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OPTIMIZATION OF FERTILIZER RATE BASED ON FARMERS' PRACTICE IN POTATO-HYBRID MAIZE RELAY CROPPING SYSTEM

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Abstract

The experiment was conducted at the research field of Agronomy Division, BARI, Joydebpur, Gazipur during consecutive seasons of 2011-12 and 2012-13 to optimize fertilizer rate for potato hybrid maize relay cropping system. Seven treatments viz., T_1= Farmers' fertilizer dose of potato (FFDP: $N_{504}P_{162}K_{309}$ kg/ha) + Farmers' fertilizer dose of hybrid maize (FFDM: N_0 P_0 K_0 kg/ha), T_2= FFDP + 100% N of recommended fertilizer dose of hybrid maize (RFDM: N_{255} P_{55} K_{140} S_{40} Zn_6 B_2 kg/ha), T_3= FFDP + 100% N & 25% others of RFDM, T_4= FFDP + 100% N & 50% others of RFDM, T_5= Recommended fertilizer dose of potato (RFDP: N_{198} P_{44} K_{194} S_{24} Zn_6 $B_{1.2}$ kg/ha) +100% N of RFDM, T_6= RFDP +100% N & 25% others of RFDM, and T_7= RFDP +100% N & 50% others of RFDM were tested on potato-hybrid maize relay cropping system. Potato (var. Diamant) and hybrid maize (var. BARI Hybrid Maize-9) were used in this experiment. Results indicated that yield of potato (28.38 - 28.83 t/ha) did not differ significantly but yield of hybrid maize (4.90 - 8.74 t/ha) varied significantly under different treatments. The higher grain yield (8.74 t/ha) of hybrid maize was recorded in farmers' fertilizer dose of potato or recommended fertilizer dose of potato (8.61 t/ha) along with 100% N plus 25% other fertilizers or 100% N plus 50% other fertilizers from recommended dose of hybrid maize. The highest potato equivalent yield (41.94 t/ha) and gross return (Tk. 335520/ha) were obtained from FFDP along with 100% N plus 25% others of RFDM (T_3). But the highest gross margin (Tk. 219790/ha) and benefit cost ratio (3.01) were found from RFDP along with 100% N plus 25% others of RFDM (T_6). The results revealed that recommended fertilizer rate of potato (N_{198} P_{44} K_{194} S_{24} Zn_6 $B_{1.2}$ kg/ha) along with 100% N plus 25% other fertilizers from recommended fertilizer rate of hybrid maize (N_{255} P_{55} K_{140} S_{40} Zn_6 B_2 kg/ha) might be optimum for potato hybrid maize relay cropping system for obtaining higher economic return.

Keywords: Optimization, fertilizer rate, potato, hybrid maize and relay cropping.

Introduction

Potato is the third most important food crop in Bangladesh and its potential yield is about 30 t/ha (Hossain *et al.,* 2008). On the other hand, hybrid maize is a high yield potential cereal crop and is capable of producing about 10-11 t/ha of grain yield in the rabi season However, grain yield of hybrid maize decreases towards

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the kharif season due to exposure in higher temperature (Waha *et al*., 2013). Relay cropping is a system in which second crop is sown at the later stage of first crop. In potato-hybrid maize relay cropping system, maize is sown 12-15 days before potato harvesting i.e., in late February/early March. This system is advantageous in reducing the yield loss of hybrid maize through avoiding the possibility of exposing in stress situation like early flood and high temperature during pollination. Potato hybrid maize relay cropping is a common and popular practice in Comilla, Daudkandi, and Rangpur areas. Through adopting it, farmers in those areas get higher grain yield of maize compared to maize sown after potato. Fertilizer management is another important agronomic management option for increasing system productivity of potato–hybrid maize relay cropping system (Akhteruzzaman *et al.*, 2008). Potato responds well to fertilizer depending on inherent soil fertility and climatic conditions. Combined application of an optimum dose of NPK maximizes the growth and yield of crop and increases efficiency of each nutrient (Singh and Trehan, 1998). In inter/relay cropping system, the crops are grown in rows and the fertilizers are generally applied in the rows of the respective crop at the time of planting as well as top dressing (Singh *et al.*, 2008). Majority of the farmers in Comilla, Daudkandi, and Rangpur areas use NPK fertilizers in potato but they use no fertilizer or only few amount of N fertilizer in hybrid maize under relay cropping system. On the other hand, crops uptake more K from the soil particularly in potato-based cropping systems resulting the soil deficient in K with time (Singh and Trehan, 1998). However, information on economic fertilizer management for potato-hybrid maize relay cropping system is meagre in Bangladesh. Therefore, the experiment was conducted to optimize fertilizer rate for potato-hybrid maize relay cropping system for obtaining higher productivity and economic return.

Materials and Method

The experiment was conducted at the research field of Agronomy Division, BARI, Joydebpur, Gazipur during the consecutive seasons of 2011-12 and 2012-13. The soil of the experimental field was silty clay loam in texture with pH 5.8 belonging to Chhiata series under AEZ 28. The soil was low in organic matter (1.2%) and deficient in total N (0.07%), available P (13 ppm), exchangeable K (0.15 meq/100 g soil), available S (12 ppm), and available B (0.12 ppm). The crops received total rainfall of 210 and 222 mm during crop growing period in 2011-12 and 2012-13, respectively. The monthly mean maximum and minimum air temperature were 29.1 ^{o}C and 17.7 ^{o}C, respectively, during 2011-12, while 28.9 ^{o}C and 17.5 ^{o}C, respectively, in 2012-13. Seven treatments consisted of T_1= Farmers fertilizer dose of potato (FFDP: $N_{504}P_{162}K_{309}$ kg/ha) + Farmers fertilizer dose of hybrid maize (FFDM: N_0 P_0 K_0 kg/ha), T_2= FFDP + 100% N of

recommended fertilizer dose of hybrid maize (RFDM: N_{255} P_{55} K_{140} S_{40} Zn_6 B_2 kg/ha), T_3= FFDP + 100% N & 25% others of RFDM, T_4= FFDP + 100% N and 50% others of RFDM, T_5= Recommended fertilizer dose (N_{198} P_{44} K_{194} S_{24} Zn_6 $B_{1.2}$ kg/ha) of potato (RFDP) +100% N of RFDM, T_6= RFDP +100% N & 25% others of RFDM and T_7= RFDP +100% N and 50% others of RFDM. The experiment was laid out in a randomized complete block design with 3 replications. The unit plot size was 3m x 3m. 'Diamant' variety of potato and BARI Hybrid Maize-9 variety of hybrid maize were used in this study. Potato was planted on 29 November 2011 and 28 November 2012 maintaining 60cm × 25cm spacing. Maize was sown in between two potato rows with a seed to seed distance of 20 cm when vegetative growth of potato was ceased as relay crop on 13 February in 2012 and 2013 (76 days after potato planting). In the case of potato, ½ of N and full amount of PKSZnB were applied as basal in the form of urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate, and boric acid, respectively. The remaining N was top dressed at 30 days after potato planting followed by earthing up and irrigation. In hybrid maize, ½ of N and full amount of other fertilizers (where applicable) were applied as side dressing just after potato harvesting followed by irrigation. The rest N was side-dressed at 30 days after potato harvesting followed by irrigation. A light irrigation was given after potato sowing for proper emergence. Other intercultural operations were done as and when required. Potato was harvested on 02 March in 2012 and 2013 (94 DAS) and maize on 14 June in 2012 and 2013 (122 DAS). Yield components of potato and maize were taken from randomly selected 5 plants from each plot. Yields of both the crops were taken from whole plot. Potato equivalent yield was computed by converting yield of intercrops on the basis of prevailing market price of individual crop following the formula of Bandyopadhyay (1984) as given below:

$$Peq = Yip + \frac{Yim \; x \; Pm}{Pp}$$

Where,

Peq = Potato equivalent yield

Yip = Yield of intercrop potato

Yim = Yield of intercrop maize

Pm = Market price of maize

Pp = Market price of potato

Data on yield and yield components of both the crops for two consecutive years showed similar trend. So, those data were pooled and means were adjudged by Least Significant Difference (LSD) test at 5% level of significance. Benefit- cost analysis was also done.

Results and Discussion

Potato: Potato yields and yield components in all the fertilizer management practices were identical and its tuber yield ranged from 28.38 to 28.83 t/ha (Table 1). However, tuber yields of potato were slightly more at farmers' fertilizer dose of potato than that of recommended fertilizer dose. This might be occurred due to higher NPK rates in potato which is supported by the findings of Sharma *et al.* (1999).

Table 1. Yield and yield components of potato in potato-hybrid maize relay cropping under different fertilizer management (pooled data of 2011-12 & 2012-13).

Treatment	Hills/m^2 (no.)	Tubers/ plant (no.)	Tuber wt/plant (g)	Single tuber wt (g)	Tuber yield (t/ha)
T_1: FFDP + FFDM	6.3	11.2	507.3	45.3	28.77
T_2: FFDP + 100%N of RFDM	6.3	11.0	501.5	45.6	28.44
T_3: FFDP + 100%N & 25% others of RFDM	6.3	11.2	508.2	45.4	28.83
T_4: FFDP + 100%N & 50% others of RFDM	6.3	11.1	502.0	45.6	28.70
T_5: RFDP + 100%N of RFDM	6.2	11.0	500.9	45.5	28.38
T_6: RFDP + 100%N & 25% others of RFDM	6.2	11.1	501.6	45.2	28.45
T_7: RFDP + 100%N & 50% others of RFDM	6.3	11.0	503.1	45.7	28.50
LSD (0.05)	NS	NS	NS	NS	NS
CV (%)	10.7	12.3	8.2	6.9	12.6

NS= Not significant
FFDP= Farmers Fertilizer Dose of Potato = 504-162-309 kg/ha of NPK
FFDM= Farmers Fertilizer Dose of Maize =0-0-0 kg/ha of NPK
RFDP= Recommended Fertilizer Dose of Potato = 198-44-194-24-6-1.2 kg/ha NPKSZnB
RFDM= Recommended Fertilizer Dose of Maize = 255-55-140-40-6-2 kg/ha NPKSZnB

Hybrid maize: Number of grains/cob, 1000-grain weight and grain yields of hybrid maize differed significantly under different fertilizer management practices in potato hybrid maize relay cropping system except cobs/m^2 (Table 2). Number of grains/cob increased with the increase of other fertilizers along with 100%N, and this increment was accelerated in case of FFDP (588) where P and K rate were higher. Minimum number of grains/cob was recorded in hybrid maize grown with FFDM (401) or with 100%N of RFDM (429 and 431) in potato hybrid maize relay cropping system. Higher 1000-grain weight or grain size (277.7-282.7 g) was observed when hybrid maize was grown with higher

fertilizer doses while lower 1000-grain weight was obtained with only N fertilizer in potato hybrid maize relay cropping system. The lowest 1000-grain weight (227.7 g) was recorded in FFDP + FFDM where hybrid maize was grown without fertilizer in potato hybrid maize relay cropping system. Similar results were reported by Alam *et al.* (2003).

Table 2. Grain yield and yield components of hybrid maize in potato-hybrid maize relay cropping under different fertilizer management (pooled data of 2011-12 & 2012-13).

Treatment	Cobs/m^2 (no.)	Grains/cob (no.)	1000-grain wt (g)	Grain yield (t/ha)
T_1: FFDP + FFDM	6.1	401	227.7	4.90
T_2: FFDP + 100%N of RFDM	6.2	431	256.0	6.02
T_3: FFDP + 100%N & 25% others of RFDM	6.4	555	279.6	8.74
T_4: FFDP + 100%N & 50% others of RFDM	6.3	558	282.7	8.74
T_5: RFDP + 100%N of RFDM	6.0	429	254.8	5.78
T_6: RFDP + 100%N & 25% others of RFDM	6.3	550	277.7	8.46
T_7: RFDP + 100%N & 50% others of RFDM	6.3	556	279.5	8.61
LSD (0.05)	NS	75.2	20.3	1.65
CV (%)	10.9	8.5	4.3	12.7

NS= Not significant
FFDP= Farmers' Fertilizer Dose of Potato = 504-162-309 kg/ha of NPK
FFDM= Farmers' Fertilizer Dose of Maize =0-0-0 kg/ha of NPK
RFDP= Recommended Fertilizer Dose of Potato = 198-44-194-24-6-1.2 kg/ha NPKSZnB
RFDM= Recommended Fertilizer Dose of Maize = 255-55-140-40-6-2 kg/ha NPKSZnB

Grain yield of hybrid maize under different fertilizer management practices changed with the change of yield attributes, especially number of grains/cob and 1000-grain weight in potato hybrid maize relay cropping system (Table 2). Higher grain yields were recorded in FFDP + 100%N plus 25% others of RFDM (8.74 t/ha) and it was statistically identical with treatment combination of FFDP + 100%N plus 50% others of RFDM (8.74 t/ha), RFDP + 100%N plus 25% others of RFDM (8.46 t/ha) and RFDP + 100%N plus 50% others of RFDM (8.61 t/ha). On the contrary, the lowest grain yield (4.90 t/ha) was obtained from FFDP + FFDM where maize was grown without applying any fertilizer. The results indicated that grain yield of hybrid maize increased towards higher fertilizer doses. This result is in agreement with the findings of Berenguer *et al.* (2009).

Table 3. Potato equivalent yield (PEY) and benefit-cost analysis of potato-hybrid maize relay cropping under different fertilizer management (pooled data of 2011-12 & 2012-13).

Treatments	PEY (t/ha)	Gross return (Tk/ha)	Cost of production (Tk/ha)	Gross margin (Tk/ha)	Benefit cost ratio
T_1: FFDP + FFDM	36.12	288960	123629	165331	2.34
T_2: FFDP + 100%N of RFDM	37.47	299760	133590	166170	2.24
T_3: FFDP + 100%N & 25% others of RFDM	41.94	335520	138112	197408	2.43
T_4: FFDP + 100%N & 50% others of RFDM	41.81	334480	142635	191845	2.35
T_5: RFDP + 100%N of RFDM	37.05	296400	104808	191592	2.83
T_6: RFDP + 100%N & 25% others of RFDM	41.14	329120	109330	219790	3.01
T_7: RFDP + 100%N & 50% others of RFDM	41.42	331360	113853	217507	2.91

Price (Tk/kg): Potato 8/- and hybrid maize 12/-
FFDP= Farmers Fertilizer Dose of Potato = 504-162-309 kg/ha of NPK
FFDM= Farmers Fertilizer Dose of Maize =0-0-0 kg/ha of NPK
RFDP= Recommended Fertilizer Dose of Potato = 198-44-194-24-6-1.2 kg/ha NPKSZnB
RFDM= Recommended Fertilizer Dose of Maize = 255-55-140-40-6-2 kg/ha NPKSZnB

Relay crop efficiency: Potato equivalent yield (PEY) increased towards higher fertilizer rates due to higher yield of both potato and hybrid maize. The highest PEY was recorded in T_3 (41.94 t/ha), which was very close to T_4 (41.81 t/ha) treatment, while the lowest PEY (36.12 t/ha) was observed in T_1 treatment indicating higher PEY at higher fertilizer dose. Islam *et al*. (2013b) also obtained higher maize equivalent yield at higher fertilizer dose in maize-mukhikachu relay cropping system. Gross return followed the trend similar to that obtained in PEY. The highest gross return was recorded in T_3 (Tk.335520/ha) treatment, which was very close to T_4 treatment (Tk. 334480/ha). Cost of production increased in accordance with fertilizer cost. However, the highest cost of production was observed in T_4 (Tk. 142635/ha), which was close to T_3 treatment (Tk.138112/ha). Gross margin depends on gross return as well as cost of production. The highest gross margin was found from T_6 treatment (Tk. 219790/ha) because of the involvement of lower cost of production (Tk. 109330/ha) and it was close to that in T_7 treatment (Tk.217507/ha). Maximum benefit cost ratio was obtained from T_6 (3.01) treatment due to lower cost of production as well as reasonable gross return. Islam *et al*. (2013a) also obtained higher economic returns from potato-hybrid maize intercropping system. It was recorded from the target area that farmers generally did not use fertilizer or use only N in maize. But farmers used

much higher fertilizer in potato which should be minimized and motivation is necessary.

The above results revealed that recommended fertilizer rate of potato (N_{198} P_{44} K_{194} S_{24} Zn_6 $B_{1.2}$ kg/ha) along with 100% N plus 25% other fertilizers from recommended fertilizer rate of hybrid maize (N_{255} P_{55} K_{140} S_{40} Zn_6 B_2 kg/ha) might be optimum for potato hybrid maize relay cropping system for getting higher economic return.

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