Journal of Nature Studies 10 (2): 38-43
ISSN: 1655-3179

AGRONOMIC AND PHYSIOLOGICAL RESPONSES OF MAIZE CULTIVARS TO LOW NUTRIENT SUPPLY IN THE FIELD

Renih Hayati[1)], Asmawati[2)], and Munandar[1)]
[1)]Faculty of Agriculture, Sriwijaya University and
[2)] Palembang University, South Sumatera, Indonesia

Abstract - Low soil fertility can constrain the maize (*Zea mays* L.) yield. The objectives of the experiment were (i) to evaluate the agronomic and physiological responses of maize cultivars to low nutrient supply to be able to determine the most sensitive character and (ii) to identify the tolerant and nutrient efficient cultivar under low nutrient supply. The experiment was conducted at Agro Techno Park, South Sumatra. Experimental design was Split Plot with three replications. Nutrient supply was the main plot and cultivar (Lamuru, Sukmaraga, Bisma, Bayu, Srikandi Kuning dan Srikandi Putih) the subplot. The nutrient supply treatments were (i) H1: standard rate of fertilizer and (ii) H2 :low nutrient supply, which is 30% of standard rate. The results showed that each cultivar responded differently to low nutrient supply. Based on all characters of the cultivars evaluated in this study, the most sensitive character was LAI for agronomic character with a tolerance index of 39-89 % and Nitrate Reductase (NR) activity for physiological character with a tolerant index of 39-86 %. This suggests that LAI and NR can be used as selection criteria in maize for nutrient efficient character. Furthermore, Sukmaraga and Lamuru were the most tolerant cultivars to low nutrient supply while Srikandi Putih was the most susceptible one. Sukmaraga had a highest yield (6.23 ton/ha) under low nutrient supply. Therefore Sukmaraga can be considered as nutrient efficient cultivar.

Keywords: maize, nitrate reductase, nutrient efficiency, nutrient supply

INTRODUCTION

Maize plants usually suffer in the soil type with pH less than 5.6, especially due to deficiency of macro elements and toxicity of Al and Fe (Granados *et al*., 1993). Liming and high rate of chemical fertilizer can reduce the effects, but farmers often cannot afford their uses. Maize cultivars with high nutrient efficiency and tolerance to acid soil offer an alternative as well as environmental friendly solution to the problem. So far, tolerant maize cultivars to the acid soil have been released such as Antasena and Sukmaraga. However, high nutrient efficient cultivars have not been made available.

Nutrient efficient genotype has the ability to produce a higher yield than other genotypes in a soil that is limiting in one or more mineral nutrients or under low nutrient supply (Presterl *et al*., 2003; Worku *et al*., 2007). Selection for nutrient efficient genotypes can be done by comparing the yields under low and the yields under normal nutrient supply condition (Baligar *et al*., 1989). Genotype having equal or less difference in yield between those two conditions is considered tolerant genotype and expected to carry the nutrient efficient character.

Nutrient uptake by the roots is an important factor which determines the nutrient efficiency. Genotype can be different in developing the root morphology to increase the nutrient uptake when grown in deficient soils or media. Hayati *et al.* (2006) studied the root system and tolerance of 18 maize cultivars/lines to low nutrient availability in the nutrient solution media. Plants were grown in the Kimura B solution (pH 5.8) with 30 % of standard nutrient rate in the greenhouse for four weeks. They found that Lamuru was the most tolerant cultivar, Srikandi Putih was the most susceptible, while Sukmaraga, Srikandi Kuning, Bisma, and Bayu were moderates. Tolerant cultivar was characterized by having longer roots, higher root numbers and dry weight compared to moderate or susceptible ones.

Hayati *et al.* (2006) conducted the research for four weeks (vegetative period) in the nutrient solution media with pH around 5.8. In the present study the maize plants were planted until the harvest maturity in the field with the objectives (i) to evaluate the agronomic and physiological responses of maize cultivars to low nutrient supply in order to determine the most sensitive character and (ii) to identify the tolerant as well as nutrient efficient cultivars under low nutrient supply. Result of the studies can be used by farmers in choosing the appropriate maize cultivars with high nutrient efficiency character or can be used by plant breeders in developing the nutrient efficient maize genotypes.

MATERIALS AND METHODS

The research was conducted at Agro Techno Park (ATP), Indralaya, South Sumatra. The

To cite this paper: Hayati, R., Asmawati and Munandar. 2011. Agronomic and physiological responses of maize cultivars to low nutrient supply in the field. *Journal of Nature Studies*. 10 (2): 38-43

soil used was Cambisol with 5.4 pH, 35.6 g kg^{-1} organic carbon, 2.7 g kg^{-1} total nitrogen (N), 18.75 mg kg^{-1} P- Bray I. The total cation exchange capacity of the soil was 15.23 Cmol kg^{-1}. The exchangeable cations present in the soil and the amounts were as follows: 0.26 potassium (K), 0.33 calcium (Ca), 0.75 sodium (Na), 0.1 magnesium (Mg), and 0.7 aluminum (Al). Open pollinated maize cultivars which were considered tolerant to low nutrient supply, Lamuru (L), moderate, Sukmaraga (S), Bisma (B), Bayu (Y), Srikandi Kuning (SK), and susceptible, Srikandi Putih (SP) based on Hayati *et al.* (2006) were planted in plots applied with standard liming and nutrient supply at ATP (H1: 2 ton ha^{-1} lime, 5 ton ha^{-1} organic fertilizer, 300, 100, and 50 kg ha^{-1} Urea, SP 36 and KCl, respectively) or low nutrient supply (H2: 30 % of standard rate for Urea, SP 36, and KCl without lime and organic fertilizer). The experimental design used was Split Plot Design with three replications. Nutrient supply was the main plot and maize cultivar was the sub plot.

Seeds of each cultivar were planted manually in 7 m x 3 m plot with two seeds per hole. The plant spacing was 70 cm x 20 cm, so each plot consisted of 10 rows of plant with 15 plants per row after the plants were thinned to one per hole at 2 weeks after planting (WAP). Fertilizers (SP 36, KCl and 1/3 of Urea) were applied at planting and the rest of Urea was applied at 4 WAP. Plant height and leaf chlorophyll of 10 sample plants were measured at 6 WAP (the end of vegetative period). Leaf chlorophyll at the second top leaf was recorded using the chlorophyll meter SPAD 502. NR Activity was determined by the method of Alnopri (2004). The fresh leaf material for analysis was taken at 6 WAP. It was immersed in the 0.1 M phosphate buffer (pH 7.6) for 24 hours, the medium was changed into phosphate buffer (pH 7.5) which contained 0.08 % of sodium dodecyl sulfate and 0.1 M $NaNO_3$. The leaf material was incubated for three hours. The enzyme activity was calculated based on the absorbance value at 540 nm. Leaf area of 1.4 m^2 ground area was measured by leaf area meter and used to calculate the leaf area index. At harvest maturity, all the ears in each plot were hand harvested, counted, and dried in the drying room for two weeks and weighed (13% moisture). Ear weight (kg) per plot was converted into yield (ton) per ha. Ear weight per plant was obtained by dividing the ear weight per plot with the number of ears per plot. Other data yield components were measured on the 10 sample plants. After the ears were harvested, the soil around the 10 sample plants were dug. The roots were separated from the shoot, washed, dried, and weighed.

The evaluation of cultivar's tolerance to low nutrient supply was based on the formula of Baligar *et al.* (1989) as written in Hayati *et al.* (2006). Tolerance index is the percentage of value at low (H2) to the value at standard (H1) nutrient supply for certain variable. The cultivar is considered tolerant if its tolerance index ≥ the mean + standard deviation of tolerance indexes of all cultivars evaluated. In contrast, the cultivar is considered susceptible if its tolerance index ≤ the mean – standard deviation, and moderate if the tolerance index is in between these indices. Correlation coefficients were computed to determine the relationship among the characters.

RESULTS AND DISCUSSIONS

Results

Root development was restricted under low

Table 1. Agronomic responses (growth characteristics) and tolerance indexes of several maize cultivars under low nutrient supply.

Variable	**Cultivar**					
	L	**S**	**B**	**Y**	**SK**	**SP**
Root dry weight (g)						
H1: Standard	14.3	24.8	12.5	11.8	21.0	14.3
H2: Low	10.4	20.1	9.6	11.4	11.2	8.3
Tolerance Index H2 / H1 (%)	72	81	77	97	53	58
Mean	73		Mean + SD		89	
Standard deviation	16		Mean – SD		57	
Plant height (cm)						
H1: Standard	132	161	145	142	141	135
H2: Low	122	143	126	128	103	95
Tolerance Index H2 / H1 (%)	92	89	87	90	73	71
Mean	84		Mean + SD		93	
Standard deviation	9		Mean – SD		75	
Leaf Area Index						
H1: Standard	3.42	5.35	2.88	3.45	3.65	3.50
H2: Low	2.85	3.60	2.57	2.81	2.24	1.35
Tolerance Index H2 / H1 (%)	83	67	89	82	61	39
Mean	70		Mean + SD			89
Standard deviation	19		Mean – SD			51

nutrient supply. This was seen in lower root dry weight (H2) for all cultivars compared to root dry weight under standard nutrient supply (H1). Srikandi Putih had the lowest root dry weight at H2 and higher root dry weight reduction (42 %) compared to other cultivars except Srikandi Kuning (Table 1). Based on tolerance index for root dry weight, Bayu was considered a tolerant cultivar (≥ mean + Standard Deviation (SD) but Srikandi Kuning and Srikandi Putih were susceptible (≤ mean – SD). The other cultivars were moderate.

Shoot growth was also inhibited under low nutrient supply (H2). Plant height at vegetative stage and leaf area index were lower at H2 for all cultivars, compared to H1, with the lowest for Srikandi Putih (Table 1). Therefore, based on tolerance indexes for plant height and leaf area index, Srikandi Putih was considered a susceptible cultivar with the highest reduction for plant height (29%) and leaf area index (61%).

Reduction of nutrient supply to the plant also reduced the leaf chlorophyll by 11 to 41 % and NR activity by 14 to 61% (Table 2). Sukmaraga had the highest leaf chlorophyll and NR activity, while Bisma had the lowest leaf chlorophyll and Srikandi Putih had the lowest NR activity under low nutrient supply (H2) (Table 2). Sukmaraga was considered a tolerant cultivar based on tolerance index of NR activity.

The yield and its components were also affected by low nutrient supply with 1000-kernel weight as the least weight. The reduction observed was between 14 to 42 % for yield, 11 to 34 % for ear weight, 7 to 20 % for kernel number and 2 to 12 % for 1000-kernel weight (kernel size). Sukmaraga had the highest yield and yield components under low nutrient supply except for 1000-kernel weight variable. The lowest data observed was not consistent among cultivars (Table 3). The most tolerant cultivar based on tolerance index of kernel number and yield was Lamuru, for ear weight was Sukmaraga, and for 1000-kernel weight was Bayu. The most susceptible cultivar based on tolerance index of yield and yield components were Bisma followed by Srikandi Putih (Table 4).

Table 2. Physiological responses and tolerance indexes of several maize cultivars under low nutrient supply.

Variables	Cultivars					
	L	S	B	Y	SK	SP
Leaf Chlorophyll						
H1: Standard	53	56	54	49	51	55
H2: Low	45	48	32	44	42	42
Tolerance index H2 / H1 (%)	84	86	59	89	81	76
Mean	79		Mean + Sd			90
Standard deviation (Sd)	11		Mean – Sd			68
Nitrat Reductase Activity (umol NO2 / g/ h)						
H1: Standard	30,76	37,31	20,33	20,93	26,74	15,40
H2: Low	20,24	32,03	10,78	8,17	15,20	8,11
Tolerance Index H2 / H1 (%)	66	86	53	39	57	53
Mean	59		Mean + Sd			75
Standard deviation (Sd)	16		Mean – Sd			43

Discussion

The plant growth was inhibited under low nutrient supply (H2) (Table 1). Plant responded to low nutrient supply by decreasing the root, stem, and leaf growth as shown by lower root dry weight, plant height and leaf area index observed under low nutrient supply compared to standard nutrient supply. Srikandi Kuning and Srikandi Putih had the highest reduction in these variables. The leaf growth rate, and thus the LAI can be limited by low rates of net photosynthesis and/or insufficient cell expansion when the nutrient supply is low or sub optimum (Marschner, 1995). The significant positive correlation of LAI with plant height (r = 0. 798*) (Table 4) probably was due to the relationship between plant height and leaf number. The reduction in plant height can lower the leaf number and LAI. Results of other researchers showed a decrease in plant height, plant dry weight and leaf area index where the N supply is decreased (Uhart and Andrade, 1995; Ding *et al.*, 2005; Hirel *et al*., 2007).

Generally, tolerant and moderate cultivars had better root and shoot growth than susceptible cultivar such as Srikandi Putih (Table 1). The root dry weight had significant positive correlation with leaf area index (Table 4). This implies a relationship between root and shoot. Well developed roots have the ability to supply nutrient adequately to the shoot for shoot growth. According to Fitter and Hay (1991), the amount of photosynthate produced by photosynthetic process in the shoot defines the root ability to get the nutrient, whereas the nutrient supply from the root to the shoot will control the photosynthetic rate. Mineral nutrients such as nitrogen can be directly or indirectly involved in the photosynthetic process. Most of the total inorganic N in green leaf cells is located in the chloroplasts especially as enzyme protein. Nitrogen is also required for chlorophyll synthesis, a photosynthetic pigment. A deficiency of N, therefore, can result in low photosynthetic activity (Marschner. 1995; Boussadia *et al*., 2010). Relationship between root and shoot in maize plants was also found by Tian *et al.* (2006) and Peng *et al.* (2010). N-efficient maize plant with large total green leaf area had large root system while N-inefficient one with small shoot size also had small root size (Peng *et al*., 2010).

Yield is a function of seed number and seed size which means weight per seed (Egli, 1998). The kernel number and kernel size positively correlated with ear weight and yield but the correlation coefficient was higher for kernel number than kernel size (Table 4). This suggests that ear weight and yield are affected more by kernel number than by kernel size. Similar result was found by Barbieri *et al*. (2000). The kernel number per ear had significant positive correlation with root dry weight and LAI (Table 4). Nutrient uptake by the root can affect the LAI, photosynthetic capability (Boussadia *et al*., 2010) and the supply of photosynthate for seed development. Hayati *et al*. (2009 a; b) also found that leaf area significantly correlated with seed number and ear weight. The yield and yield components were decreased by reducing the nutrient supply from standard to low rate. Bisma and Srikandi Putih cultivars had the highest reduction and were considered susceptible cultivars based on the tolerance indexes for ear weight and yield.

Table 3. Agronomic responses (yield and yield components) and tolerance indexes of several maize cultivars under low nutrient supply.

Variable	Cultivar					
	L	**S**	**B**	**Y**	**SK**	**SP**
Kernel number						
H1: Standard	532	608	473	451	529	473
H2: Low	492	530	429	403	482	379
Tolerance Index H2 / H1 (%)	93	87	91	89	91	80
Mean	89		Mean + SD			93
Standard deviation (SD)	4		Mean – SD			85
1000- kernel weight (g)						
H1: Standard	270	296	309	269	272	310
H2: Low	251	280	273	263	261	285
Tolerance Index H2 / H1 (%)	93	94	88	98	96	92
Mean		94	Mean + SD			97
Standard deviation		3	Mean – SD			91
Ear weight (g)						
H1: Standard	108	134	132	101	133	129
H2: Low	93	120	88	75	103	93
Tolerance Index H2 / H1 (%)	86	89	66	74	77	72
Mean	78		Mean + SD			87
Standard deviation	9		Mean – SD			69
Yield (ton/ha)						
H1: Standard	5,15	8,28	7,77	5,03	7,75	6,96
H2: Low	4,41	6,23	4,54	3,53	5,41	4,14
Tolerance Index H2 / H1 (%)	86	75	58	70	70	59
Mean		70	Mean + SD			80
Standard deviation (Sd)		10	Mean – SD			60

Based on the agronomic characters (growth, yield and yield components) of the cultivars evaluated in this study, the most sensitive character in response to low nutrient supply was LAI with the tolerance index of 39 to 89 % and the least sensitive character was 1000-kernel weight with the tolerance index of

88 to 98 %. This implies that LAI can be used as selection criterion for nutrient efficient character.

Physiological characteristics were represented by leaf chlorophyll and NR activity. The leaf chlorophyll measured by SPAD 502 was less in low nutrient supply compared to standard data (Table 2). Nitrogen is a constituent of leaf chlorophyll, so low N supply could reduce the leaf chlorophyll as found by Ding *et al.* (2005).

analyzed but the soil pH without liming was probably lower than standard nutrient supply plus liming. Sukmaraga had the highest NR activity under low nutrient supply; and was considered a tolerant cultivar based on tolerance index of NR activity. This suggests that Sukmaraga had the highest ability to take up nitrate than ammonium compared to other cultivars evaluated under low nutrient supply. Utama (2008) found that Al-

Table 4. Correlation coefficient (r) among characters evaluated under low nutrient supply.

	Root Weight	Plant Height	LAI	Chlo.	NRA	Seed No	1000-kernel wt.	Ear Weight
Root Wt.	-							
Plant Height	0.313	-						
LAI	0.619*	0.798*	-					
Chlorophyll	0.368	0.087	0.084	-				
NRA	0.584*	0,562*	0.732*	0.428	-			
Seed No	0.589*	0.362	0.633*	0.371	0.744*	-		
1000-seed Wt	0.097	0.055	0.139	0.049	0.075	0.062	-	
Ear Weight	0.080	0.358	0.244	0.255	0.609*	0.273	0.186	-
Yield	0.109	0.411	0.326	0.222	0.600*	0.373	0.188	0.957*

*Significant at the 0.05 probability level (n = 18).

NR catalyzes the reduction of nitrate to nitrite. This is the initial step in the conversion of nitrate to ammonium, and thought to be the most limiting step in N assimilation (Kelly *et al*., 1995). Therefore, it could be important in determining growth and yield potential. Some effort has been devoted to selection of crop plants having high NR activity. Komariah *et al.* (2004) found a correlation between leaf NR activity and yield of flooding tolerance soybean genotypes. Sopandie (1999) *in* Utama (2008) also found that NR activity of Al tolerance was higher than Al susceptible soybean. This study showed that NR activity had significant positive correlation with ear weight and yield under low nutrient supply (Table 4). This implies that NR activity could be used as selection criterion of nutrient efficiency in maize during vegetative period. NR activity, as physiological character, had more sensitive response to low nutrient supply compared to leaf chlorophyll. The tolerance index of the cultivars evaluated ranged from 39 to 86 % for NR activity and 59 to 89 % for leaf chlorophyll (Table 2).

The leaf NR activities of all cultivars were lower under low nutrient supply compared to standard nutrient supply (Table 2). According to Marchner (1995), leaf NR activity is inhibited by ammonium. The uptake of ammonium is higher than nitrate uptake when soil pH is low. In contrast, liming increased soil pH, nitrate uptake, nitrate translocation to the shoot, and NR activity. The soil pH after nutrient and lime application were not tolerant legume crop showed an increase in nitrate uptake when the concentration of Al in the media was increased (Al stress). The opposite direction was observed for the susceptible cultivar.

In general, each cultivar responded differently to low nutrient supply. Based on the tolerance index of all characters evaluated, Sukmaraga and Lamuru were considered the most tolerant cultivars while Srikandi Putih was the most susceptible. The results of this field experiment support the results of nutrient solution culture experiment of Hayati *et al.* (2006) in terms of Srikandi Putih as the most susceptible cultivar and Lamuru as the most tolerant cultivar to low nutrient supply. However, Sukmaraga cultivar had inconsistent responses. It was considered moderate cultivar based on the nutrient culture experiment but tolerant cultivar based on the field experiment. Sukmaraga cultivar, inn this field experiment, had the highest yield under low nutrient supply among the cultivars evaluated. The Sukmaraga was considered a nutrient efficient cultivar. Sukmaraga had the highest for the agronomic characters (root dry weight, plant height, LAI, kernel number, ear weight) and physiological characters (leaf chlorophyll and NR activity).

CONCLUSIONS

Each cultivar responded differently to low nutrient supply. The most sensitive character observed was LAI for agronomic characteristic with the tolerance index of 39-89 % and NR activity for physiological character with the tolerance index of 39-86 %. This suggests that LAI and NR activity can be used as selection criteria in maize for nutrient efficient character.

Sukmaraga and Lamuru were the most tolerant cultivars to low nutrient supply while Srikandi Putih was the most susceptible one. Sukmaraga had a highest yield (6.23 ton/ha) under low nutrient supply, therefore Sukmaraga can be considered as nutrient efficient cultivar.

REFERENCES

Alnopri. 2004. NR assay procedure of ‘ manggis ‘ leaves. Jurnal Akta Agrosia. 7: 62-66.

Baligar, V.C., H.L. Dos Santos, G.V.E. Pitta, E.C. Filho, C.A. Vasconcellos, and A.F. deC Bahis Filho. 1989. Alumunium effects on growth, grain yield and nutrient use efficiency ratios in sorghum genotypes. J. Plant and Soil 116: 257-264.

Barbieri, P.A., H.R. Saint Rozas, F.H. Andrade, and H.E. Echeverria. 2000. Row spacing effects at different levels of nitrogen availability in maize. Agron. J. 92: 283-288.

Boussadia, O., K. Steppe, H. Zgallai, S. Ben El Hadj, M. Braham, R. Lemeur, and M.C. Van Labake. 2010. Effects of nitrogen defficiency on leaf photosynthesis, carbohydrate status and biomass production in two olive cultivars ‘Meski’ and ‘Koroneiki’. Scientia Horticulturae. 123: 336-342.

Ding, L., K.J. Wang, G.M. Jiang, D.K. Biswas, H. Xu, L.F. Li, and H. Li. 2005. Effects of nitrogen defficiency on photosynthetic traits of maize hybrids released in different years http://aob.oxfordjournal.org/misc/ terms.shtml

Egli, D.B. 1998. Seed Biology and the Yield of Grain Crops. Department of Agronomy, University of Kentucky, USA.

Fitter, A.H. and R.K.M. Hay. 1991. Environmental physiology of plants.

Granados, G., S. Pandey, and H. Ceballos. 1993. Response to selection for tolerance to acid soil in a tropical maize population. Crop Sci. 33: 936-940.

Hayati, R. Munandar and Irmawati. 2006. Root system and maize *(Zea mays* L.) cultivar selection under nutrient deficient condition with water culture method. Tanaman Tropika 9: 1-11.

Hayati, R. Munandar and F.K.S. Lestari. 2009 a. Agronomic performance of corn population selected for nutrient efficiency in marginal land. J. Agron. Indonesia 37: 8-13.

Hayati, R. Munandar and L.D Eriyani. 2009 b. Plant characteristics associated with yield of 48 maize selection lines developed for nutrient efficiency. Prosiding SemNas TTG Agroindustri dan Diseminasi Hasil-hasil Penelitian Dosen Polinela. Bandar Lampung 1-2 April 2009. hal 277-283.

Komariah, A., A. Baihaki, R. Setiamihardja, and S. Djakasutami. 2004. Relationship between Nitrate Reductase activity, total N content, and other important characters with plant tolerance to flooding in soybean. Zuriat 15: 163-169.

Marschner, H. 1995. Mineral Nutrition of Higher Plants. Academic Press Inc., London.

Peng, Y., J. Niu, Z. Peng, F. Zhang, and C. Li. 2010. Shoot growth potential drives N Uptake in maize plants and correlates with root growth in the soil. Field Crops Res. 115: 85-93.

Presterl, T., G. Seitz, M. Landbeck, E.M. Thiemt, W. Schmidt and H.H. Geiger. 2003. Crop breeding genetics and citology improving nitrogen use efficiency in European maize: Estimation of quantitative genetic parametes. Crop Sci. 43: 1259-1265.

Tian, Q.Y., F.J. Chen, F.S. Zhang and G.H. Mi. 2006. Genotypic difference in nitrogen acquisition ability in maize plants is related to the coordination of leaf and root growth. J. Plant Nutr. 29: 317-330.

Uhart, S.A. and F.H. Andrade. 1995. Nitrogen deficiency in maize: I. Effects on crop development, dry matter partitioning and kernel set. Crop Sci. 35: 1376-1383.

Utama, M.Z.H. 2008. Physiological mechanisms of Al-tolerance in legume cover crop species to metabolism of nitrate (NO3), ammonium (NH4), and nitrite (NO2). Bul. Agron. 36: 175-179.

Worku, M., M. Banziger, G.S. auf’m Early, D. Friesen, A.O. Diallo, and W.J. Horst. 2007. Nitrogen uptake and utilization in contrasting nitrogen efficient tropical maize hybrids. Crop Sci. 47: 519-528.

PHILIPPINE SOCIETY FOR THE STUDY OF NATURE • 2000 •

JOURNAL OF NATURE STUDIES
(formerly Nature’s Bulletin)
ISSN: 1655-3179