Accelerating Adoption of Suitable Cultural Practices of Maize to Minimize the Yield Gap and Increase Farmers' Income in Karo, North Sumatra

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Abstract. The district of Karo, located in a hilly region characterized by high rainfall intensity, is a major maize-producing area in North Sumatra. Farmers here practise a maize-maize cropping system. Productivity is low at about 7-8 t ha^{-1}. Site-specific nutrient management (SSNM) was introduced to farmers of this region, with a recommendation of 160 kg ha^{-1} N, 72 kg ha^{-1} P_2O_5 and 90 kg $ha^{-1}K_2O$. This study was conducted in Tigabinanga subdistrict of Karo district at a site located 600-700 m above mean sea level during August-December 2007. The study also disseminated a new high-yielding variety of maize together with recommendations for planting density and the number of seeds per hole. The purpose of this participatory experiment was to identify suitable technologies and practices that can increase productivity and labor efficiency. The results indicated that 15 farmers applied SSNM recommendations besides 47 farmer's cooperator, cause labor limitation and the same planting date with the whole farmers. The study found that SSNM technology can increase production by about 11.49% and farmers' income by 17.13%.

Key words: Maize, SSNM recommendations, labor, increased farmers' income

Introduction

Increase in maize production is possible through expansion of cultivable area and/or by intensifying cultivation practices. Expansion of area under maize is difficult because of the limited land available. Intensification of cultivation through measures such as balanced use of fertilizers to supply appropriate and adequate nutrients to the crop, therefore, offers a better opportunity of increasing production and enhancing farmers' income.

Site-specific nutrient management (SSNM) is an approach toward delivering nutrients to crops in dosages appropriate for the season and the location. This approach was developed for irrigated rice farming in Asia (Doberman *et al*. 2002; Witt *et al*. 2002) and has since been disseminated in Indonesia (Samijan *et al*. 2003). Adoption of SSNM for paddy has been shown to have increased the efficiency of fertilization of N, P and K. This approach is being applied to develop site-specific recommendations for maize too (Doberman *et al*. 2003a).

An SSNM study of maize done in Tigabinanga subdistrict in North Sumatra during 2004-2007 obtained a site-specific recommendation for fertilization of maize of 160 kg ha^{-1} N, 72 kg ha^{-1} P_2O_5 and 90 kg ha^{-1} K_2O with plant spacing of 70 x 20 cm (1 seed per hole) and 70 x 40 cm (2 seeds per hole) (Akmal *et al*. 2007). These recommendations were then disseminated to farmers by various means including conducting farmers' meetings. It was left to the farmers whether or not to adopt any or all of these technologies. They were given freedom to choose the technology they were capable of executing.

Methodology

Studies of the impact of a technology are generally of two types: (1) ex-post impact studies assess the effects of a technology that has already been adopted and applied by the farmer; and (2) ex-ante impact studies deal with technology that has not yet been adopted but is showing good enough promise. At this activity will be focused at study (ex-ante impact). Approach which applied in this study is (1) before and after (ex-ante vs ex-post) and (2) adopter vs non-adopter (with before and after) adopter vs non-adopter (with vs without).

Our study evaluated the recommendations obtained from an SSNM study on maize done in Tigabinanga subdistrict in the previous year. Our purpose was to promote the use of SSNM for maize with the aim of increasing production and raising farmers' income. The study was carried out at five sites, Perbesi, Pertumbuken, Gunung, Simolap and Kutabangun, in Tigabinanga subdistrict, a dryland farming region located 600-700 m above mean sea level during August-December 2007.

Table1. Farmers' adoption of site-specific nutrient management recommendations on fertilization ofmaize at five sites in Tigabinanga subdistrict, North Sumatra.

Date	Location	Σ of farmers who attended the meeting	Σ of farmers who accepted the FPE	Σ of farmers who implemented the FPE
07/08/2007	Perbesi	16	10	1
07/08/2007	Pertumbuken	15	6	1
08/08/2007	Gunung	22	15	6
08/08/2007	Simolap	25	8	3
08/08/2007	Kutabangun	14	8	4
	Total	92	47	15

Results and Discussion

The results of the study are presented as follows:

Farmers' meeting

A meeting of farmers was conducted over two days (7-8 Aug 2007) to assess the adoption of of SSNM recommendations on fertilization of maize in Tigabinanga subdistrict (Table 1).

The meeting was attended by a total of 92 farmers in the five study sites. The number of farmers who had agreed to adopt the fertilization recommendations was 47, but only 15 actually had begun to practise them.. The following were the constraints to the adoption of this technology: (1) farmers were not yet convinced about the working of these recommendations and there was a lack of infrastructure and an information network that facilitates spread of awareness among farmers; (2) the absence of an agriculture technology dissemination system and the low level of knowledge of farmers makes it difficult for them to access the benefits of new technology; (3) in general, resource-poor farmers are risk-averse because change of technology often means additional requirement of labor; and (4) change of technology also often adds toproduction costs, which, given the high marketing and transport costs and the low market prices for produce, makes the farmer wary of investing in new technology. As a result of these constraints, farmer enthusiasm for adopting new technology is less.

Agronomic findings

Agronomic survey. The cropping system prevalent in Tigabinanga is maize-maize with use of hybrid varieties. Application of fertilizers is generally in abundance, reaching 1 t ha^{-1} with use of urea going up to 500 kg ha^{-1}, SP36 200 kg ha^{-1}, KCl 100 kg ha^{-1} and Ponska 200 kg ha^{-1}. Weed control is usually done by spraying herbicide (gliposat). Farmers in Tigabinanga prefer to burn the crop residue in theirfields to prepare the land for cultivation and remove any pests and diseases (Table 2).

Table 2. Maize farmers' practices in Tigabinanga subdistrict, North Sumatra, Indonesia, 2007.

Parameter	Farmers' practice
Cropping system	Maize-maize
General soil fertility	Fertile
Rainfall pattern	WS: Oct-DecDS: June-July
Crop calendar	Feb/March-June/July Aug/Sep-Dec/Jan
Fertilizer rates	N = 46-184 kg ha^{-1}, P_2O_5 = 18-144 kg ha^{-1} K_2O = 30-90 kg ha^{-1}
Plant spacing (cm)	70 x 40, 75 x 40, 80 x 40, 2 seeds $hole^{-1}$
Plant density	65,000-75,000 plants ha^{-1}
Crop management	
Manure	Generally no manure application
Variety	Hybrid
Water management	Rain-fed, short dry sessions
Crop residue	Burn
Weed control	Herbicide (gliposat) and manual
Best yield	12 t ha^{-1}

The abundant use of fertilizers and the imprecise method and time of application point to the need for site-specific nutrient management of maize in this region. SSNM is an effort to supply nutrients to the crop in accurate doses appropriate for the particular location. In keeping with the approach of prescription farming, SSNM considers the nutritional requirement of that particular plant/variety, the soil conditions, and also the season and intensity of solar radiation (Makarim 2000). Therefore nutrients are delivered more efficiently to the crop in accordance with its requirements.

Study of fertilization of maize, 2004-2006. To derive SSNM recommendations for N, P and K fertilization of maize in this location, we first assessed the impact of omission of N, P and K separately. Separate maize subplots were cultivated without either N, P or K fertilizer but with optimal crop management. The relevant nutrient accrued to the

Table 3. Results of a study of SSNM nutrient requirements for maize in Tigabinanga, North Sumatra, 2004-2006.

NPK/SSNM ± ICM yield (t ha^{-1})	10.2 ± 1.4	Yield target (t ha^{-1})	11.0
N-limited yield (t ha^{-1})	6.2 ± 2.3		
P-limited yield (t ha^{-1})	8.9 ± 1.2		
K-limited yield (t ha^{-1})	9.2 ± 1.3		
Yield response to N (t ha^{-1})	3.8 ± 1.9	Expected yield response to N (t ha^{-1})	4.0
Yield response to P (t ha^{-1})	1.0 ± 0.7	Expected yield response to P (t ha^{-1})	1.5
Yield response to K (t ha^{-1})	0.8 ± 0.7	Expected yield response to K (t ha^{-1})	1.0
AEN (kg grain kg^{-1} N)	17.5 ± 9.6	Expected AEN (kg grain kg^{-1} N)	25.0
AEP (kg grain kg^{-1} P)	28.3 ± 17.7	Expected AEP (kg grain kg^{-1} P)	40.0
AEK (kg grain kg^{-1} K)	6.1 ± 4.8	Expected AEK (kg grain kg^{-1} K)	12.0
		Fertilizer N (kg ha^{-1})	160
		Fertilizer P_2O_5 (kg ha^{-1})	72
		Fertilizer K_2O (kg ha^{-1})	90

crop from the soil, inclusion from water and fixation from air but not from applied fertilizer. The yield thereby obtained indicated the ability of the local soil to supply the required nutrients. From the agronomic efficiency figures thus obtained, we derived the SSNM requirements of N, P and K for maize in this region..

The yield achieved by the treatment NPK/SSNM±ICM in 2004 approached 11 t ha^{-1}, the targeted yield. The yield response to N, P and K amounted to 4.0 t ha^{-1}, 1.5 t ha^{-1} and 1.0 t ha^{-1} respectively (Table 3). The expected agronomic efficiency of N (kg of grain per kg of N) was 25 kg kg^{-1}; that of P equalled 40 kg kg^{-1} and of K 12 kg kg^{-1}. From this study the following recommendations for site-specific nutrient management of maize in Tigabinanga were obtained: 160 kg ha^{-1} N, 72 kg ha^{-1} P_2O_5 and 90 kg ha^{-1} K_2O (Table 4).

Recommendations for site-specific nutrient management of maize. The SSNM recommendations have been disseminated in the location during 2004-2006 (Table 4).

At activity of socialization site-specific nutrient management of maize, BPTP North Sumatra make rules in execution of specific fertilizations recommendations of locations for farmers (a) Farmer determine technology type which will be applied by farm each farmers; (b) Farmer using fertilization technology type is obliged apply foliage color schema in the application of fertilization of III; (c) Farmer make note of execution of maize technology evaluation like: technological type, date of planting, date of fertilization (I, II and III) and date of crop, (d) no aid in the form of supporting facilities and expense of execution of evaluation and available in the form of technological adjacent and foliage leaf color chart; (e) given opportunity of training for maize technology evaluation participant farmer concerning usage of foliage color schema which will be submitted by researcher; (f) At the (time) of crop,

Table 4. SSNM recommendation for maize in North Sumatra.

Parameter	SSNM recommendation
(A) Plant spacing	70 x 20 cm
(B) Number of seeds $hole^{-1}$	1 seed $hole^{-1}$
Fertilizer rates	(C) Urea 350 kg ha^{-1}
	(D) SP36 200 kg ha^{-1}
	(E) KCl 150 kg ha^{-1}
Fertilizer splits	(F) 7 DAP
	Urea 100 kg ha^{-1}
	SP36 200 kg ha^{-1}
	KCl 150 kg ha^{-1}
	(G) 30 DAP (urea 125 kg ha^{-1})
	(H) 45-50 DAP (based on LCC)
	(I) VT (based on LCC)

researcher permit for taking result data; (g) accompany is technological at least 5 times; rill that is at the (time) of planting, fertilization of I II and III and harvest. (Team BPTP, SUMUT, 2007)

Production

Folowing the dissemination of SSNM fertilization recommendations for maize in five locations, we assessed their impact on production in Aug-Dec 2008 (Table 5).

The average production achieved by farmers who used farmers' fertilizer practice (FFP) was 8278 t ha^{-1} whereas those who adopted SSNM recommendations averaged 9353 t ha^{-1}, an increment of 11.49%. This thing happened because the application of fertilization by the way of SSNM 3 application times; rill by the way of dibber and then cover, differ from way of FFP the application of fertilization counted 2 times; rill by the way of put down by is crop side without closed so that happened runoff and evaporation. The constraints to farmers adopting SSNM technology were: (1) Rainfall uncertainty which makes it difficult to

Table 5. Maize production at five sites in North Sumatra.

Site	Average yield (kg ha^{-1})		
	PHSL	FFP cooperator	FFP noncooperator
Perbesi	10,122	8141	-
Pertumbuken	8521	8056	-
Gunung	8826	8000	-
Simolap	9708	8879	-
Kutabangun	9586	8313	-
Average	9.53	8278	-
% to FFP Co	11.49	-	-

Table 6. Economics of maize cropping (per ha) under SSNM recommendations and farmers' fertilization practices (FFP) in North Sumatra, 2007.

Parameter	FFP (Rp.)	SSNM (Rp.)
Land rent	500000	500000
Tractor	550000	550000
Planting	200000	200000
Herbicide on plant	75000	75000
Weed clearance I	100000	160000
Weed clearance II	100000	160000
Fertilization I	-	200000
Fertilization II	160000	200000
Fertilization III	160000	160000
Harvest cost (@ Rp.75000 t^{-1})	620850	701475
Transportation cost (@ Rp.70000 t^{-1})	579460	654710
Processing (@ Rp. 75 kg^{-1})	620850	701475
Dolomite labor cost	100000	100000
Total UHL	3766160	4362660
Urea (kg)	500	350
SP36 (kg)	250	200
KCl (kg)	150	150
Urea cost kg^{-1}	1500	1500
SP36 cost kg^{-1}	1800	1800
KCl cost kg^{-1}	3000	3000
Total fertilizer cost (Rp. ha^{-1})	1650000	1335000
Total seed cost (Rp. ha^{-1})	880000	792000
Dolomite 500 kg (1 sack = 50 kg)	120000	120000
Herbicide	255000	180000
Sack	321000	375000
Total material	3226000	2802000
Yield (t ha^{-1})	8.278	9.353
Maize price (Rp. kg^{-1})	2000	2000
Gross output (Rp. ha^{-1})	16556000	18706000
Total cost	6992160	7164660
Income	9563840	11541340
R:C ratio	2.37	2.61
B:C ratio	1.37	1.61
Increas in income (%)		17.13

apply fertilizer three times; according to fomentation; (2) difficulty in getting labor because of the planting schedule, crop and fertilization do together; (3) Rare of urea and if was have to be bought by tandem with other fertilizer (4) Lack of capital farmer so that have to borrow to warehouse maize or fertilizer shop with interest money large 5-10% per month; (5) farmers' habit of using abundant fertilizers; (6) Far the apart settlement of resident to hilly agriculture location so that many farmers only rely on labor in cultivations, fertilization, operation of HPT and harvest so that less observation (7) Habit of farmer in receiving seed, fertilizer, free herbicide so that difficulty in socialization without there is aid.

Because limitation of the farmer so that for planting season here in after BPTP North Sumatra give solution that is introducing appliance plant and fertilization for overcoming faced by problems is farmer.

Farmers' income

The benefit:cost ratio of farmers' fertilizer practice (FFP) treatment was 1.37 while that of the SSNM treatment was 1.61. The FFP treatment earned farmers an income of Rp. 9563.840 while the SSNM treatment fetched Rp. 11 541.340, an increase of 17.13%. this thing is caused by treatment of SSNM cost money compared higher labor of way of farmer, where farmers sweeping of weed apply herbicide which will influence continuity of life of soil microorganism and health of area of whereas treatment of SSNM apply way of manual this thing is for the sake of soil fertility and area. (Table 6).

Conclusions

1. SSNM recommendation for fertilization of maize in Tigabinanga subdistrict: 160 kg ha^{-1} N, 72 kg ha^{-1} P_2O_5 and 90 kg ha^{-1} K_2O.
2. 31.9% of farmers followed the fertilizer recommendation.
3. Production under SSNM recommendations was9,353 t ha^{-1} while production under farmers' practices was 8,278 t ha^{-1}, an increase of 11.49%.
4. Farmers' income increased 17.13% from Rp. 9,563.840 to Rp. 11,541.340
5. Due to labor constraints, farmers did not follow all the recommended practices.
6. Introduction of seed planters can solve difficulties of labor.
7. There is need for fertilizer applicators and seed planters to minimize labor costs.

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