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Delineation and Mapping of Soil Available Micronutrients Status in Virudhunagar District of Tamil Nadu using GIS and GPS Techniques

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Abstract: Micronutrients are as essential as macronutrients but required in smaller quantities by plants. Crop growth, quality and yield of many crops may be affected if any of essential micronutrients such as zinc, iron, copper, manganese, boron, molybdenum and cobalt are lacking in the soil. Over the years with intensive cultivation, Indian agriculture has moved from an era of scattered single element deficiencies to more complex multiple nutrient deficiencies. It is essential to have an idea of depletion studies and future projections for prediction of micronutrient requirements. Refinement of critical level and delineation of micronutrient deficient and toxic areas. Integrated nutrient management is used with greater thrust on organic to improve the micronutrient availability and to reduce micro nutrient fertilizer level. In the context of today's changing scenario, there is a need to generate the spatial data of micronutrients using Global Positioning System (GPS) and the spatial variability maps for individual nutrient (Zn, Fe, Cu and Mn) is prepared using GIS software.

INTRODUCTION

Distribution of available micronutrients in surface soil

Available zinc: Katyal and Sharma (1991) reported that the mean content of DTPA-extractable zinc in 8 soil orders representing 57 benchmark soils of India namely Entisol (0.44 ppm), Inceptisols (0.60 ppm), Aridisol (0.38 ppm), Vertisol (0.41 ppm), Alfisol (0.55 ppm), Ultisol (0.28 ppm), Mollisol (1.86 ppm) and Oxisol (0.86 ppm). Singh and Sekhon (1993) observed that alluvial (12-29%), black (22-82%), red (3-7%) and laterite (84%) and arid soils had zinc deficiency.

Singh and Sekhon (1993) assessed the DTPA extractable zinc in soil series of Indore district in Madhya Pradesh (Sarol 96% and Kamaliakheri 74%), Coimbatore district of Tamil Nadu (Doddabhai 52% and Kalathur 62%), Nalgonda district of Andhra Pradesh (Kodad 47%) and Kangra district of Himachal Pradesh (Bagru 42%).

Takkar (1996) reported the extent of zinc deficiency in soils of Andhra Pradesh (51%), Assam (34%), Bihar (54%), Delhi (20%), Gujarat (24%), Haryana (61%), Jammu and Kashmir (12%), Karnataka (78%), Kerala (34%), Meghalaya (57%), Orissa (54%), Pondicherry (8%), Punjab (47%), Rajasthan (21%), Tamil Nadu (53%), Uttar Pradesh (45%) and West Bengal (36%). Singh and Singh reported that mean available zinc content in potato (1 ppm), mustard (0.8 ppm), lentil

(0.7 ppm), wheat (0.6 ppm) and rice (0.6 ppm). Siddhamalai *et al*. (1999) reported that the available zinc extracted by DTPA varied from 0.52-8.40 ppm in rice soils of Tamil Nadu. Patiram *et al*. (2000) reported that the available zinc reserves of mandarin orchards varied from 2.9-11.8 ppm. Jethra, etc., reported that the available zinc in soils of semi-arid eastern plain zone of Rajasthan, ranged from 0.34-5.76 ppm with a mean value of 1.17 ppm. Manchanda and Chhibba indicated that DTPA extractable zinc contents of surface soils in submontane region of Punjab varied widely from 0.14-7.8 ppm with a mean value of 1.2 ppm.

Shanmugasundaram and Savithri (2000) observed that the range of DTPA-Zn in Ooty (1.22-5.4 ppm), Coonoor (1.49-5.4 ppm) and Kotagiri Taluks of Nilgiris district (1.8-4.8 ppm) of Tamil Nadu. Vasudeva and Ananthanarayana (2001) reported that the range of available zinc extracted by DTPA was 0.73-2.63 ppm in acid soils of Karnataka. Sharma (2004) reported that percentage of samples deficient for DTPA extractable zinc in different agro ecological regions of Punjab namely Amritsar (36%), Hoshiarpur (31%), Ludhiana (7%), Mukstar (37%) and Patiala (12%).

Sureshkumar *et al*. (2004) revealed that the mean content of DTPA extractable zinc was found to be 1.30 ppm in seventeen soil groups of India.

Mehra *et al*. (2005) reported that the percentage of available zinc was 25.41 in Haplustalfs of sub Southern plain and Aravalli hills of Rajasthan.

Sharma and Katyal (2006) reported that mean content of DTPA extractable zinc in different block of Leh district of Ladakh region namely Leh (0.45ppm), Kharma (0.52 ppm), Nubra (3.34 ppm), Nyoma (0.44 ppm), Khaltse (0.37 ppm) and Durback (0.27 ppm) and also they found that soil samples deficient for available zinc in Leh (79.3%), Kharma (60%), Nubra (17.65%), Nyoma (75%), Khaltse (100%) and Durback (100%) in Leh district of Ladakh region.

Dwivedi *et al*. (2005) found that 63.54 and 48% of surface soil samples were deficient with mean value of 1.03 and 1.2 ppm of DTPA-Zn in Leh and Kargil district of Ladak region, respectively. Tur *et al*. (2005) reported that DTPA-zinc content varied from 0.14-4.9 ppm with an average of 1.459 ppm and considering the critical limit (>0.6 ppm), about 11% of the total geographical area of Patiala district was deficient in available zinc.

Nayak *et al*. (2006) reported that mean content of DTPA-extractable zinc was 1.24 ppm in Bara tract of Sardor Sarovar Canal Command Area in Gujarat. Jegan (2006) found that the percent of surface soil sample deficient for available zinc was 74.6 with mean content of 0.87 mg kg^{-1} for Sivagangai block of Tamil Nadu.

Hundal *et al*. (2006) reported that mean content of AB-DTPA extractable zinc in 8 soil sub groups of Punjab namely active recent flood plains (2 ppm), alluvial plains partly salt affected (1.23 ppm), alluvial plains with sand dunes (2.38 ppm), predominant plains (1.42 ppm), siwalkis (0.70 ppm), alluvial plains (2.0 ppm) and alluvial plains with occasional sand dunes (2.0 ppm).

Soils of Thiruvannamalai district are severely deficient in available zinc (65.12%). In Coimbatore district available zinc deficiency is noted as (68.5%). In Tamil Nadu the different agroclimatic zones such as Northeastern (63%), Northwestern (48%), Western (60)%, Southern (59.4%), Cauvery Delta (69%), High Rainfall (28%), Hill and high altitude zones (19%). Soils of Virudhunagar district are severely deficient in available zinc (83%).

AVAILABLE IRON

Lal and Biswas (1973) reported that the content of available iron varied from 0.3 ppm in the grey brown soil to 5.6 ppm in the desert (calcareous) soils of Rajasthan. Sakal *et al*. (1988) reported that the available iron in surface soils from old alluvial soils of Bihar, comprising the districts of Bhojpur, Gaya, Nalanda, Patna and Rohtas ranged from 1.2-173.8 ppm with an average value of 29.4 ppm. They also observed that soils of Bhojpur (30%), Nalanda (3%), Patna (7%) and Rohtas (16%) districts were deficient whereas soils of Gaya district were adequate in available iron content. Katyal and Sharma (1991) reported that the mean content of DTPA-extractable iron in Entisol (19.1 ppm), Inceptisol (23.2 ppm), Aridisol (9.6 ppm), Vertisol (9.1 ppm), Alfisol (28.5 ppm), Ultisol (17.5 ppm), Mollisol (59 ppm) and Oxisol (17.8 ppm) representing 57 benchmark soils of India.

Maji *et al*. (1993) found that the available iron content of the coastal soils of Sundarbans ranged from 14.4-370.5 ppm. Bhogal *et al*. (1993) observed that the available iron content of the entire surface soils (0-15 cm) from recent alluvium non-calcareous soils of Purnea, Saharsa and Katihar districts of Bihar were 13-35.2 ppm and only 1% was found deficient in iron in Purnea district. Velvikar *et al*. (1996) showed that the content of DTPA-Fe in surface soils (0-20 cm) of Bhir district from different locations representing Typic Chromusterts (1.92- 5.40 ppm), Vertic Ustochrepts (1.44-5.28 ppm), Typic Ustorthents (0.83-8.44 ppm) and Lithic Ustorthents (0.75-6.66 ppm) of Uttar Pradesh.

Singh, etc., stated that soils belonging to the Entisol of Meghalaya contained 26.0-42.2 ppm DTPA-Fe that increased with increasing altitude. Singh and Nayyar (1999) reported that the available iron content of Indian soils ranged from 0.8-196 ppm with a mean value of 19.0 ppm. Tiwari, etc., indicated that the mean content of DTPA-extractable iron in soils of Bhadohi (3.89 ppm), Ghazipur (5.56 ppm), Mirzapur (6.21 ppm), Sorebhadra (3.74 ppm) and Varnasi districts of Eastern Uttar Pradesh (9.67 ppm).

Sud and Sharma showed that the DTPA-Fe content in surface soils of Shimla district in Himachal Pradesh ranged from 9.70-62.92 ppm with a mean of 36.98 ppm. Chatterji *et al*. (1999) revealed that the mean values of available iron in warm-per humid (47.5 ppm), hot-per humid (51.4 ppm), hot dry-sub humid (54.0 ppm), hot moist-sub humid (72.5 ppm) and hot moist-sub humid (coastal) regions of West Bengal (49.6 ppm).

Shanmugasundaram and Savithri (2000) indicated that DTPA-iron distribution in soils of the Nilgiris district ranged from 20.7-196 ppm in Ooty, 20-134 ppm in Coonoor and 30- 97 ppm in Kotagiri. Siddhamalai *et al*. (2002) reported that the DTPA extractable iron content in the surface soil from established soil series of the rice growing tracts in Thanjavur district, Tamil Nadu ranged from 3.90-33.34 ppm.

Sharma *et al*. (2003) showed that available iron content in some soils of Nagaur district in semi-arid region of Rajasthan ranged from 1.0-6.6 ppm with a mean of 4.32 ppm and 52% soil samples were deficient in available iron considering 4.5 ppm as critical limit.

Sharma (2004) reported that percentage of samples deficient for DTPA extractable iron in different agro ecological regions of Punjab namely Amritsar (4%), Hoshiarpur (24%), Ludhiana (7%), Mukstar (31%) and Patiala (5%). Mehra *et al*. (2005) reported that the percentage of available iron was 40.63% in Haplustalts of sub Southern plain and Aravalli hills of Rajasthan. Dwivedi *et al*. (2005) found that 82.89 and 66% of surface soil samples were deficient with a mean value of 4.21 mg kg^{-1} and 7.67 mg kg^{-1} of DTPA extractable Fe in Leh and Kargil district of Ladak region, respectively.

Tur *et al*. (2005) reported that DTPA-Fe content varied from 1.78-38.2 ppm with an average of 17.9 ppm and was in sufficient amount (>4.5 ppm) in 95% of the area in Patiala district. Nayak *et al*. (2006) reported that mean content of DTPA-extractable iron was 39.70 ppm in Bara tract of Sardor Sarovar Canal Command Area in Gujarat. Jegan (2006) found that percentage of surface soil sample sufficient for available iron was 100% with mean content of 25.56 mg kg^{-1} for Sivagangai block of Tamil Nadu.

Hundal *et al*. (2006) reported that mean content of AB-DTPA extractable iron in eight soil sub groups of Punjab namely active recent flood plains (21.3 ppm), alluvial plains partly salt affected (23.03 ppm), alluvial plains with sand dune (18.68 ppm), predominant plains (21 ppm), siwalkis (11.35 ppm), alluvial plains (29.68 ppm) and alluvial plains with occasional sand dunes (14.56 ppm).

In Coimbatore district available iron deficiency is noted as 40.4%. In Tamil Nadu the different agroclimatic Zones such as North Eastern (24.7%), North Western (28%), Western (25%), Southern (8.22%), Cauvery Delta (4.5%), High Rainfall (3%), Hill and High Altitude Zones (3%) are deficient in available iron. Soils of Virudhunagar district are severely deficient in available iron as 59%.

AVAILABLE MANGANESE

Katyal and Sharma (1991) observed that the mean content of DTPA extractable manganese in India were Entisol (13.0 ppm), Inceptisol (30.9 ppm), Aridisol (12.7 ppm), Vertisol (12.4 ppm), Alfisol (31.3 ppm), Ultisol (40.1 ppm), Mollisol (47.3 ppm) and Oxisol (86.8 ppm). Singh (2001) reported that the available manganese content of Indian soils ranged from 0.2-118 ppm with a mean value of 21.0 ppm. Bhogal *et al*. (1993) reported that available manganese in surface soils representing Aquic Ustifluvents and Udifluvents varied from 0.7- 92.1 ppm. Manchanda and Chhibba (1993) reported that DTPA extractable manganese cation status of surface soils of submontane region of Punjab ranged from 6-115 ppm with a mean value of 34 ppm.

Jethra, etc., reported that the available manganese in the soils of semi-arid eastern plain zone of Rajasthan ranged from 2.82-39.4 ppm with a mean value of 11.29 ppm. Tiwari, etc., reported that the mean available content of manganese in the districts of Bhadohi (5.59 ppm), Ghazipur (8.48 ppm), Mirzapur (23.95 ppm), Sonebhadra (15.60 ppm) and Varnasi in Eastern Uttar Pradesh (14.74 ppm).

Sud and Sharma reported that the DTPA-Mn content in surface soils of Shimla district in Himachal Pradesh ranged between 16.08 and 45.56 ppm with a mean of 33.76 ppm. Chatterji *et al*. (1999) reported that the mean content of available manganese in warm per humid (12.16 ppm) hot per humid (22.63 ppm), hot dry sub humid (40 ppm), hot moist sub humid (28.4 ppm) and hot moist sub humid (coastal) regions of West Bengal (30.6 ppm). Siddhamalai *et al*. (2002) reported that DTPA-Mn content in surface rice soils of Tamil Nadu was found to be in the sufficient range and the content varied from 3.00-43.2 ppm based on the critical limit of 2.0 ppm.

Sharma (2004) reported that percent of samples deficient in DTPA extractable manganese in different agro ecological regions of Punjab namely Amritsar (5%), Hoshiarpur (25%), Ludhiana (22%), Mukstar (8%) and Patiala (5%). Dwivedi *et al*. (2005) found that 79.16 and 94% of surface soil samples deficient with mean value of 3.99 ppm and 1.01 ppm of DTPA- Mn in Leh and Kargil district of Ladak region.

Tur *et al*. (2005) reported that the content of available manganese ranged from 1.28-18.60 ppm with an average of 9.44 ppm in the surface soils of Patiala district in Punjab and it was in sufficient amount (>3.5 ppm) in 96% of the area of Patiala district. Mehra *et al*. (2005) reported that percentage of available manganese was 9.73 in Haplustalfs of sub Southern plain and Aravalli hills of Rajasthan.

Jegan (2006) found that percent of surface soil sample deficient for available manganese was 5.16 with mean content of 19.87 ppm in Sivagangai block of Tamil Nadu. Nayak *et al*. (2006) reported that mean content of DTPA-extractable manganese was 3.74 ppm in Bara tract of Sardor Sarovar Canal Command Area in Gujarat.

Hundal *et al*. (2006) reported that mean content of AB-DTPA extractable manganese in eight soil sub groups of Punjab namely active recent flood plains (4.27 ppm), alluvial plains partly salt affected (3.84 ppm), alluvial plains with sand dunes (5.12 ppm), predominant plains (6.85 ppm), siwalkis (3.11ppm), alluvial plains (5.38 ppm) and alluvial plains with occasional sand dunes (4.23 ppm).

Soils of Thiruvannamalai district are moderately deficient in available manganese (10.91%). In Coimbatore district available Zinc deficiency noted as (15.3%). In Tamil Nadu the different agroclimatic zones such as North Eastern (8.43%), Northwestern (5.67%), Western (16.7%), Southern (6.67%), Cauvery Delta (0.50%), High Rainfall (11%), Hill and high altitude zones (5%) are deficient in available manganese. Soils of Virudhunagar district are severely deficient in available manganese (37%).

AVAILABLE COPPER

Singh (2001) reported that the available copper content of Indian soils ranged from 0.1-8.2 ppm with a mean value of 2.1 ppm. Singh and Sekhon (1993) reported that the mean of DTPA extractable copper content in surface soils of Sarol (11.4 ppm), Kalathur (3.75 ppm), Kamaliakheri (2.46 ppm), Bagru (2.15 ppm), Kodad (1.82 ppm) and Doddabhavi (0.85 ppm) soil series of India.

Manchanda and Chhibba reported that DTPA-Cu status of surface soils in submontane region of Punjab ranged from 0.21-16 ppm with a mean of 2.5 ppm. Bhogal *et al*. (1993) reported that available copper in surface soils of Aquic Ustifluvents and Udifluvents of Bihar varied from 0.3-7.3 ppm.

Dhane and Shukla (1995) reported that the available copper content in surface soils of some soil series of Maharastra ranged from 0.9-2.1 ppm. Vijaykumar *et al*. (1997) reported that available copper content in soils of Karimnagar (0.5-2.8 ppm), Nizamabad (0.4-2.8 ppm) and Adilabad of Northern Telangana (1.0-2.2 ppm) of Andhra Pradesh. Singh and Randhawa (1997) reported that the soils belonging to Entisol of Meghalaya contained 0.40-3.00 ppm DTPA-Cu with a mean value of 1.33 ppm. Khan *et al*. (1997) reported that DTPA-Cu content in some soils of Bangladesh ranged from 1.0-14.2 ppm.

It was observed that DTPA extractable copper content in the soils of Varanasi region of eastern Uttar Pradesh ranged from 0.73-2.80 ppm. Sud and Sharma reported that DTPA copper content in surface soils of Shimla district in Himachal Pradesh ranged from 0.64-2.90 ppm with an average of 1.54 ppm.

Siddhamalai *et al*. (2002) reported that the distribution of DTPA extractable copper in rice soils of Tamil Nadu ranged from 0.40-8.48 ppm. Sharma *et al*. (2003) reported that available copper content in some soils of Nagaur district in semi-arid region of Rajasthan ranged from 0.5-3.9 ppm with a mean value of 2.11 ppm. Sharma (2004) reported that percentage of samples deficient in DTPA extractable copper in different agro ecological regions of Punjab namely Amritsar (0.5%), Hoshiarpur (6%), Ludhiana (2%), Mukstar (5%) and Patiala (1%).

Mehra *et al*. (2005) reported that the extent the percentage of available copper was 18.74% in Haplustalfs of sub Southern plain and Aravalli hills of Rajasthan. Tur *et al*. (2005) reported that available copper in soils of Patiala district ranged from 0.16-4.4 ppm with an average value of 1.33 ppm and was in sufficient amount in nearly 95 per cent area of the Patiala district. Jegan (2006) found that per cent of surface soil sample deficient in available copper was 74.6 with mean content of 2.38 mg kg^{-1} for Sivagangai block of Tamil Nadu.

Nayak *et al*. (2006) reported that mean content of DTPA-extractable copper was 2.88 ppm in Bara Tract of Sardor Sarovar Canal Command Area in Gujarat. Hundal *et al*. (2006) reported that mean content of AB-DTPA extractable copper in eight soil sub groups of Punjab namely active recent flood plains (2.19 ppm), alluvial plains partly salt affected (1.78 ppm), alluvial plains with sand dunes (1.89 ppm), predominant plains (1.39 ppm), siwalkis (1.29 ppm), alluvial plains (1.93 ppm) and alluvial plains with occasional sand dunes (4.23 ppm).

Soils of Thiruvannamalai district are moderately deficient in available copper (16.23%). In Coimbatore district available copper deficiency noted as (56.6%). In Tamil Nadu the different agroclimatic Zones such as North Eastern (5.43%), Northwestern (4.67%), Western (4.66%), Southern (7.33%), Cauvery Delta (6.75%), High Rainfall (7%), Hill and high altitude zones (8%) are deficient in available copper. Soils of Virudhunagar district are severely deficient in available copper (86%).

AVAILABLE BORON

Boron deficiency of (<0.5 mg kg^{-1}) was reported in acid soils of Bihar. Rai *et al*. (1972) reported that the available boron varied from 0.30-3.8 ppm (average l.10 ppm) in soils of Betul district, from 0.30-2.41 ppm (average 1.05 ppm) in soils of Chindwara district and from 0.16-6.23 ppm (average 1.01 ppm) in soils of Seoni district of Madhya Pradesh.

Berger and Truog (1945) reported that 29% of soils had available boron content below the critical level of 0.5 ppm. Rajagopal *et al*. (1974) found that available boron content in different taluks of the Nilgiris district namely Ootacamund (0.37 ppm), Coonoor (0.46 ppm), Gudalur (0.60 ppm) and Kotagiri (0.22 ppm).

Singh and Sinha (1976) reported that available boron content in the soil of 6 blocks of Pornea district in the North Eastern part of Bihar ranged from traces to 1.05 ppm with an average of 0.42 ppm.

Bansal *et al*. (1991) reported a range of 0.3-2.0 mg kg^{-1} hot water extractable boron in some soils of Punjab. Similarly, soils derived from alluvium deposits in Ferozepur and Faridkot districts of Punjab, the boron ranged from 0.20-3.85 mg kg^{-1} soil (Singh and Nayyar, 1999). Available boron content in Indian soils ranged from 0.08-2.6 mg kg^{-1} and about 33% soils tested to be deficient in boron (Singh, 2001).

Considering the critical limit of 0.46 mg kg^{-1} soil for available boron 63.0, 33.0 and 21.0% of surface soil samples have found to be deficient in Shimla, Kull and Mandi district of Himachal Pradesh, respectively (Upender, 2002).

Gathala *et al*. (2004) reported that available boron in surface soils of pomegranate orchards in Jaipur district of Rajasthan ranged from 0.4-0.6 mg kg^{-1} with a mean value of 0.5 mg kg^{-1} soil. Moafpouryan and Shukla (2004) reported that the value of hot water extractable boron ranged from 0.14-0.36 mg kg^{-1} in Inceptisols of Delhi. Chaudhary and Shukla (2004) found that available boron content ranged from 0.26 (Petrogypsid) to 7.10 mg kg^{-1} soil (Haplosalid) and 0.22 (petrogypsid and petrocalid) to 1.15 mg kg^{-1} soil (Haplocambid) with mean values of 1.51 and 0.51 mg kg^{-1} soil for irrigated and rainfed soils, respectively in arid region of western Rajasthan.

Chinchmalatpure *et al.* (2005) found that HWSB in soils of Bara tract under Sardar Sarovar Canal Command Area of Gujarat ranged from 0.07-2.98 mg kg^{-1} with an average of 1.02 mg kg^{-1}.

Arora and Chahal (2005) found that available boron (hot water soluble boron) ranged from 0.28-0.84 mg kg^{-1} in some surface benchmark soils of Punjab. Sharma and Katyal (2006) reported that HWSB in surface soils of 57 benchmark soils of India ranged from 0.07-3.62 mg kg^{-1} with a mean value of 0.72 mg kg^{-1} of soil.

Raina *et al*. (2006) found that mean values of available boron in the surface soils of apple orchard of different district of Himachal Pradesh revealed that available boron in surface soils of Shimla (0.12-0.72 mg kg^{-1}), Kullu (0.16-1.09 mg kg^{-1}) and Manali districts (0.40-0.74 mg kg^{-1}) of soil with an average of 0.40, 0.56 and 0.57 mg kg^{-1} soil and also the found that in different districts of Chamba (0.36-1.25), Simoor (0.35-0.95) and Kinnaur (0.20-0.83) the available boron content in surface soils with mean values of 0.63, 0.61 and 0.51 mg kg^{-1} soil.

Choudhary and Shukla (2004) observed that the available boron in acid soils of Western Rajasthan was between 0.10 and 0.71 mg kg^{-1}. Mishra *et al*. (2006) found that available boron varied from 0.17-3.57 mg kg^{-1} with mean values of 0.62 mg kg^{-1} in soils of Northern alluvial plain of UP and Uttaranchal.

Hundal *et al*. (2006) reported that mean contents of AB-DTPA extractable boron in eight soil sub groups of Punjab namely active recent flood plains (1.32 ppm), alluvial plains partly salt affected (1.08 ppm), alluvial plains with sand dunes (1.53 ppm), predominant plains (0.51 ppm), siwalkis (1.46 ppm), alluvial plains (0.98 ppm) and alluvial plains with occasional sand dunes (1.44 ppm).

CONCLUSION

In Tamil Nadu the different agroclimatic zones such as North Eastern (28.5%), North Western (20%), Western (16%), Southern (36%), Cauvery Delta (12%), High Rainfall (66%), Hill and high altitude zones (32%) are deficient in available boron.

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