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STUDIES ON THE RESPONSE OF POTATO TO BORONATED SULPHUR

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Abstract

The effect of different levels of Boronated Sulphur on potato was studied in a field experiment conducted at Agriculture Farm of Institute of Agriculture, Visva-Bharati University, Sriniketan during *rabi* season of 2018-19. The growth and yield parameters were recorded at 40 DAP and 80 DAP. The experimental finding revealed that fertilization with Boronated Sulphur (10 kg/acre), Boronated Sulphur (15 kg/acre) and Boronated Sulphur (20 kg/acre) improved most of the growth as well as yield parameters of potato crop significantly. However, T_4 (Boronated Sulphur @ 15 kg/acre) was found to record highest value of growth as well as yield parameters of potato such as plant height, number of leaves per plant, number of shoots per plant, tuber bulking rate and tuberization efficiency, yield and quality parameters such as (tuber yield per plant, tuber yield (kg/m^2) and ascorbic acid content of tubers. Highest plant height (43.33cm.), number of leaves per plant (47.80), number of shoots per plant (6.22), tuber bulking rate (62.07), tuberization efficiency (2.47), tuber yield/plant (449.55g), tuber yield (4.50kg/m^2), tuber yield (31.47t/ha) and ascorbic acid content (24.57mg/100g) was recorded from the same treatment.

Key words : Boron, boronated sulphur, growth, potato, sulphur, yield.

Introduction

Potato is an annual, tuberous vegetable crop, botanically known as *Solanum tuberosum* belongs to the family Solanaceae. India is among one of the major potato producing countries in the world. The leading potato producing state of India is Uttar Pradesh, followed by West Bengal and Bihar (NHB, 2018). The other major potato producing states are Gujarat, Madhya Pradesh, and Punjab. Potato is a temperate climate crop and the optimum temperature for its vegetative growth is 24^0C, but prefers relatively lower temperature for the tuber formation. Potato responds well to the application of primary nutrients such as N, P and K. The application proper dose of nitrogen has significant effect on the yield and quality of potato owing to increase in leaf area, photo assimilation and tuber growth (Vaezzadeh and Naderidarbaghshahi, 2012). While Phosphorous is essential for early seedling growth, root growth and tuber formation, Potassium is required for water metabolism, transport of minerals and translocation of photosynthates between source and sink (Singh *et al.*, 2018). The potato crop responds well to irrigation as it has a sparse shallow tap root system. The yield of the crop varies from variety to variety as well as region to region. It also depends upon the package of practices followed during cultivation. Among the secondary nutrients, sulphur is required more than other elements. It is considered as the fourth major nutrient after NPK and known to be essential for crop production. Crops requiring higher nitrogen usually need higher amount of sulphur for optimum growth. The soils of most of the states of India are deficient in Sulphur. According to Biswas *et al.*, (2004), more than 70% of samples of soil tested from states Uttar Pradesh, Madhya Pradesh, Maharashtra, Andhra Pradesh, Karnataka Jharkhand, Odisha and West Bengal were found low to medium in available sulphur. Owing to the deficiency of Sulphur in Indian soil, high crop response to sulphur application is observed. Sulphur plays an important role in the growth and development of plants. Sulphur is a constituent of three important amino acids *i.e.* cystine, cysteine and methionine. Adequate application of sulphur in potato helps in nutrient uptake, chlorophyll biosynthesis, abiotic and biotic stress resistance, carbohydrate formation and vitamin biosynthesis. The availability of micronutrients such as zinc, iron, copper and manganese to plant is improved by application of sulphur (El-Tantawy and El-Beik, 2009). The assimilation of primary nutrients such as nitrogen, phosphorus and potash by plants is

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reduced under Sulphur deficient condition (Nasreen *et al.*, 2008). The soils of West Bengal are deficient of different micronutrients such as Zinc and Boron. According to Mondal et al. (2015) about 34 per cent soils of West Bengal are Zn-deficient and which is more prominent in potato growing alluvial soils. About 68% of the soils of West Bengal are deficient in Boron (Singh, 2001). Hence the management of micronutrient deficiency especially Zinc and Boron needs utmost attention in potato growing areas (Banerjee *et al*., 2016). According to Singh (2001) about 33% of the soils of India are deficient in available B. Boron is essential for transport of carbohydrates, maintenance of sugar starch balance, pectin formation, amination of sugars and pollen germination in plants. It is also essential for transport of auxin, synthesis protein and nucleic acids. It plays important role in cellular activities such as division, differentiation, maturation, respiration, growth etc. Boron is considered as the most important micronutrient for potato and essential for yield as well as quality of potatoes. Considering the above facts, the present study was carried out to evaluate the response of potato to Boronated Sulphur in terms of growth and yield of tubers.

Material and Methods

The field experiment was carried out during *rabi* season of 2018-19 at Agriculture Farm, Institute of Agriculture with seven treatments each replicated thrice. All the plots demarcated by 10 cm high ridges on all sides. Adequate numbers of irrigation channels were also constructed to provide irrigation independently to each plot. This farm is located at the heart of the sub-humid, sub-tropical belt. The soil of the experimental plot was sandy loam in texture. The soil was medium in available P_2O_5 and available K_2O and low in available N. The experiment was laid out in Randomized Block Design (RBD) with seven treatment combinations, replicated thrice in 5m×4m plots.The spacing of the crop was 50 cm × 20 cm. The variety Kufri Jyoti was used for raising the crop. The land was ploughed with tractor drawn plough followed by harrowing and levelling. The recommended dose of fertilizers of State recommendation of 200-150-150 kg N-P_2O_5-K_2O/ha was followed in all the treatments. No organic manure was applied. Boronated Sulphur was used as the only source of Sulphur and Boron. DAP (18-46-0) and Urea will be used as source Nitrogen. SSP was not used as source of phosphorous as it contains Sulphur. The treatments of fertilizers included Control (T_1), Boronated Sulphur @7.5 kg/acre (T_2), Boronated Sulphur @10 kg/acre (T_3), Boronated Sulphur @ 15 kg/acre (T_4), Boronated Sulphur @ 20 kg/acre (T_5), Bentonnite Sulphur (90%) @ 10 kg/acre (T_6) and Bentonnite Sulphur+ Boron (equivalent to Boronated Sulphur 10 kg/acre) [T_7]. The NPK fertilizers, Boronated Sulphur, Bentonnite Sulphur and Boron were applied as basal dose. Seed tubers of Kufri Jyoti were planted manually on furrows opened at a spacing of 50 cm × 20cm and depth of 15 cm, and finally covered with soil. The furrows were opened and earthing up was done with the help of phawrah. Irrigation was applied at regular intervals as and when required. First irrigation was applied immediately after planting the tubers and subsequently during the crop period at a regular interval of 10 days. Two manuals weeding and hoeing were done at 30 and 45 days after planting of tubers. Carbendazin (12%) + Mancozeb (63%) WP @ 2g per litre was sprayed twice at 30 and 45 DAP for protection of the crop from diseases and Chlorpyrifos 20% EC @2ml per litre was sprayed twice to avoid the pest attack. When crop matured fully and plants dried, tubers were harvested by digging carefully with help of manual labours. The growth parameters such as plant height, number of leaves per plant, number of shoots per plant were recorded twice at 40 and 80 DAP, whereas tuber bulking rate and tuberization efficiency were recorded during 40-60 and 60-80 DAP. Tuber Bulking Rate (TBR) was calculated by the formula $TBR=(W_2-W_1)/(T_2-T_1)$, where W_1 and W_2 are the dry weights of tubers in unit area of land at two successive time intervals T_1 & T_2, respectively. It was expressed in the unit g $m^{-2}day^{-1}$. Tuberization efficiency was calculated by dividing tuber weight with shoot weight. Tuberization efficiency = Fresh weight of tubers per plant(g)/Fresh weight of shoots per plant (g). For yield and yield attributes such as fresh tuber weight (g $plant^{-1}$), all the tubers from three plants were separated from stolon and fresh weight of tubers was measured by electronic balance and the average tuber weight per plant was worked out. The tuber yield per plot (m^2) and per hactare was recorded by weighting the tubers after harvest in kg/plot and finally expressed as ton/ha. The ascorbic acid content in tubers was determined as per method described by Rangana (1979) by using standard dye solution.

Results and Discussion

Effect on plant height

The effect of boronated sulphur on the plant height of potato was studied at 40 and 80 DAP (Table 1) The plant height was found to increase by the application of boronated sulphur. However highest plant height was recorded from T_4 (Boronated Sulphur @ 15 kg/acre) where as lowest was recorded from T_1 (control). Plant height recorded at both stages (40 and 80 DAP) from T_3, T_4 and T_5 were found to be significantly higher than the control. However the plant height recorded from T_2, T_6 and T_7 was found to be at par with control. The plant height was also found to increase by application of Bentonnite Sulphur+ Boron (equal to Boronated Sulphur 10 kg/acre) but it was significantly lower as compared to T_4 (Boronated Sulphur @ 15 kg/acre). Similar results were also obtained by Muthanna *et al.*, (2017) and Singh *et al.*, (2018).

Effect on number of leaves per plant

The effect of boronated sulphur on the number of leaves per plant was studied at 40 and 80 DAP (Table 1) The number of leaves was found to increase by the application of boronated sulphur. However highest number of leaves was recorded from T_4 (Boronated Sulphur @ 15 kg/acre) where as lowest was recorded from T_1 (control). The number of leaves recorded at both stages (40 and 80 DAP) from T_3 and T_4 were found to be significantly higher than the control, where as number of leaves recorded from T_2, T_5, T_6 and T_7 were at par with control. The number of leaves was also found to increase by application of Bentonnite Sulphur+ Boron (equal to Boronated Sulphur 10 kg/acre) but it was significantly lower as compared to T_4 (Boronated Sulphur @ 15 kg/acre). This result corroborates the finding of Muthanna *et al.*, (2017), Sarkar *et al.,* (2018) and Singh *et al.*, (2018).

Number of shoots per plant

The effect of boronated sulphur on the number of shoots (haulms) per plant was studied at 40 and 80 DAP table 1 The number of shoots was found to increase by the application of boronated sulphur. However highest the number of shoots was recorded from T_4 (Boronated Sulphur @ 15 kg/acre) where as lowest was recorded from T_1 (control). The number of shoots recorded at both stages (40 and 80 DAP) from T_3, T_4, T_5 and T_6 were found to be significantly higher than the control. However number of shoots recorded from T_2 was at par with control. The number of shoots was also found to increase by application of Bentonnite Sulphur+ Boron (equal to Boronated Sulphur 10 kg/acre) but it was significantly lower as compared to T4 (Boronated Sulphur @ 15 kg/acre). This result corroborates the finding of Sarkar *et al.,* (2018) and Singh *et al.*, (2018).

Tuber bulking rate

The effect of boronated sulphur on tuber bulking rate was studied during 40-60 and 60-80 DAP table 2 The tuber bulking rate was found to increase by the application of boronated sulphur. However highest tuber bulking rate was recorded from T_4 (Boronated Sulphur @ 15 kg/acre) where as lowest was recorded from T_1 (control). The tuber bulking rate recorded during both stages (40-60 and 60-80 DAP) from T_3, T_4, T_5 and T_6 were found to be significantly higher than the control. But the tuber bulking rate recorded from T_2 and T_7 was found to be at par with control. The tuber bulking rate was also found to increase by application of Bentonnite Sulphur+ Boron (equal to Boronated Sulphur 10 kg/acre) but it was significantly lower as compared to T_4 (Boronated Sulphur @ 15 kg/acre).

Tuberization efficiency

The effect of boronated sulphur on tuberization efficiency was studied during 60 DAP table 2. The tuberization efficiency was found to increase by the application of boronated sulphur. However highest tuberization efficiency was recorded from T_4 (Boronated Sulphur @ 15 kg/acre) where as lowest was recorded from T_1 (control). The tuberization efficiency recorded from T_2, T_3, T_4, T_5, T_6 and T_7 were found to be significantly higher than the control. Though the tuberization efficiency was found to increase by application of Bentonnite Sulphur+ Boron (equal to Boronated Sulphur 10 kg/acre) but it was significantly lower as compared to T_4 (Boronated Sulphur @ 15 kg/acre).

Tuber yield

The effect of boronated sulphur on tuber yield per plant, tuber yield (kg/m^2) and tuber yield (ton/ha) was studied at harvest Table 3 The tuber yield per plant, tuber yield (kg/m^2) and tuber yield (ton/ha) were found to increase by the application of boronated sulphur. However highest tuber yield per plant, tuber yield (kg/m^2) and tuber yield (ton/ha) were recorded from T_4 (Boronated Sulphur @ 15 kg/acre) where as lowest was recorded from T_1 (control). The tuber yield per plant, tuber yield (kg/m^2) and tuber yield (ton/ha) recorded from T_3 and T_4 were found to be significantly higher than the control. Though the tuber yield per plant, tuber yield and tuber yield was also found to increase in T_2, T_5, T_6 and T_7, but it was at par with control. The tuber yield per plant, tuber yield (kg/m2) and tuber yield (ton/ha) were also found to increase by application of Bentonnite Sulphur+ Boron (equal to Boronated Sulphur 10 kg/acre) but it was significantly lower as compared to T_4 (Boronated Sulphur @ 15 kg/acre). This result corroborates the finding of Sharma *et al.*, (2011), Barczak *et al.*, (2013), Muthanna *et al.*, (2017), Sarkar *et al.*, (2018) and Singh *et al.*, (2018).

Ascorbic acid (Vitamin C) content

The effect of boronated sulphur on Ascorbic acid content (mg/100g) of tubers was studied during at harvest table 3 The Ascorbic acid content was found to increase

Table 1: Effect of Boronated Sulphur on the growth parameters of potato.

Treatments	Plant Height (cm)		Number of leaves/plant		Number of shoots/plant	
	40 DAP	80DAP	40 DAP	80 DAP	40 DAP	80DAP
T_1	28.55	35.73	28.20	37.80	3.80	4.54
T_2	30.64	36.55	29.13	40.27	4.42	5.33
T_3	32.05	38.91	33.73	44.87	5.13	5.88
T_4	35.25	43.33	35.50	47.80	5.48	6.22
T_5	32.55	38.47	31.10	42.13	5.03	5.78
T_6	28.87	37.23	30.37	40.20	4.92	5.67
T_7	31.20	37.06	29.40	39.20	4.36	5.21
SEm(±)	0.96	1.33	1.47	1.84	0.21	0.24
CD(0.05)	2.83	3.93	4.33	5.42	0.63	0.71

Table 2: Effect of Boronated Sulphur on the tuber bulking rate and tuberization efficiency of potato.

Treatments	Tuber bulking rate (40-60DAP)	Tuber bulking rate (60-80DAP)	Tuberization efficiency
T_1	38.67	46.43	1.93
T_2	43.27	53.13	2.18
T_3	48.20	58.39	2.31
T_4	51.13	62.07	2.47
T_5	49.30	60.08	2.27
T_6	45.23	54.87	2.25
T_7	42.00	51.10	2.16
SEm(±)	2.19	2.44	0.05
CD(0.05)	6.45	7.20	0.14

Table 3: Effect of Boronated Sulphur on the yield and ascorbic acid content of potato.

Treatments	Tuber yield/ plant (g)	Tuber yield (kg/m^2)	Tuber yield (t/ha)	Ascorbic acid content (mg/100g)
T_1	320.28	3.20	22.42	19.23
T_2	359.44	3.59	25.16	21.44
T_3	408.40	4.08	28.59	23.11
T_4	449.55	4.50	31.47	24.57
T_5	353.62	3.54	24.75	23.25
T_6	348.43	3.48	24.39	22.25
T_7	344.43	3.44	24.11	21.17
SEm(±)	21.26	0.21	1.49	0.80
CD(0.05)	62.71	0.63	4.39	2.35

by the application of boronated sulphur. However highest Ascorbic acid content was recorded from T_4 (Boronated Sulphur @ 15 kg/acre) where as lowest was recorded from T_1 (control). The Ascorbic acid content recorded from T_3, T_4, T_5 and T_6 was found to be significantly higher than the control. However the ascorbic acid content of tibers recorded from T_2 and T_7 were found to be at par with control. The Ascorbic acid content was also found to increase by application of Bentonnite Sulphur+ Boron (equal to Boronated Sulphur 10 kg/acre) but it was significantly lower as compared to T_4 (Boronated Sulphur @ 15 kg/acre). Similar results were also obtained by Mondy and Munshi (1993), who reported increase in ascorbic acid content of tubers by application of boron.

Conclusion

From the results it was found that application of boronated sulphur (T_3, T_4 and T_5) improved most of the growth as well as yield parameters of potato crop. However, T_4 (Boronated Sulphur @ 15 kg/acre) was found to be the best treatment which not only significantly increased the growth parameters of potato such as plant height, number of leaves per plant, number of shoots per plant, tuber bulking rate and tuberization efficiency but also increased the yield and quality parameters such as (tuber yield per plant, tuber yield (kg/m^2) and ascorbic acid content of tubers. Hence T_4 *i.e.* Boronated Sulphur @ 15 kg/acre can be recommended for achieving significantly higher yield of potato.

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