Reprint **ISSN 1991-3036 (Web Version)**

International Journal of Sustainable Crop Production (IJSCP)

(*Int. J. Sustain. Crop Prod.*)

Volume: 12 **Issue: 1** **February 2017**

Int. J. Sustain. Crop Prod. 12(1): 10-14 (February 2017)

EFFECT OF POULTRY MANURE AND LIME IN COMBINATION WITH CHEMICAL FERTILIZER ON GROUNDNUT PRODUCTION IN CHAR AREAS UNDER TISTA MEANDER FLOODPLAIN AGRO-ECOLOGICAL ZONE IN BANGLADESH

Z. FERDOUS, A. HOSSAIN, N.U. MAHMUD, R. ALI AND N.U. AHMED

An International Scientific Research Publisher

Green Global Foundation©

Web address: http://ggfjournals.com/e-journals archive
E-mails: editor@ggfjournals.com and editor.int.correspondence@ggfjournals.com

ISSN-1991-3036 (Online)
Int. J. Sustain. Crop Prod. 12(1):10-14(February 2017)

EFFECT OF POULTRY MANURE AND LIME IN COMBINATION WITH CHEMICAL FERTILIZER ON GROUNDNUT PRODUCTION IN CHAR AREAS UNDER TISTA MEANDER FLOODPLAIN AGRO-ECOLOGICAL ZONE IN BANGLADESH

Z. FERDOUS[1*], A. HOSSAIN[2], N.U. MAHMUD[3], R. ALI[4] AND N.U. AHMED[5]

[1]Senior Scientific Officer, On-Farm Research Division, Bangladesh Agricultural Research Institute, Agricultural Research Station, Alamnagar, Rangpur, Bangladesh; [2]Scientific Officer, On-Farm Research Division, Bangladesh Agricultural Research Institute, Agricultural Research Station, Alamnagar, Rangpur, Bangladesh; [3]Senior Scientific Officer, Soil Science Division, Bangladesh Agricultural Research Institute, RARS, Jessore, Bangladesh; [4]Program Officer, CIP, Jessore, Bangladesh; [5]Scientific Officer, Tuber Crop Research Sub-station, Bangladesh Agricultural Research Institute, Munsigonj, Bangladesh.

*Corresponding author & address: Zannatul Ferdous, E-mail: zferdous80@gmail.com
Accepted for publication on 20 January 2017

ABSTRACT

Ferdous Z, Hossain A, Mahmud NU, Ali R, Uddin N (2017) Effect of poultry manure and lime in combination with chemical fertilizer on groundnut production in char areas under Tista Meander Floodplain Agro-Ecological Zone in Bangladesh. *Int. J. Sustain. Crop Prod.* 12(1), 10-14.

A field experiment was conducted at the Ulipur MLT site, OFRD, Rangpur during Rabi season, 2010-2011 to investigate the yield potentiality of groundnut in the farmer's field. Three treatments *viz.*, T_1= 20-45-50-20-2-1 kg ha^{-1} NPKSZnB + 4 t PM + 2 t Lime ha^{-1}, T_2= 20-30-50-20-2-1 kg ha^{-1} NPKSZnB + 2 t PM + 2 t Lime ha^{-1} and T_3= Farmers practice (30-20-18 NPK kg ha^{-1} based on field survey) were compared for this purpose. The experiment was laid out in a randomized complete block design with six dispersed replications. Significantly the highest BARI Chinabadam-8 grain yield (2.38 t ha^{-1}) was obtained from T_1 compared to T_3 and it was statistically similar to T_2. The highest gross margin (Tk. 38450 ha^{-1}) and benefit cost ratio (1.74) was obtained from T_2. The lowest gross margin (Tk. 24050 ha^{-1}) and benefit cost ratio (1.60) was obtained from T_3 (farmers practice).

Key words: *poultry manure, nutrient management, char areas, groundnut*

INTRODUCTION

The groundnut or peanut is one of the important legume crops of tropical and semiarid tropical countries, where it provides a major source of edible oil and vegetable protein. Groundnut kernels contain 47-53% oil and 25-36% protein. Groundnut is a self-pollinated crop whereas flowers are produced above ground and, after fertilization, pegs move towards the soil, and seed-containing pods are formed and developed underneath the soil. The productivity of groundnuts varies from 3500 kg ha^{-1} in the United States of America to 2500 kg ha^{-1} in South America, 1600 kg ha^{-1} in Asia, and less than 800 kg ha^{-1} in Africa (Prasad *et al*. 2009; Singh *et al*. 2013). This is due mainly to various abiotic and biotic constraints. Abiotic stresses of prime importance include temperature extremes, drought stress, soil factors such as alkalinity, poor soil fertility and nutrient deficiencies.

Groundnuts are one of the major oilseed crops of Bangladesh, but yields of groundnuts are lower in Bangladesh compared to the world average, with the result that Bangladesh produces only about 40 percent of its domestic oil consumption. Groundnut is the second major oil seed crops in Bangladesh covering an area of 0.076 million ha producing 1.2 million MT of nuts (Sarker *et al.* 2015). Increase in the production of this crop can help to minimize the shortage of edible oil in the country. It is the richest plant source of thiamin (B_1). Groundnut contains at least 13 different types of vitamins and also rich in 26 essential minerals. Incidence of disease is the most important obstacle for groundnut production. Groundnut is an important oilseed crop in Bangladesh on the basis of both in acreage and annual production (Biswas *et al.* 2000; Mondal and Wahhab, 2001.) Its cultivation covered about 0.087 million ha and produced about 1.25 million MT of seeds during 2011-12 (Krishi Diary, 2013). Groundnuts are mostly used as ingredients for a number of industrially processed foods and contribute little to oil production. Groundnut is a major crop in the char lands of Bangladesh, but because of poor yields, farmers derive a limited income from the crop. Fertilizer use improves nutrient supply, but little is used by resource-poor smallholder farmers, partly because of high cost which is two to six times that in Europe or the USA (Sanchez 2002; Vlek 1993). In addition to high cost, fertilizer use is constrained by very limited smallholder access to money for fertilizer purchase and insufficient to apply fertilizer to all of their land. Therefore, returns on fertilizer use need to be high such as benefit cost ratios (BC) >1 (CIMMYT 1988). Although fertilizer recommendations are commonly developed to maximize net returns ha^{-1}, smallholder farmers around the world often cannot apply enough fertilizer for groundnut production in char land areas. Groundnut production in char areas can potentially be maximized by identifying the right combinations of crop, nutrient, and application of organic manure rate. The production of groundnut is fluctuated more or less in every year (BBS 2012). The Non-Calcareous Grey Floodplain Soil under AEZ 3 at grater Rangpur region is extremely acidic with low level of soil fertility (Anowar *et al.* 2015). The vast area can be brought under successful crop cultivation through proper organic and inorganic fertilization. Sustainable crop production is also possible through the integrated use of nutrient management (Anwar *et al.* 2012; Ferdous *et al*. 2011a). Integrated nutrient management determines sustainable soil fertility and productivity (Baruah and Baruah, 2015; Ferdous *et al*. 2011a, b; Hasan *et al*. 2006; Ferdous *et al.* 2005). Poultry manure may be supplied a major portion of plant nutrients in soil and improved soil health (Sarker *et al*. 2010; Rahman *et al.* 2011). Groundnut is one of the major crops in char area. Though area and production of groundnut is going down day by day, most of the rural people are dependent on groundnut cultivation for their poverty reduction as they live in char area. Therefore,

Copyright© 2017 Green Global Foundation
www.ggfjournals.com

the present investigation was undertaken to investigate the yield potentiality of groundnut influenced by poultry manure in combination with chemicals fertilizer as well as to determine the optimum nutrient management for groundnut production in char areas.

MATERIALS AND METHODS

Site description and experimental design

The study was initiated at Multilocation Testing (MLT) site Ulipur, Kurigram, Bangladesh during 2010-2011 cropping seasons in the farmer's field condition of 6 selected farmers to evaluate the yield potential of groundnut in char land areas through organic and inorganic fertilizer management. The study area is located at 21°24' N latitude and 88°23' E longitude with 31 m above mean sea level. The area mostly falls under high and medium high land areas of the Tista Meander Floodplain (AEZ-3) with an extent of 946,803 ha (Anowar *et al*. 2015; Ferdous *et al*. 2016). Soils are rapidly permeable, loamy on the upper part of high floodplain ridges and slowly permeable, heavy silt loam or silty clay loam on lower land. Organic matter content is low in higher parts, but moderate in lower parts. The general fertility level is low to medium (FRG 2012). The initial soil samples of the experimental fields were collected and total N content of soil determined by Kjeldahl method (Jackson 1973), available P by ascorbic acid and blue color method (Watanabe and Olsen, 1965), exchangeable K by flame photometer (Gallenkamp) and available S by turbidimetric method (Chesnin and Yien, 1951). The analytical report has been presented in the Table 1. Weather data during crop growing season were presented in Table 2. The area receives an annual rainfall of around 1669 mm with relatively early onset and late cessation and the mean annual temperature is about 25.08°C.

Table 1. Initial status of soils at MLT site, Ulipur, Kurigram during 2010-2011

Soil characteristics	MLT site Ulipur, Kurigram
Land type and soil texture	Medium High Land and Loamy
pH	5.91
Organic Matter (%)	1.03
K (mleq/100 soil)	2.69 (High)
N (%)	0.08 (Very low)
P (Micro gram/g soil)	24.61 (Very high)
S (Micro gram/g soil)	32.7 (High)
Zn (Micro gam/g soil)	0.61 (Low)
B (Micro gram/g soil)	0.43 (Optimum)

Table 2. Weather conditions during the growing period of Radish-Potato/maize-Transplant aman rice in Tista Meander Floodplain Agro Ecological Zone in Bangladesh at 2010 and 2011

Year	Month	Total rainfall (mm)	Temperature		
			Maximum	Minimum	Mean
2010	January	--	22.6	10.5	16.55
	February	--	25.4	13.4	19.4
	March	--	31.7	19.1	25.4
	April	168.4	31.6	23.2	27.4
	May	237.5	31.7	23.3	27.5
	June	647.8	31.3	24.9	28.1
	July	346.6	32.4	26.4	29.4
	August	240.6	31.8	26.6	29.2
	September	331.8	32.1	25.5	28.8
	October	122.4	30.8	23.6	27.2
	November	0.6	29.1	18.5	23.8
	December	2	24.8	12.7	18.75
2011	January	--	20.8	9.2	15.0
	February	20.6	29.1	14.8	21.95
	March	9.9	29.8	18.3	24.05
	April	26.5	31.5	21.4	26.45
	May	262.4	32.8	23.4	28.1
	June	305.7	32.7	25.2	28.95
	July	388.3	32.2	26	29.1
	August	540.4	32.1	26	29.05
	September	367.3	32.5	26.1	29.3
	October	5.8	31.2	24.5	27.85
	November	0.06	28	17.7	22.85
	December	--	23.2	12.9	18.05

Source: Regional Meteorological Office, Rangpur, Bangladesh

There were three fertilizer treatments (calculated by initial soil analysis based on soil test) in MLT site in 2010-2011 *viz*., T_1= 20-45-50-20-2-1 kg ha^{-1} NPKSZnB + 4 t PM + 2 t Lime ha^{-1}, T_2= 20-30-50-20-2-1 kg ha^{-1} NPKSZnB + 2 t PM + 2 t Lime ha^{-1} and T_3 = Farmers practice (30-20-18 NPK kg ha^{-1} based on field survey) were evaluated for this purpose. Zinc sulphate monohydrate ($ZnSO_4.H_2O$) was used as a source of Zn. Urea, TSP, MOP, Gypsum and Boric acid were used as the sources of N,P,K,S and B, respectively. The experiment was laid out in a RCB design which was also replicated in six dispersed farmer's field (Ferdous *et al.* 2016).

Crop management

The entire amount of organic manure was applied 4 days before final land preparation. Full amount of PKS and 1/3 of N were applied at the time of final land preparation. One weeding was done at 30 days after emergence (DAE). The rest of N was applied into two equal splits at 25-30 DAS and at 40-50 DAS. Other intercultural operation was done as and when necessary. The seeds of BARI Chinabadam-8 were sown on 11 December, 2010, maintaining 30 cm x15 cm plant spacing. Lime @ 2 t ha^{-1} (dolomite) (Khandakhar *et al*. 2004) was applied one month before sowing in T_1 and T_2 treatment. The crop was harvested on 26 May, 2011.

Data collection and statistical analysis

After maturing randomly 5 plants were harvested to record the yield and yield contributing characters of ground nut. Fresh nut yield was harvested from randomly pre-selected central areas (about 9 m^{-2}) of each plot and converted into tons per hectare (t ha^{-1}). Mean data was analyzed statistically and was carried out to analysis of variance (ANOVA) using the MSTAT-C. Gross return (GR), total variable cost (TVC) and gross margin (GM) have been calculated using the following formula:

GR = Return of main product.
= Yield Price (Tk.)
TVC = All input cost except land cost and interest on operating capital.
GM = GR-TVC

RESULTS AND DISCUSSION

Yield and contributing character of groundnut

The yield and yield contributing characters are presented in Table 3. The highest number of pods/ plant was obtained from T_1 (15.73 pods $plant^{-1}$) which were statistically similar to T_2 (14.47 pods $plant^{-1}$) but differed significantly from T_3 (farmers practice). The number of seeds /pod did not vary due to fertilizer treatments. Significantly the highest 100 seed weight (53.40 g) was recorded from T_1 followed by T_2 and the lowest 100 seed weight was obtained from T_3 (farmers practice). These results may be due the parameters of growth components increased with increasing amount of organic and inorganic fertilizers applied. This can be due to the role of organic fertilization in plant physiology and improving the quantity and quality growth characterization and can provide plants with essential elements required (Sun *et al*. 2003; Lin *et al*. 2010; Ferdous *et al*. 2014). The highest pod yield (2.38 t ha^{-1}) was obtained from T_1 which was statistically similar to T_2 (2.26 t ha^{-1}) treatments but deferred significantly from T_3 (farmers practice). Combination of organic and inorganic fertilizer treated plots produced higher yield that plots without combination of organic and inorganic fertilizer (Ferdous *et al*. 2011a,b; Sarker *et al*. 2010; Rahman *et al*. 2011; Anwar *et al*. 2012; Ferdous *et al*. 2017). Similar results are reported by Tran Thi (2003), Ahmed *et al.* (2017) and Anil *et al*. (2008) who report increase grain yield with phosphorus and organic manure application. Anil *et al.* (2008) observed an increase in seed yield of chickpea with combine application of organic and inorganic fertilizers. Tarawali and Quee (2014) reported that the number of pods per plant at harvest and pod yield per hectare and consequently yield in groundnut were influenced by different levels of fertilizer application.

Table 3. Effect of different fertilizer dose on yield and Yield contributing characters of groundnut at Ulipur MLT site, Kurigram during rabi 2010-2011

Treatments	Number of pods $plant^{-1}$	Number of Seeds pod^{-1}	100 seed weight (g)	Yield (t ha^{-1})
T_1	15.73 a	1.77	53.40 a	2.38 a
T_2	14.47 a	1.73	52.60 b	2.26 a
$T_{3\,(FP)}$	13.00 b	1.71	50.07 c	1.60 b
CV (%)	4.32	1.80	4.11	2.98
Level of significance	NS	NS	**	**

Note: ** significant at 1 percent level, T_1= 20-45-50-20-2-1 kg ha^{-1} NPKSZnB + 4 t PM + 2 t Limeha^{-1}, T_2= 20-30-50-20-2-1 kg ha^{-1} NPKSZnB + 2 t PM + 2 t Limeha^{-1} and T_3 = Farmers practice

Economic performance

The cost and return analysis of different treatments are presented in Table 4. The highest gross return (BDT. 95200) was found in T_1 treatment followed by T_2 and the lowest gross return (Tk. 64000) was recorded from T_3 (farmers practice). The highest gross margin (BDT. 38450 ha^{-1}) and benefit cost ratio (1.74) was obtained from T_2. The lowest gross margin (Tk. 24050 ha^{-1}) and benefit cost ratio (1.60) was obtained from T_3 (farmers

practice) (Anwar *et al*. 2012). Similar result was reported by Ferdous *et al*. (2011a, 2011b) who report highest gross margin with combination of organic and inorganic fertilizer application.

Table 4. Cost and return analysis of groundnut at Ulipur MLT site, OFRD, Kurigram, Rangpur during rabi season, 2010-2011

Treatments	Yield (t ha^{-1})	Gross return (BDT. ha^{-1})	Total variable cost (BDT. ha^{-1})	Gross margin (BDT. ha^{-1})	BCR
T_1	2.38	95200	57950	37250	1.64
T_2	2.26	90400	51950	38450	1.74
T_3	1.6	64000	39950	24050	1.60

Exchange rate in 2012: 1 USD = approx. 82 BDT (Bangladeshi Taka)

Market price of Ground nut @ 40 BDT kg^{-1}, urea @ 16, triple super phosphate @ 25, muriate of potash @15, gypsum @10, zinc sulphate @ 150 and boric acid@ 150 BDT kg^{-1}, Organic manure @ 6 BDT kg^{-1}

T_1= 20-45-50-20-2-1 kg ha^{-1} NPKSZnB + 4 t PM + 2 t Limeha^{-1}, T_2= 20-30-50-20-2-1 kg ha^{-1} NPKSZnB + 2 t PM + 2 t Limeha^{-1} and T_3 = Farmers practice

CONCLUSION

Fertilizer application, especially for NPK and organic manure applied to groundnut, can be highly profitable with sustainable production increases for smallholder farming in char land areas of Bangladesh. Mean groundnut grain yield increase was 0.78 and 0.66 t ha^{-1} with application of 20-45-50-20-2-1 kg ha^{-1} NPKSZnB + 4 t PM + 2 t ha^{-1} Lime, and 20-30-50-20-2-1 kg ha^{-1} NPKSZnB+2 t PM +2 t ha^{-1} Lime, respectively. Integrated nutrient management (combination of organic and inorganic fertilizer) is the best option for higher groundnut production in char areas.

REFERENCES

Ahmed NU, Mahmud NU, Salim M, Halder SC, Ullah H (2017) Yield maximization of potato (*Solanum tuberosum* L.) through integrated nutrient management system. *Int. J. Nat. Soc. Sci.* 4(1), 49–56.

Anil KD, Qazi AK, Moynul H, Shafil L (2008) Effect of phosphorus fertilization on dry matter accumulation, nodulation and yield of chick pea, *Bangladesh Res. Publ. J*. 1(1), 47–60.

Anowar M, Parveen A, Ferdous Z, Kafi AH, Kabir ME (2015) Baseline survey for farmer livelihood improvement at farming system research and development, Lahirirhat, Rangpur. *Int. J. Bus. Manag. Soc. Res*. 2, 92–104. doi: http://dx.doi.org/10.18801/ijbmsr.020115.10

Anwar M, Ferdous Z, Islam M (2012) Determination of nutrient management for potato-mungbean-T. aman based cropping pattern. *Bangladesh J. Prog. Sci. Tech*. 10, 173–176.

Baruah A, Baruah KK (2015) Organic manures and crop residues as fertilizer substitutes: impact on nitrous oxide emission, plant growth and grain yield in pre-monsoon rice cropping system. *J Environ Prot*. 6, 755–770.

BBS (Bangladesh Bureau of Statistics) (2012) Statistical year book of Bangladesh, Bangladesh Bureau of statistics. Statistical Division, Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka.

Biswas GC, Begum S, Mian MY (2000) Leaf infestation and yield loss caused by thrips and jassids in groundnut. *J. Asiat. Soc. Bangladesh Sci*. 26(2), 253–258.

Chesnin L, Yien CH (1951) Turbidimetric determination of available sulfates. *Soil Sci. Soc. Ame. Proc*. 15, 149–151.

CIMMYT (1988) From agronomic data to farmer recommendations: an economics training manual. Mexico, D.F. pp. 34–35.

Ferdous Z, Anowar MM, Haque Z, Mahamud NU, Hossain MM (2014) Comparative performance of two magnesium source on yield and yield attributes of potato. *Bangladesh. J. Environ. Sci.* 27, 98–101.

Ferdous Z, Anwar M, Mahamud NU, Sarker MAI, Mannaf MA (2011b) Performance of cowdung bio-slurry as a source of organic manure on wheat production. *Int. J. Ecotoxicol. Agric. Technol.* 1, 115–118.

Ferdous Z, Anwar M, Rahman MA, Yasmine F, Nain J (2011a) Fertilizer management for maize-mungbean-T. aman based cropping pattern. *J. Agrofor. Environ.* 5, 129–132.

Ferdous Z, Anwar M, Uddin N, Ullah H, Hossain A (2017) Yield performance of okra (*Abelmoschus esculentus*) through integrated nutrient management. *Int. J. Biosci.* 10, 294–301. http://dx.doi.org/10.12692/ijb/10.1.294-301

Ferdous Z, Datta A, Anal AK, Anwar M, Khan MR (2016) Development of home garden model for year round production and consumption for improving resource-poor household food security in Bangladesh. *NJAS – Wagen. J. Life Sc.* 78, 103–110. http://www.sciencedirect.com/science/article/pii/S1573521416300306

Ferdous Z, Sarkar MAR, Hasan AK (2005) Effect of variety and split application of nitrogen on yield of wheat. *Bangladesh J. Seed Sci. Tech*. 8, 97–103.

FRG (2012) Fertilizer Recommendation Guide, Bangladesh Agricultural Research Council, BARC, Farmgate, Dhaka, 1215, 274p.

Hasan AK, Ferdous Z, Rahman AKMM, Mahmud NU (2006) Yield and yield components of wheat as influenced by tillage, fertilizer level and water regime. *J. Agric. Educ. Technol*. 9, 123–126.

Jackson M L (1973) Soil Chemical Analysis. Prentice Hall of India Pvt. Ltd. New Delhi pp 498.

Khandakhar SMAT, Rahman MM, Uddin MJ, Khan SAKU, Quddus KG (2004) Effect of lime and potassium on potato yield in acid soil. *Pak. J. Biol. Sci*. 7, 38-383.

Krishi Diary (2013) Crop production target and achieved 2011–12. Agriculture Information Service, Khamarbari, Farmgate, Dhaka. 98p.

Lin X, Wang F, Cai H, He C, Li Q, Li Y (2010) Effects of different organic fertilizers on soil microbial biomass and peanut yield. 19th World Congress of Soil Science, Soil Solutions for a Changing World.

Mondal MRI, Wahhab MA (2001) Production Technology of Oilcrops. Oilseed Research Centre, BARI, Gazipur, 111p.

Prasad PVV, Kakani VG, Upadhyaya HD (2009) Growth and production of groundnut. In: Verheye WH (ed) Soils, plant growth and crop production, encyclopedia of life support systems. Eolss Publishers, Oxford.

Rahman MM, Yasmine F, Rahman MA, Ferdous Z, Kar PS (2011) Performance of poultry bio-slurry as a source of organic manure on potato production. *J. Agrofor. Environ*. 5, 81–84.

Sanchez PA (2002) Soil fertility and hunger in Africa. *Science* 295, 2019–2020.

Sarker JR, Akhter S, Jahan M (2015) Credit Facilities in Groundnut Production and its Impact on Poverty Reduction- A Farm Level Survey in Mymensingh District. *J. Environ. Sci. & Natural Resources*, 8(2), 57–62.

Sarker MAI, Ferdous Z, Anwar M, Mahamud NU, Ali M (2010) Performance of poultry bio-slurry as a source of organic manure on wheat production. *Bangladesh J. Environ. Sci*.19, 36–38.

Singh P, Nedumaran S, Ntare BR (2013) Potential benefits of drought and heat tolerance in groundnut for adaptation to climate change in India and West Africa. *Mitig. Adapt. Strateg. Glob. Chang.* 19, 509–529.

Sun R, Zhao B, Zhu L (2003) Effect of long-term fertilization on soil enzyme activities and its role in adjusting-controlling soil fertility. *Plant Nutrition and Fertilizer Sci.* 9, 406–410.

Tarawali AR, Quee DD (2014) Performance of groundnut (*Arachis hypogaea* L.) varieties in two agro-ecologies in Sierra Leone. *Afr. J. Agric. Res*. 9(19), 1442-1448. doi: 10.5897/AJAR2014.8660

Tran Thi Thu Ha (2003) Effect of phosphorus fertilizer on groundnut yield in poor alluvial and sandy soils of Thua Thein Hue, *Beeter crops Int.* 17, 2 November 2003.

Vlek PLG (1993) Strategies for sustaining agriculture in sub-Saharan Africa. In: Rogland, J., Lal, R. (Eds.), Technologies for Sustaining Agriculture in the Tropics. ASA, CSSA, and SSSA, Madison, WI, pp. 265–277, ASA Spec. Publ. 56

Watanabe FS, Olsen SR (1965) Test of an ascorbic acid method for determining phosphorus in water and $NaHCO_3$ extracts from soil. *Soil Sci. Soc. Ame. Proc*. 29, 677–678.