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Effect of inorganic fertilizers in maize (*Zea mays*) + ginger (*Zingiber officinale*) intercropping system in humid hilly soils

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ABSTRACT

A field experiment was conducted during 1990–92 to study the use of different inorganic fertilizers on productivity of maize (*Zea mays* L.) + ginger (*Zingiber officinale* Roscoe) intercropping system. The pure crop of maize gave significantly higher grain yield than maize + ginger intercrops. The pure crop of ginger also gave significantly higher rhizome yield over intercropping treatments. On equivalence basis the highest maize-equivalent yield was recorded in pure crop of ginger (340.85, 244.15 and 88.42 q/ha), followed by maize + ginger 1 : 2 (187.94, 151.71 and 79.78 q/ha) and maize + ginger 1 : 1 (168.98, 155.59 and 75.99 q/ha) intercropping systems in 1990, 1991 and 1992 respectively. Application of 180, 120 and 80 kg N, P_2O_5 and K_2O/ha gave significantly higher grain and stover yields of maize and rhizome yield of ginger than the control in all the 3 years.

Maize (*Zea mays* L.) and ginger (*Zingiber officinale* Roscoe) intercropping proved advantageous because of difference in their growth and feeding habits (Roy and Braun, 1983; Singh, 1983). However, Willey *et al.* (1981) reported that the yields of both the components of intercrop were higher in sole system compared to yield in intercropping systems. The maize + ginger intercropping systems provides food, fodder and spices to the people of the region. Both maize and ginger crops show higher nutrients demand in the rainy season. Therefore a great challenge to sustain productivity with the application of inorganic fertilizers as N, P_2O_5 and K_2O under high-rainfall area on terraced land to know the suitability. Hence an experiment was conducted.

MATERIALS AND METHODS

The field experiment was carried out for 1990—1992 at the Research Farm, Tadong (1,350 m mean sea-level, Sikkim; 27—28° N and 88—89° E) in the rainy season. The experiment was laid out in randomized block design with 4 replications. The treatment combinations involved 4 cropping systems, viz. maize pure, ginger pure, maize + ginger in 1 : 1 ratio and maize + ginger in 1 : 2 ratio; and 4 fertility levels (N, P_2O_5 and K_2O @ 0,0 and 0; 60, 40 and 30; 120, 80 and 60; and 180, 120 and 80 kg/ha respectively). The soil was silty clay-loam having pH 5. It was medium in organic carbon (0.69%), low in available P (3.2—4.0 kg/ha) and medium in available K (174.5—186.8 kg/ha). Maize ('NLD White') and ginger ('Gorubathan') were sown on 30 April 1990, 19 February 1991 and 22 April 1992. The harvesting dates for maize and ginger were 28 August 1990, 3 August 1991, 10 September 1992; and 6 December 1991, 29 January 1991 and 24 December 1992,

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Table 1. Effect of different treatments on growth and yield parameters of maize

Treatment	Plants/ha ('000)			Plant height (m)			Cob length (cm)			Cob diameter (cm)			Test weight (g)		
	1990	1991	1992	1990	1991	1992	1990	1991	1992	1990	1991	1992	1990	1991	1992
Cropping system															
Maize (pure)	82.25	75.17	76.83	3.22	3.40	3.07	15.64	15.93	14.14	14.37	15.43	15.00	35.50	37.25	31.95
Maize + ginger (1 : 1)	42.92	42.25	43.16	3.16	3.27	3.02	15.39	15.39	14.20	14.35	15.09	14.87	35.25	36.25	31.75
Maize + ginger (1 : 2)	33.41	33.33	34.83	3.13	3.27	3.00	14.92	14.68	13.12	13.96	14.99	14.76	34.52	35.62	30.76
CD (P = 0.05)	2.06	3.15	3.22	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
N, P_2O_5, K_2O (kg/ha)															
0, 0, 0	52.66	49.66	49.55	2.93	3.14	2.84	13.37	14.37	12.65	13.45	14.20	14.18	34.16	35.33	30.19
60, 40, 30	25.53	50.44	51.22	3.24	3.34	3.02	15.98	15.50	13.93	14.30	14.47	15.02	35.23	36.75	31.48
120, 80, 60	52.53	50.44	51.81	3.21	3.37	3.16	15.83	15.51	14.17	14.52	15.27	15.18	35.35	36.83	31.88
180, 120, 80	53.60	50.44	53.78	3.31	3.41	3.10	16.08	15.96	14.52	16.65	16.25	15.22	35.65	37.33	32.39
CD (P = 0.05)	NS	NS	NS	0.34	0.17	0.21	1.57	1.50	1.70	0.68	0.69	0.73	1.21	1.32	1.56

during 3 years respectively, having 50 cm distance between lines and 25 cm between plants. The ginger was intercropped in replacement series. The yield attributes were studied based on the average of 5 cobs and plants each. The total rainfall received during the crop season was 2,952.8 mm in 159 rainy days, 3,214.5 mm in 204 rainy days and 2,841.0 mm in 171 rainy days during 1990, 1991 and 1992 respectively.

RESULTS AND DISCUSSION

Growth and yield-attributing characters

All the growth and yield-attributing characters of maize, viz. number of plants (1,000/ha), plant height, cob length, diameter, number of grains/cob and 100-grain weight, were higher in pure stand as compared with intercropping at 1 : 1 and 1 : 2 row proportions in 1990, 1991 and 1992 respectively. The plant height, cob diameter, number of grains/cob and 100-grain weight were significantly higher at 180, 120 and 80 kg N, P_2O_5 and K_2O/ha over the control in all the 3 years (Table 1). Similar findings were reported by Singh *et al.* (1991).

Grain and stover yields

The grain and stover yields of maize were significantly higher in pure crop of maize than intercropping system at 1 : 1 and 1 : 2 row proportions in 1990, 1991 and 1992 respectively (Table 2). The use of inorganic fertilizers @180 kg N + 120 kg P_2O_5 + 80 kg K_2O/ha gave significantly higher grain and stover yields than the other dose of N, P and K and the control. The increase in grain and stover yields of maize was 44.26, 38.56, 40.21 and 118.4, 125.90, 68.98 q/ha over the control in 1990, 1991 and 1992 respectively. Similar findings were reported by Gaur (1991) and Singh and Dubey (1991), Shah *et al.* (1992). The increase in grain

Table 2. Effect of different treatments on yield of main and intercrop

Treatment	Maize-grain yield (q/ha)			Maize-stover yield (q/ha)			Intercrop yield (q/ha)			Maize-grain-equivalent yield (q/ha)		
	1990	1991	1992	1990	1991	1992	1990	1991	1992	1990	1991	1992
Cropping system												
Maize (pure)	71.87	87.31	59.18	238.15	290.32	157.71				71.87	87.31	39.18
Ginger (pure)							136.34	97.66	35.37	340.85	244.15	88.42
Maize + ginger (1 : 1)	58.68	69.89	50.69	169.25	248.66	140.63	44.12	34.28	10.12	168.98	155.77	75.99
Maize + ginger (1 : 2)	54.57	60.65	45.01	142.67	202.91	138.21	52.95	36.45	13.91	187.94	151.77	79.78
CD (P = 0.05)	7.93	12.64	2.45	32.91	30.74	3.92	15.11	11.47	1.87	20.00	12.93	4.33
N, P_2O_5, K_2O (*kg/ha*)												
0, 0, 0	20.69	49.58	28.61	109.41	169.95	104.42	70.95	42.71	12.76	198.06	156.35	60.51
60, 40, 30	46.35	73.43	53.18	196.34	252.27	149.63	76.86	53.97	15.25	238.50	208.40	91.30
120, 80, 60	52.82	78.52	55.89	200.11	271.77	154.63	77.71	63.24	22.71	247.09	236.62	112.66
180, 120, 80	64.95	88.14	68.82	227.55	295.55	173.40	85.70	64.60	28.49	279.20	249.64	140.04
CD (P = 0.05)	13.73	11.04	3.21	57.11	26.63	5.26	10.51	9.993	2.16	20.00	12.93	4.33

and stover yields of maize at highest tested dose of inorganic fertilizers might be attributed to better utilization of plant nutrients at the initial stage of crop growth. Besides, improvement in all the yield-attributing characters also contributed towards high yield recorded under high doses of fertilizer.

Ginger yield

In the pure crop of ginger the rhizome yield was significantly higher than the different intercropping systems in all the years. The intercropping system with 1 : 1 and 1 : 2 row proportions did not show significant differences but higher rhizome yield was noted in 1 : 2 intercropping systems, owing to the higher plant population of ginger in the system. The ginger is shade-loving crop and therefore, it did not offer competition with maize crop for nutrients and light. The yield reduction was noted in 1991 (97.66, 34.28 and 36.45 q/ha) and in 1992 (35.37, 10.12 and 13.91 q/ha) in sole crop, under 1 : 1 and 1 : 2 crop proportions respectively over 1990 (136.34, 44.12 and 52.95). These yield reductions might be due to continuous cropping in the same field year after year.

The every increase in dose of fertilizer significantly increased the yield of ginger rhizome. The higher yields were observed with the application of 180, 120 and 80 kg N, P_2O_5 and K_2O/ha respectively over the control (Table 2). Other fertilizer doses also increased the rhizome yield but not significantly. This is because of higher fertilizer demand of ginger crop. The findings confirm the results of Singh and Awasthi (1990).

Maize-equivalent yield

The maize yield was significantly higher in pure crop of ginger, followed by maize + ginger 1 : 2 and maize + ginger 1 : 1 intercropping systems. The minimum maize-equivalent yield was obtained in pure crop of maize. It was due to higher ginger price as compared to maize crop. The application of higher fertilizer dose of N, P and K @180, 120 and 80 kg/ha gave significantly higher grain-equivalent yield by 42.93, 59.67, 113.43% over the control in 1990, 1991 and 1992 respectively. The similar results were reported by Singh and Awasthi (1990).

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