

RESEARCH NOTE

Identification of Suitable Planting Method for Potato + Maize Intercropping System in the Hill of Eastern Nepal

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ABSTRACT

Field experiments to identify suitable planting method under potato + maize system in the high hill (2200 m) of eastern Nepal Sindhuwa, Dhankuta, was conducted during 2000 and 2001 seasons for the potato variety Hale and maize variety Ganesh 1. Of the different planting methods tested, significantly the highest yield of potato (15.5 t/ha) was recorded from the alternate row planting followed by recommended practice and flat row planting. Early emergence (by 7-12 days) was in farmers' practice, whereas uniform plants (1-5 scale) observed in flat row and double row planting. Maize did not follow this trend. Double row and farmer's practice favored good ground coverage (80-95%) by potato plants, which attained height from 49.8cm (farmer's practice) to 56.8 cm (flat row). Number of main stems/plant was higher in all treatments, except farmer's practice. Similar trend was followed in tuber numbers. Maturity of crops did not depend on planting methods. Final stand of potato ranged between 46.9 (alternate row) and 68.6 thousand/ha (farmer's practice). Late blight and bacterial wilt infection was higher in the farmers' practice. The height of maize plants was significantly differed between sole cropping (220 cm), which yielded higher followed by alternate row (183 cm) and flat row plantings. Gross income from maize and potato was higher in flat row planting. The data revealed that alternate row and flat row planting methods were superior over the common farmers' practice and the recommended practice, so the identified planting methods were recommended.

Key words: Effect, intercropping, maize, planting method, potato

INTRODUCTION

Potato (*Solanum tuberosum* L.) and maize (*Zea mays* L.) are the main staple food crops in the hills of Nepal. In the mid hills, maize ranks first in terms of area and production, similarly potato is the dominating crop in the high hills (above 2000 m). Inter-cropping of these two crops is common in the potato-based cropping system adopted by the farmers (above 1800 masl) as potato + maize system. The average yields of potatoes (9.50 t/ha) and maize (1.60 t/ha) in the eastern hills are lower than the national average (10.5 and 1.77 t/ha respectively). One of its reasons identified was lack of suitable planting techniques and spacing (Barakoti 2001a). One of the research areas identified by Pakhribas Agriculture Centre was to identify suitable husbandry practices for potato + maize system (Chand et al 1993). In general, potato and maize are compatible, depending upon the varieties, as the farmers are aware of the possible competition (Chand et al 1993), as they are traditionally grown in the eastern and central regions since decades. Luxuriantly growing potato varieties suppress maize during initial growth period. Shade of maize plants adversely affect yield of potato. However, their yields might depend on planting methods, and varieties that compete for nutrient elements, space, water, light etc. Therefore, inclusion of some legumes such as peas and beans were started and found profitable (Poudel 2001) under potato + maize system. Result of participatory rural appraisal in the eastern hills identified more severe incidence of diseases and pests in this system, whereas plant protection measure applied is rare. Lack of technical know-how and technology is one of the limiting factors (Barakoti 2001b). Haphazard planting without following recommended row and plant spacing without ridging is common for both maize and potato in the hills. This may create

unfavorable environment for growth and development to either crop. Earthing-up is not practiced for potato planted in flat. Peak growing period of both these crops is summer to rainy season, when there is development and attack of diseases and insect pests in the agro-crops. It is one of the reasons that the yields of maize and potato are lower in the high hills compared to Tarai. In the plain, potato is planted in narrow spacing (60- × 25-cm). Kushwah (2001) reported that planting distance of 50- × 15-cm and 50- × 20-cm was economically suitable in Gujarat condition, India.

MATERIALS AND METHODS

The experiments were conducted in Sindhuwa, Sub-station of the Agricultural Research Station (ARS) Pakhribas, Dhankuta district, in the high hill condition 2200 masl, East Nepal, during 2000 and 2001 cropping seasons. Recommended variety of maize- Ganesh 1 (white grain) and potato- Hale local (red skinned, well stable and popular in the area) were included in the study. It was assumed that this variety might have brought from Holland and so named as Hale. Recommended rates of chemical fertilizers, i.e. half dose of Nitrogen and full dose of Phosphorus and Potash @ 40:60:60 N:P₂O₅:K₂O kg/ha and farmyard manure (FYM) @ 20 t/ha were applied as basal at the time of planting. Recommended seed rate of potato was medium sized tubers @ 1.2 to 1.5 t/ha depending on row spacing. Maize was sown @ 18-20 kg/ha as per number of rows and spacing. Plot size was 3- x 3.5 m. Trials were laid out in RCB design in 4 replicates. Details of different planting methods tested were as following:

1. **Alternate row planting (ARP):** Potato and maize planted alternately at 60 cm row distance.
2. **Double row planting (DRP):** Two rows of potato planted at 30 cm in between maize rows of 90 cm.
3. **Flat row planting (FRP):** Potato planted at 60 cm without ridging at planting and tuberization.
4. **Farmer's practice (FP):** Haphazard planting of cut pieces and small tubers, making pits with spade, applying double handful of FYM and a teaspoonful of urea per pit.
5. **Recommended practice (RP):** Planting potato and maize in rows of 60 cm and 75 cm respectively as intercropping alternately and slight ridging.
6. **Sole potato:** Planting potato only in its recommended spacing of 60- × 25-cm.
7. **Sole maize:** planting maize only in its recommended spacing of 75- × 25-cm.

Row spacing of potato and maize and ridging for potato differed between the planting practices. The intra row for all treatments, except FP was 20 cm. Potato was planted during first half of February, common time for the variety and maize planted/dibbled during fourth week of March each year, after emerging out of the seed tubers. Harvesting of potato was done in third week of July and maize during second to third week of October both years, three months later than potato. Intercultural operations: two weeding, thinning (for maize) and earthing-up were done as recommended and normally practiced by the farmers. Top-dressing with Nitrogen @ 40 kg/ha was done during the tuberization. No pesticide was applied against diseases and insect pests to observe the effect of treatments under varied spacing and ridged conditions. Late blight was scored in 1-9 rating according to CIP scale.

Parameters recorded in the experiments were: emergence, plant height, uniformity, ground cover, plant stand, maturity, yields, cost of cultivation, and severity of major diseases and insect pest. Tubers were analyzed based on size class to identify the ratio of seed size tubers. Analysis of variance was performed through Genstat for F-test, SED and CV.

Potato and maize planted and harvested situation in the experimental plots (3- × 3-m)

Treatment	Crops	Planted	Harvested
Farmers' practice	Potato	Without row	Whole plot
	Maize	Without row	Whole plot
Recommended practice	Potato	5 rows	3 rows
	Maize	4 rows	4 rows
Alternate row planting	Potato	3 rows	3 rows
	Maize	4 rows	4 rows
Double row planting	Potato	6 rows	4 rows
	Maize	3 rows	3 rows
Flat row planting	Potato	5 rows	3 rows
	Maize	5 rows	5 rows
Potato sole	Potato	5 rows	3 rows
Maize sole	Maize	4 rows	4 rows

RESULTS AND DISCUSSION

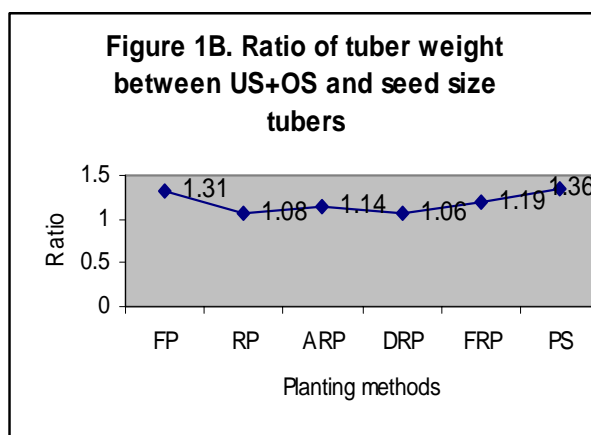
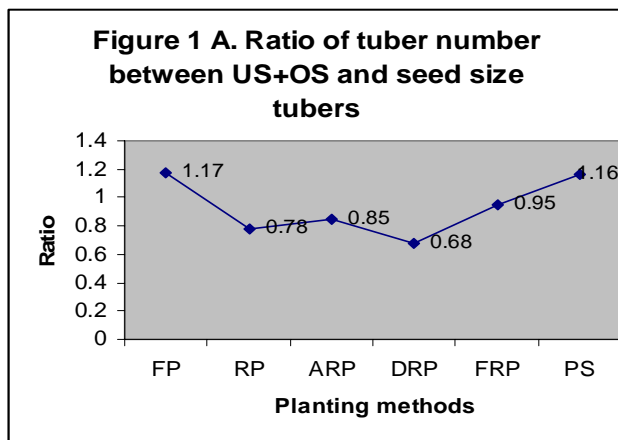
The mean data on major agronomic traits recorded in potato are presented in Table 1a and 1b. Length of tuber sprouts at planting was normal (2.4-3.0 cm) differing slightly. The tubers took long time (above 70 days) for attaining more than 90% emergence due to cool winter period. Earlier emergence was observed in farmer's practice (FP) due to cut tubers. Relatively higher emergence of tubers in FP followed by recommended practice (RP) was due to higher number of hills, which was due to close (15-25 cm) and uneven planting without rows, and the least number in ARP was due to less number of rows (4) compared to other planting practices. The ground coverage by the plants as an important agronomic parameter was visually estimated at 18th weeks after planting. The data were highly significant ($P < 0.01$) attaining 80% (ARP) to 95% (sole cropping). The ground cover in ARP was lowest because potato and maize were planted widely at 60 cm rows alternately. Uniformity of plants visually scored at initial tuberization, showed superior in flat and double row plantings. Uniformity was homogenous in all treatment plots both years. The uniformity was good (4 scale) according to the standard ranking. The data did not give significant result. The plant height of potato measured at harvesting time did not vary markedly. The results were not significant. Similar trend was found in the maturity days and main stem number, which were too non-significant. The No of main stem was highest in RP (4.3), whereas it was least (2.3) in the FP, which might be due to close or dense plants. Planting method did not show significant variation on plant height, number of stems and maturity period, which might depend genetically as compared to environmental factors. Number of harvested plants varied significantly ($P < 0.01$), where FP and DRP were at par and significantly differed with the remaining planting practices, which were also at par (Table 1b). Total number of tubers/plot was also found non-significant.

Table 1a. Agronomic traits of potato under potato + maize cropping system in the eastern Nepal's hill (2200 masl), Sindhuwa, Dhankuta district, 2000 and 2001

Planting methods	50% emergence DAP	Emergence at 80 DAP, %	Ground cover at 125 DAP, % (2 nd wk, May)	Uniformity (1-5 scale)* at 110 DAP (3 rd wk, April)	Plant height at harvesting, cm	Maturity days from planting
Farmers' practice (FP)	66.8	99.0	87.5	3.8	49.8	155
Recommended practice (RP)	74.0	97.5	92.5	3.8	55.0	155
Alternate row planting (ARP)	76.5	93.0	80.0	3.8	52.8	156
Double row planting (DRP)	75.5	95.6	90.0	4.3	53.0	155
Flat row planting (FRP)	74.3	95.5	92.5	4.5	56.8	157
Potato sole	74.8	96.3	95.0	4.5	49.8	156
F-test	ns	ns	***	ns	ns	ns
SED	4.15	3.30	2.71	0.40	3.11	0.61
CV, %	4.30	7.52	1.90	13.9	8.30	3.10

DAP, Days after planting. ns, Non significant. * 1, Very poor. 2, Poor. 3, Fair. 4, Good. 5, Excellent.

The number of plants in FP was highest but the number of tubers was the lowest. The plant numbers of FP and DRP varied highly significantly between the other treatments. But the numbers of main stems were not significant. Similarly, the number and weight of tubers showed non-significant



There are some economic diseases and insect pests of potato in the hill conditions. Late blight caused by *Phytophthora infestans* is the number one disease commonly occurring every year when the weather favors its development (Poudel 2001). In the potato + maize cropping system, microclimate differs due to maize plants, which not only competes with potato, but also provides environment for the development of diseases and pests during the summer-rainy season. Late blight (LB), bacterial wilt, potato virus (PV) and aphid infestation were observed in the experiment. Very few symptoms of LB as 2 scales were observed in the plants on third week of May, whereas its incidence rose to 10-25% after one month. Then it spread rapidly and within 10 days attained 6-7.2 score scale equivalent to 50-95% at maturity. The severe infection was observed in the farmers' practice, which might be due to contamination from cut tubers as well as close plants. Due to early variety, tubers were already matured at that time and so there was no harm to the yield of potato. Similarly bacterial wilt (BW) was found highest in the FP (6 n/plot). Potato virus-like symptoms were observed in small scale, and early blight (EB) was negligible. Aphid observation taken on two dates did not exceed 5% (FP) infestation. It was the least (2.7%) in the sole cropped plots. Higher population of potato and maize enhanced aphid population.

Table 3. Aphid infestation and late blight incidence in potato under potato + maize system in the Eastern region high hills (2200 m), Sindhuwa, Dhankuta district, 2000 and 2001

Planting methods	Aphid (<i>Aphis</i> sp.) damage, %		Late blight (1-9 scale)* (<i>Phytophthora infestans</i>)			Bacterial wilt incidence, %
	May, 100 DAP	June, 130 DAP	3 wk May, 100 DAP	2 wk June, 125 DAP	4 wk June, 140 DAP	2 wk June, 125 DAP
Farmers' practice	5.0	3.0	2	4.0	7.2	6
Recommended practice	4.5	2.7	2	3.5	6.2	0.5
Alternate row planting	3.7	3.0	2	4.0	6.2	0.8
Double row planting	4.0	3.0	2	3.5	6.0	0.0
Flat row planting	4.2	3.2	2	3.5	6.0	0.3
Potato Sole	2.7	2.7	2	3.7	6.0	1.2
Maize Sole	-	-	-	-	-	-

* 1, no symptoms. 9, all leaves and stems dead.

Maize parameters in the potato+maize husbandry trial are presented in Table 4. The maize variety Ganesh 1 emerged out about 3-4 times latter than Tarai due to low temperature in the high hill. Plant heights of maize were measured thrice during the vegetative period (at peak tuberization, silking and harvesting). The tallest plants were formed in sole cropping. Analysis of variance of the treatment means showed highly significant ($P < 0.01$) differences at silking stage, when potato tubers were harvested. It followed the previous trend. The second highest was in alternate row planting. The height recorded finally at harvesting varied 187-232 cm, the second highest was in double row planting.

Final plant population of maize varied significantly between the treatments. The stands in all treatments were maintained close to the recommended number (53333). Means of grain and stover yields were highly significant, where the highest yield was recorded in sole cropping. In potato + maize planting practice, significantly higher yield of maize grain (7083 kg/ha) was obtained from flat row planting followed by farmers practice. The highest yield of stover was found in alternate row planting.

Table 4. Maize parameters in the husbandry trial under potato + maize system in the Eastern region high hills, Sindhuwa Sub-station, Dhankuta, 2000-2001

Treatment	50% emergence, days	Plant height of maize		Plant population/ha	Stover yield, t/ha	Grain yield, kg/ha
		At silking, cm	At harvesting, cm			
Farmers' practice	28.0	144	193	51944	9.444	6072
Recommended practice	27.5	138	193	51666	8.639	5494
Alternate row planting	26.5	182	196	48889	9.666	4880
Double row planting	28.0	138	201	40555	6.361	4277
Flat row planting	28.5	132	187	49166	8.944	7083
Maize Sole	28.0	220	232	49722	12.416	8016
F-test	ns	***	**	*	**	***
SED	0.61	12.6	10.3	3130	1.37	516
CV, %	3.10	11.2	12.5	9.10	20.9	11.9

ESTIMATED AVERAGE INCOME FROM POTATO AND MAIZE

The income from potato and maize intercropping was calculated based on the then mean prices of the commodities (Table 5). The total gross income value showed that flat row planting (FRP) appeared superior over other treatments. It might be due to the better environment for longer period drought during tuberization as the stress was less in the non-ridged plots. Similar income from the farmers' practice compared to alternate row and recommended practices seems at par however while judging from the disease and quality points of views, farmers' practice seems inferior and other practice/ methods need to select. Flat row planting may not be appropriate for early rainfall year because of excess moisture in the soil.

Table 5. Income from potato and maize estimated based on yield produced and market price

Planting methods	Income from		Gross income, Rs
	Potato, Rs	Maize, Rs	
Farmers' practice	77,700	50,700	128,400
Recommended practice	84,200	44,900	129,100
Alternate row planting	93,240	38,800	132,040
Double row planting	78,600	32,800	121,400
Flat row planting	88,020	56,800	144,820
Maize sole planting	-	76,200	76,200
Potato sole planting	79,920	-	79,920

Traditional planting method of potato and maize is inferior to tested planting methods. Row planting in appropriate spacing is beneficial where most agronomic parameters are superior, and diseases and pests severity is lowered due to better environment. Yield and biomass are increased. Intercropping is more beneficial over sole cropping due to combined yields of two crops. Alternate row planting (ARP) of potato and maize at 60 cm row spacing can be recommended to the growers. Recommended and flat row planting are equally suitable after ARP.

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