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Normalization the application of essential macro and micro-nutrient chemical combinations for best exploitation of growth traits in potato under terai region of West Bengal

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Abstract
Potato is one of the most important food crops after rice and wheat. The climatic condition of terrain agro ecological region favours the cultivation of potato along with this good yield. But due to deficiency of macro nutrient and micronutrient in the soil of terai region the growth of the potato crop hampers, which ultimately result in poor yield. The mentioned problem keep in mind the present experiment conducted through enrichment of soil by external use off macro and micronutrients. The experiment focused only the growth parameters of the potato. In case of sole application the calcium (Ca) play important role in case of plant height at 50DAP (23.08 cm) and 70 DAP (29.06 cm), no of leaves at 50DAP (60.50) and 70 DAP (78.05), fresh weight (242.50 g) and dry weight (42.33 g). In case of combined application calcium (Ca), magnesium (Mg), sulphur (S), zinc (Zn) and boron (B) combined shows highest plant height at 50 DAP (28.66 cm) and 70 DAP (32..15 cm), number of leaves at 50DAP (80.72) and 70 Dap (90.67), fresh weight (277.17 g) and dry weight (45.83 g). Thus the results revealed that the soil is deficient in most of the macro and micro nutrients particularly those are unavailable in acidic soil of the terai zone. Therefore its application solely or in combination with others always showed some beneficial effects.

Keywords: Potato, calcium (Ca), magnesium (Mg), sulphur (S), zinc (Zn) and boron (B)

Introduction
Potato botanically *Solanum tuberosum* L. belongs to the Solanaceae (nightshade) family, is an important starchy vegetable crop in both sub tropical and temperate region. After rice, wheat and maize; potato (*Solanum tuberosum* L.) is fourth most important food crop. It provides considerable dry matter (20 g/ 100g) per unit area and time. It is a rich source of carbohydrates (22.6 g/ 100g), starch (16.3 g/ 100 g) and proteins (1.6 g/ 100g). Potatoes are also rich source of vitamins, especially C and B and also minerals. Tubers contain 70-80% water, 20.6% carbohydrate, 2.1% protein, 0.3% fat, 1.1% crude fibre and 0.9% ash (Banjare *et al.* 2014) [1]. It is one of the most remunerative and profitable crop for the farmers due to its higher yield potential within a limited time. Macro-elements perform important building functions, are an integral part of enzymes, and play an important role as regulators of metabolic processes. Large amount of nutrients removed per unit time from per unit area through potato because of high rate of dry matter production, which generally most of the soils are not able to supply. In Terai Agro-ecological region, most of the farmers are not supplying balanced nutrient, particularly macro and micro nutrients to the crop. Hence, there is an urgent need to standardize the balance nutrient composition by incorporating macro and micro nutrient sources. In acid soils, there is a lack of calcium, magnesium and phosphorus for growing crop, and in alkaline there is lack of boron, manganese and zinc. The potato is a plant with high nutrient demands because of forming abundant vegetative mass and a high quantity of tubers at the unit area. It is a great consumer of nitrogen, phosphorus, potassium, magnesium and calcium, as well as micro and elements (Fit Hangan, 2010) [4]. In spite of micronutrients are utilized within more diminutive quantities, they are in the same way that paramount concerning illustration those macronutrients over regard about their works on plants. The micronutrients required toward plants incorporate iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), boron (B), molybdenum (Mo), chlorine (Cl) and nickel (Ni). That accessibility of these supplements clinched alongside soil relies on the dirt and the nature's domain.

Materials and Methods

The field experiments were conducted at Instructional Farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, India. The place is situated in terai region of West Bengal at $26^0 19'$ N latitude and $89^0 23'$ E longitude at an elevation of 43 meters above mean sea level (MSL) and soil pH 5.5-6.5 during autumn-winter season. In this experiment five important micronutrients *viz.,* calcium, magnesium, sulphur, zinc and boron along with their combinations were applied through soil application at the time of land preparation on locally popular cultivar "Khufri Jyoti" of potato. The soil of terai agro-ecological region lack of some important macro and micronutrient for these reason soil application of differ elements done through this experiment for better growth and development of potato. The sole doses of these five nutrient elements viz. calcium (Ca), magnesium (Mg), sulphur (S), zinc (Zn) and boron (B) were fixed with two levels 0 kg/ha and 7.2kg/ha, 6.5 kg/ha, 12.6kg/ha, 9kg/ha and 1 kg/ha respectively in form of calcium chloride, magnesium oxide, ammonium sulphate, zinc oxide and boric acid (Nesreen and Salma 2015, Sud and Sharma 2002, Thakare *et al.,* 2007,) [13, 16]. The present experiment was conducted not only by the sole application of nutrient elements, along with the sole application all the effect of nutrient combinations also studied by every possible combination among the nutrient element. Thus five sole treatments as well as twenty-six different combinations along with their control were laid out in randomized block design with 3 replications with a spacing of 50 cm x 20 cm in plot sized of 5 m x 2 m. Common cultural practices were used for the potato production such as irrigation, fertilization, weeding, dehaulming etc, according to recommended practices for potato in the commercial fields along with basal recommended dose of N, P_2O_5, K_2O (150 kg, 60 kg and 120 kg/ha, respectively) were followed. Observations were recorded on ten randomly selected plants from each plot. Data were recorded on five morphological traits viz. plant height at 50 DAP and 70 DAP (cm), leaves per plant at 50 DAP and 70 DAP, fresh shoot weight (g), dry shoot weight (g).Collected data were analyzed statistically by using SPSS 22.0.

Result and Discussion

Plant Height at 50 DAP

The effect of sole and combined soil application of macro and micro nutrients on plant height at 50DAP was found to be significant.

Among the sole application treatments, soil application of calcium (Ca) recorded maximum plant height(23.08cm) at 50DAP; among the combined application of any two nutrients, soil application of calcium (Ca) and magnesium (Mg) recorded maximum plant height(24.88 cm) at 50DAP; among the combined application of any three nutrients under study, soil application of calcium(Ca), magnesium(Mg) and sulphur (S) recorded maximum plant height(24.93 cm) at 50DAP and among the combined application of any four or all nutrients under study, soil application of calcium(Ca), magnesium(Mg), sulphur (S), zinc(Zn) and boron (B) recorded maximum number (28.86 cm) of leaves 50DAP that recorded 37.42 % increase in plant height 50DAP over the control with no macro and micro nutrients under study.

This maximum plant heightat 50DAP at per with the treatments of Ca, Mg, CaMg, CaS, CaB, CaZn, MgS, MgB, MgZn, SB, CaMgS CaMgB, CaMgZn, CaSB, CaSZn, CaZnB,CaMgSB, CaMgSZn, CaMgZnB and CaSZnB.

From these result it is apparent that calcium played an important role in increasing the plant height followed by magnesium. Combined application of macro nutrient particularly in from of calcium (Ca), magnesium (Mg) and sulphur(S) has more effect on plant height at 50DAP. Nesreen and Salma (2015), Sud and Sharma 2002 [13], Dabhi *et al.* (2004) [3], Poornima (2007), Mozumder *et al.,* (2007) and Jaggi and Raina (2008) [6] show significant effect of Ca, Mg, S, Zn and B on leaf number at 50DAP in potato and other vegetable crops.

Plant Height at 70 DAP

The effect of sole and combined soil application of macro and micro nutrients on plant height at 70DAP was found to be significant.

Among the sole application treatments, soil application of calcium (Ca) recorded maximum plant height(29.06 cm) at 70DAP; among the combined application of any two nutrients, soil application of calcium (Ca) and magnesium (Mg) recorded maximum plant height(31.46 cm) at 70DAP; among the combined application of any three nutrients under study, soil application of calcium(Ca), magnesium(Mg) and sulphur (S) recorded maximum plant height(31.97 cm) at 70DAP and among the combined application of any four or all nutrients under study, soil application of calcium(Ca), magnesium(Mg), sulphur (S), zinc(Zn) and boron (B) recorded maximum number (32.15 cm) of leaves 70DAP that recorded 39.19 % increase in plant height70DAP over the control with no macro and micro nutrients under study.

This maximum plant heightat 70DAP at per with the treatments of Ca, Mg, CaMg, CaS, CaB, CaZn, MgS, MgB, MgZn, SB, CaMgS CaMgB, CaMgZn, MgSB, MgSZn, CaSB, CaSZn, CaZnB,CaMgSB, CaMgSZn, CaMgZnB and CaSZnB.

From these result it is apparent that calcium played an important role in increasing the plant heightfollowed by magnesium. Combined application of macro nutrient particularly in from of calcium (Ca), magnesium (Mg) and sulphur(S) has more effect on plant height at 70DAP. Micro nutrient shows somewhat lower effect on increase in number of leaves. Nesreen and Salma (2015), Sud and Sharma 2002 [13], Dabhi *et al.* (2004) [3], Poornima (2007), Mozumder *et al.*, (2007), Jaggi and Raina (2008) [6] and Thakare *et al.,* (2007) [16] show significant effect of Ca, Mg, S, Zn and B on leaf number at 70DAP in potato and other vegetable crops

Numer of Leaves at 50 DAP

The effect of sole and combined soil application of macro and micro nutrients on number of leaves at 50DAP was found to be significant.

Among the sole application treatments, soil application of calcium (Ca) recorded maximum number of leaves (60.50) at 50DAP; among the combined application of any two nutrients, soil application of calcium (Ca) and magnesium (Mg) recorded maximum number of leaves (75.72) at 50DAP; among the combined application of any three nutrients under study, soil application of calcium(Ca), magnesium(Mg) and sulphur (S) recorded maximum number of leaves (77.33) at 50DAP and among the combined application of any four or all nutrients under study, soil application of calcium(Ca), magnesium(Mg), sulphur (S), zinc(Zn) and boron (B) recorded maximum number (80.72) of leaves 50DAP that recorded 38.81 % increase in number of leaves 50DAP over the control with no macro and micro nutrients under study.

This maximum number of leaves at 50DAP at per with the treatments of S, CaMg, CaS, CaB, CaZn, MgS, MgB, CaMgS, CaMgZn, CaSB, CaMgSB, CaMgSZn, CaMgZnB and CaSZnB.

From these result it is apparent that calcium played an important role in increasing the number of leaves followed by magnesium. Combined application of macro nutrient particularly in from of calcium (Ca), magnesium (Mg) and sulphur(S) has more effect on number of leaves at 50DAP. Micro nutrient shows somewhat lower effect on increase in number of leaves Dabhi *et al.* (2004) [3], Jaggi (2005) [5], Mozumder *et al.*, (2007), Jaggi and Raina (2008) [6], Thakare *et al.*, (2007) [16] and Rahaman *et al.* (2011) show significant effect of Ca, Mg, S, Zn and B on leaf number at 50DAP in potato and other vegetable crops.

Numer of Leaves at 70 DAP

The effect of sole and combined soil application of macro and micro nutrients on number of leaves at 70 DAP was found to be significant.

Among the sole application treatments, soil application of calcium (Ca) recorded maximum number of leaves (78.05) at 70 DAP; among the combined application of any two nutrients, soil application of calcium (Ca) and magnesium (Mg) recorded maximum number of leaves (85.44) at 70 DAP; among the combined application of any three nutrients under study, soil application of calcium(Ca), magnesium(Mg) and sulphur (S) recorded maximum number of leaves (86.11) at 70 DAP and among the combined application of any four or all nutrients under study, soil application of calcium(Ca), magnesium(Mg), sulphur (S), zinc(Zn) and boron (B) recorded maximum number (90.67) of leaves 70 DAP that recorded 40.66 % increase in number of leaves 70 DAP over the control with no macro and micro nutrients under study.

This maximum number of leaves at 70 DAP at per with the treatments of Mg, CaMg, CaS, CaB, CaZn, MgS, MgB, CaMgS, CaMgZn, CaSB,CaSZn, CaSB, CaMgSB, CaMgSZn, CaMgZnB and CaSZnB From these result it is apparent that calcium played an important role in increasing the number of leaves followed by magnesium. Combined application of macro nutrient particularly in from of calcium (Ca), magnesium (Mg) and sulphur(S) has more effect on number of leaves at 70 DAP. Micro nutrient shows somewhat lower effect on increase in number of leaves. Dabhi *et al.* (2004) [3], Jaggi (2005) [5], Mozumder *et al.*, (2007), Jaggi and Raina (2008) [6], Thakare *et al.*, (2007) [16] and Rahaman *et al.* (2011) show significant effect of Ca, Mg, S, Zn and B on leaf number at 70 DAP in potato and other vegetable crops.

Fresh Shoot Weight (g)

The effect of sole and combined soil application of macro and micro nutrients on fresh shoot weight at was found to be significant.

Among the sole application treatments, soil application of calcium (Ca) recorded maximum fresh shoot weight (242.50g); among the combined application of any two nutrients, soil application of calcium (Ca) and magnesium (Mg) recorded maximum fresh shoot weight (257.50g); among the combined application of any three nutrients under study, soil application of calcium(Ca), magnesium(Mg) and sulphur (S) recorded maximum fresh shoot weight (258.83 g) and among the combined application of any four or all nutrients under study, soil application of calcium(Ca), magnesium(Mg), sulphur (S), zinc(Zn) and boron (B) recorded maximum fresh shoot weight (277.17 g) that recorded 53.87% increase in fresh shoot weight over the control with no macro and micro nutrients under study.

This maximum number of fresh shoot weight at per with the treatments of CaMgS CaMgB, CaMgSB, CaMgSZn.

From these result it is apparent that calcium played an important role in increasing the fresh shoot weight followed by magnesium. Combined application of macro nutrient particularly in from of calcium (Ca), magnesium (Mg) and sulphur(S) has more effect on fresh shoot weight. Micro nutrient shows somewhat lower effect on increase in fresh shoot weight. Nesreen and Salma (2015), Singh *et al.* (2008) [12], Jaggi (2005) [5] and Bari, *et al.*, (2001) [2] show significant effect of Ca, Mg, S, Zn and B on fresh shoot weight in potato and other vegetable crops.

Dry Shoot Weight (g)

The effect of sole and combined soil application of macro and micro nutrients on dry shoot weight was found to be significant.

Among the sole application treatments, soil application of calcium (Ca) recorded maximum dry shoot weight (42.33g) ; among the combined application of any two nutrients, soil application of calcium (Ca) and magnesium (Mg) recorded maximum dry shoot weight (42.00g); among the combined application of any three nutrients under study, soil application of calcium(Ca), magnesium(Mg) and sulphur (S) recorded maximum dry shoot weight (43.33 g) and among the combined application of any four or all nutrients under study, soil application of calcium(Ca), magnesium(Mg), sulphur (S), zinc(Zn) and boron (B) recorded maximum dry shoot weight (45.83 g) that recorded 35.63% increase in dry shoot weight over the control with no macro and micro nutrients under study.

This maximum number of dry shoot weight at per with the treatments of Mg, S, B, CaMg, CaS, CaB, CaZn, MgS, MgB, MgZn, CaMgS CaMgB, CaZnB, CaMgSB, CaMgSZn, CaMgZnB.

From these result it is apparent that calcium played an important role in increasing the dry shoot weight followed by magnesium. Combined application of macro nutrient particularly in from of calcium (Ca), magnesium (Mg) and sulphur(S) has more effect on dry shoot weight. Micro nutrient shows somewhat lower effect on increase in dry shoot weight. Nesreen and Salma (2015), Ramamurthy and Devi (1982) [11], Jaggi (2005) [5], Taheri *et al.* (2011) [14], Thakare *et al.* (2007) [16], and Talukdar *et al.*, (1987) show significant effect of Ca, Mg, S, Zn and B on dry shoot weight in potato and other vegetable crops.

Table 1: Different growth parameters of potato

Treatments	Plant Height 50 Dap (cm)	Plant Height 70 Dap (cm)	Number Of Leaves 50 Dap
Control	16.27	23.17	53.33
Ca	23.08	29.06	60.50
Mg	21.26	26.72	67.94
S	21.00	26.59	61.83
B	20.75	25.98	56.89
Zn	11.38	14.53	30.25

CaMg	24.93	31.46	77.33
CaS	24.09	29.30	75.94
CaB	23.85	29.27	74.44
CaZn	23.76	28.97	72.94
MgS	23.15	28.69	72.28
MgB	21.69	27.69	72.16
MgZn	21.40	26.95	66.66
SB	21.01	26.82	65.55
SZn	20.69	26.67	63.61
ZnB	10.80	12.60	31.33
CaMgS	24.88	31.97	75.72
CaMgB	24.65	30.95	70.61
CaMgZn	22.99	29.59	68.72
CaSB	22.71	27.99	68.44
CaSZn	21.40	27.36	66.28
CaZnB	22.37	27.58	70.40
MgSB	19.88	25.83	65.22
MgSZn	19.88	25.43	64.50
MgZnB	19.61	25.07	57.83
SZnB	15.54	14.11	42.23
CaMgSB	24.67	31.23	80.05
CaMgSZn	22.62	29.13	74.50
CaMgZnB	22.59	28.81	71.67
CaSZnB	20.04	25.85	65.28
MgSZnB	14.64	16.31	57.79
CaMgSBZn	28.86	32.15	80.72
SEm±	2.74	3.10	4.89
CD(0.05)	7.76	8.76	13.82
CV(%)	6.03	4.00	4.47

Table 2: Different growth parameters of potato

Treatments	Number of Leaves 70 Dap	Fresh Shoot Weight (g)	Dry Shoot Weight (g)
Control	74.10	149.33	29.17
Ca	78.05	242.50	42.33
Mg	75.00	241.33	41.67
S	71.82	235.67	38.50
B	67.28	225.83	32.33
Zn	46.25	150.22	21.55
CaMg	85.44	257.50	42.00
CaS	85.11	242.00	40.83
CaB	84.67	236.00	40.83
CaZn	83.83	233.33	39.33
MgS	83.50	231.00	38.00
MgB	82.94	214.50	38.00
MgZn	76.33	213.00	37.33
SB	76.11	212.17	34.50
SZn	74.00	202.17	31.00
ZnB	45.94	152.93	16.33
CaMgS	86.11	258.83	43.33
CaMgB	81.11	257.00	39.33
CaMgZn	80.94	246.00	35.50
CaSB	80.55	245.50	34.83
CaSZn	78.76	227.33	34.67
CaZnB	78.17	212.83	38.83
MgSB	75.33	220.17	34.50
MgSZn	74.83	216.00	34.33
MgZnB	68.89	207.33	28.83
SZnB	49.86	161.36	18.33
CaMgSB	90.42	263.17	45.17
CaMgSZn	86.05	253.17	43.83
CaMgZnB	82.28	248.33	39.50
CaSZnB	76.05	226.67	34.50
MgSZnB	51.79	167.74	19.33
CaMgSBZn	90.67	277.17	45.83
SEm±	5.24	9.10	3.63
CD (0.05)	14.80	25.72	10.26
CV (%)	4.42	2.55	9.68

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