.56	4.34	0.96	0.56	1.54
T_8	12.53	4.01	0.95	0.51	1.46
T_9	8.15	2.61	1.00	-	1.00
T_{10}	8.61	2.76	1.00	-	1.00
T_{11}	9.39	3.00	1.00	-	1.00
T_{12}	8.99	2.88	1.00	-	1.00
T_{13}	7.88	2.52	-	1.00	1.00
		2004-05			
T_1	11.98	3.83	0.99	0.40	1.39
T_2	13.75	4.40	0.97	0.54	1.51
T_3	14.73	4.71	0.96	0.60	1.56
T_4	14.07	4.50	0.96	0.50	1.56
T_5	12.32	3.94	0.90	0.58	1.48
T_6	14.65	4.69	0.96	0.69	1.65
T_7	15.34	4.91	0.94	0.72	1.66
T_8	14.75	4.72	0.94	0.64	1.58
T_9	9.47	3.03	1.00	-	1.00
T_{10}	10.57	3.38	1.00	-	1.00
T_{11}	11.31	3.62	1.00	-	1.00
T_{12}	11.28	3.61	1.00	-	1.00
T_{13}	6.44	2.06	-	1.00	1.00

Price:

Maize: 8.00 Tk./kg and Groundnut: 25.00 Tk./kg.

Land equivalent ratio (LER)

The land equivalent ratio (LER) was used to assess the performance of an intercrop relative to the corresponding sole crop (Mead and Willey, 1980). If the value of LER is more than one (1.00), it indicates a total yield advantage of growing intercrops over sole crops, since the index denotes how much land

would be required for growing sole crops to obtain the same yields of each component as was obtained in intercropping. The highest LER value (1.54 in 2003-04 and 1.66 in 2004-05) was obtained from T_7 (four rows of groundnut in between paired rows of hybrid maize var. Pacific-11) which might be due to maximum complementary use of different growth resources in intercropping system (Table 3). It also expressed that by intercropping maize with groundnut, a farmer can produce 8.97 ton in 2003-04 and 10.68 ton maize in 2004-05 and 1.47 ton in 2003-04 and 1.49 ton groundnut in 2004-05 from one hectare of land instead of growing them separately as sole crop. These results are in agreement with that of Patra *et al.* (2000), Santalla *et al.* (2001) and Razzaque *et al.* (2007).

Maize equivalent yield, groundnut equivalent yield, relative yield of maize and groundnut and LER were highest in T_7 (four rows of groundnut in between paired rows of hybrid maize var. Pacific-II) followed by T_6 (four rows of groundnut in between paired rows of hybrid maize var. BHM-3) in maize + groundnut intercropping system. Thus it could be concluded that four rows of groundnut in between paired rows of hybrid maize var. Pacific-II (T_7) was the most productive and profitable among the treatments tested in maize + groundnut intercropping systems. So, the farmers of the maize growing areas could be suggested to grow intercropped hybrid maize var. Pacific-II with groundnut than either sole hybrid maize (any other varieties) or sole groundnut for maximum profit.

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