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Akshay S Magar
Student, Department of Biological Sciences, Faculty of Science, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad 211007, UP, India

Mohan KN
Student, Department of Biological Sciences, Faculty of Science, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad 211007, UP, India

Ambilwade B
Student, Department of Biological Sciences, Faculty of Science, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad 211007, UP, India

Burondkar SS
Student, Department of Biological Sciences, Faculty of Science, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad 211007, UP, India

Pradeep Kumar Shukla
Assistant Professor, Department of Biological Sciences, Faculty of Science, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad 211007, UP, India

Correspondence
Akshay S Magar
Student, Department of Biological Sciences, Faculty of Science, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad 211007, UP, India

Effect of different doses of Vanadium on morphological, biochemical and yield attributing characters of sweet corn (*Zea mays* L.)

Akshay S Magar, Mohan KN, Ambilwade B, Burondkar SS and Pradeep Kumar Shukla

Abstract
A pot experiment was conducted in *Rabi* session to study the effect of different concentration of Vanadium (0, 20, 40, 60, 80, 100 ppm) on morphological and biochemical character of two varieties of sweet corn (*Zea mays* L.) Madhuri & Phule Madhu. Vanadium was applied at 30 DAS & at flowering time. The observation were recorded at flowering & harvesting time. Results showed that the maximum improvement in morphological, biochemical and production characters was observed in variety Madhuri at 20 ppm Vanadium as compared to control and the Minimum effect 20 ppm was observed in variety Phule Madhu at 100 ppm. Vanadium applied to plant in low concentrate (20 ppm) resulted in improvement of morphological, biochemical and yield character of sweet corn.

Keywords: Vanadium, sweet corn, growth, biochemical characters

Introduction
Corn (*Zea mays* L.) is a versatile crop, also known as queen of cereals. It has found an important place in the human diet, animal feed as well as fodder including industrial raw material like starch and oil. Being C_4 plant maize has high yielding potential because this crop has greater ability to convert solar energy into food. Its grain contains about 10 % protein, 4 % oil, 70 % carbohydrate, 2.3 % crude fibre, 10.4 % albumins, and 1-4 % ash. It also contains vitamin A, nicotine acid and riboflavin, vitamin E. Maize is important crop in the world grown in more than 150 countries having 600 million ha area with 600 million ton of production. Special corn viz., sweet corn (*Zea mays var. saccharata*), popcorn (*Zea mays var. everta*), baby corn (*Zea mays* L.), high-oil corn etc. These corns especially sweet corn with their high market value are perfectly suitable to peri-urban agriculture as they promise higher income to maize growers. Sustainability of sweet corn scientific cultivation practices must be ensured to attain the goal of agricultural sustainability. Sweet corn is picked at milk stage and eaten as a vegetable, rather than a grain. Its consumption at immature stage as roasted and boiled ears is a popular practice as the kernels are sweet. Maize is an exhaustive crop and requires high quantities of nitrogen and phosphorus. Low soil fertility is one of the bottlenecks to sustain agricultural production and productivity in India (Khan and Singh. 2017) [6].
Sweet corn is a new choice of the progressive farmers as its green cobs as well as nutritious green fodder fetch higher market prices (Painyuli *et al*., 2013) [10].
Micronutrients play an active role in the plant metabolism process starting from cell wall development to respiration, photosynthesis, chlorophyll formation, enzyme activity nitrogen fixation and reduction (Adhikary *et al*., 2010) [1]. Vanadium (V) is a transition element widely distributed in nature and biological systems, as well as a part of fossil fuels, and agricultural supplies, such as chemical fertilizers which contain ammonium metavanadate (NH_4VO_3) (Hector *et al*., 2017) [3].
V is the 5th most abundant element among the transitional metals in the earth crust. V is extensively dispersed in the environment by different ways like leaching, combustion, use of fertilizers, and waste material from industries, resultantly, V contaminates the soil, water and atmosphere. The most common form of vanadium is Vanadium pentoxide (V_2O_5), followed by ammonium metavanadate (NH_4VO_3) and sodium orthovanadate (NaH_2PO_4) (Imtiaz *et al*., 2014). Vanadium is also essential for several species of fungi and nitrogen-fixing microorganisms but there is little evidence whether it is essential for higher plants (Saco *et al*., 2013) [12].
However, the adoption of improved agronomic practices, suitable varieties (Madhuri & Phule Madhu) and suitable dose of vanadium can increase crop productivity. Ultimately growing

suitable varieties with proper dose of vanadium increase growth and yield of crop. Therefore the objectives of this study the effect of Vanadium (V) on morphological, biochemical and yield characters of sweet corn.

Materials and Methods

The present experiment was undertaken at field of Department of Biological Sciences, Naini Agriculture Institute, Sam Higginbottom University of Agriculture, Technology and Sciences Allahabad, Uttar Pradesh, INDIA during *rabi* 2017-18. Sweet corn seeds of hybrid Madhuri and Phule Madhu were used for the pot experiment. Pot experiment was done according to completely randomized design with three replications, and recommended package of practices were followed to raise the crop. Approximately 8 kg of soil was filled in pot and sowing was done using 3-4 seed per pot by dibbling method. The observation were recorded on each plants of each pot and replication for all characters Days to 50 % tasselling, Days to silking, Plant height (cm), Number of leaf, Leaf area, Root length (cm), Chlorophyll content, Carotenoids content, Proline content, no. of cob. Cob length, cob girth and green cob yield. Sweet corn (30 DAS and flowering time) were allowed to apply Vanadium solution containing seven different Ammonium metavanadate (NH_4VO_3) concentration: 0, RDF, 20, 40, 60, 80, 100 PPM. The Vanadium solution were maintained a constant volume during the pot experiment. Analysis of variance (ANOVA) as suggested Fisher and Yates (1936) was used to determine the statistical significant of the difference between treatment means in all experiments.

Results

Result presented in table 1 showed comparative analysis of growth parameter of sweet corn varieties (Madhuri & Phule Madhu) as infused by different doses of vanadium. (0, 20, 40, 60, 80, 100 ppm).

1) **Plant height at flowering time (cm):-** Result revealed that plant height was the maximum in treatment T_2 (20 ppm) in both varieties Madhuri (122.70) and Phule Madhu (60.60). However the minimum plant height was observed in the treatment T_6 (100 ppm) in both varieties Madhuri (109.47) & Phule Madhu (42.70).
2) **Days to Tasseling:** Result revealed that days to tasseling was the maximum in treatment T_2 (20 ppm) in both varieties Madhuri (55.67) and Phule Madhu (63.33) however the minimum days to tasseling was observed in the T_6 (100 ppm) in both varieties Madhuri (62) & Phule Madhu (65.33).
3) **Days to Silking:** Result revealed that days to silking was the maximum in treatment T_2 (20 ppm) in both varieties Madhuri (70) and Phule Madhu (73.67). However the minimum days to silking was observed in the treatment T_6 (100 ppm) in both varieties Madhuri (74) & Phule Madhu (77.33).
4) **Leaf Area (dm^2):** Result revealed that leaf area was the maximum in treatment T_2 (20 ppm) in both varieties Madhuri (2427.96) and Phule Madhu (1006.83). However the minimum leaf area was observed in the treatment T_6 (100 ppm) in both varieties Madhuri (1489.95) & Phule Madhu (686.37).
5) **No. of Leaf:** Result revealed that no. of leaf was the maximum in treatment T_2 (20 ppm) in both varieties Madhuri (13) and Phule Madhu (10.67). However the minimum no. of leaf was observed in the treatment T_6 (100 ppm) in both varieties Madhuri (10) & Phule Madhu (9).
6) **Root Length (cm):** Result revealed that root length was the maximum in treatment T_2 (20 ppm) in both varieties Madhuri (69.50) and Phule Madhu (60.60). However the minimum root length was observed in the treatment T_6 (100 ppm) in both varieties Madhuri (38.7) & Phule Madhu (45.33).

Result presented in table 2 showed comparative analysis of biochemical parameter of sweet corn varieties (Mahuri & Phule Madhu) as infused by different doses of vanadium.(0, 20, 40, 60, 80, 100 ppm).

1) **Chlorophyll a (mg/g/Fr.Wt):** Result revealed that chl.a was the maximum in treatment T_2 (20 ppm) in both varieties Madhuri (2.71) and Phule Madhu (2.40). However the minimum chl.a was observed in the treatment T_6 (100 ppm) in both varieties Madhuri (2.51) & Phule Madhu (1.27).
2) **Chlorophyll b (mg/g/Fr.Wt):** Result revealed that chl.b was the maximum in treatment T_2 (20 ppm) in both varieties Madhuri (1.43) and Phule Madhu (2.27). However the minimum chl.b was observed in the treatment T_6 (100 ppm) in both varieties Madhuri (2.06) & Phule Madhu (0.97).
3) **Total Chlorophyll (mg/g/Fr.Wt):** Result revealed that total chl. was the maximum in treatment T_2 (20 ppm) in both varieties Madhuri (2.39) and Phule Madhu (2.01). However the minimum total chl. was observed in the treatment T_6 (100 ppm) in both varieties Madhuri (1.26) & Phule Madhu (0.98).
4) **Carotenoids (mg/g/Fr.Wt):** Result revealed that Carotenoids was the maximum in treatment T_2 (20 ppm) in both varieties Madhuri (1.09) and Phule Madhu (0.82). However the minimum Carotenoids was observed in the treatment T_6 (100 ppm) in both varieties Madhuri (0.95) & Phule Madhu (0.47).
5) **Proline (µg/g.Fr.Wt):** Result revealed that proline was the maximum in treatment T_6 (100 ppm) in both varieties Madhuri (0.14) and Phule Madhu (0.19). However the minimum proline was observed in the treatment T_2 (20 ppm) in both varieties Madhuri (0.04) & Phule Madhu (0.04).

Result presented in table 3 showed comparative analysis of yield parameter of sweet corn varieties (Mahuri & Phule Madhu) as infused by different doses of vanadium. (0, 20, 40, 60, 80, 100 ppm).

1) **No. of cob:** Result revealed that no. of cob was the maximum in treatment T_2 (100 ppm) in both varieties Madhuri (2) and Phule Madhu (1.67). However the minimum no. of cob was observed in the treatment T_6 (20 ppm) in both varieties Madhuri (1) & Phule Madhu (1).
2) **Cob length (cm):** Result revealed that cob length was the maximum in treatment T_2 (100 ppm) in both varieties Madhuri (20.33) and Phule Madhu (16.47). However the minimum cob length was observed in the treatment T_6 (20 ppm) in both varieties Madhuri (16.87) & Phule Madhu (13.93).
3) **Cob girth (cm):** Result revealed that cob girth was the maximum in treatment T_2 (100 ppm) in both varieties Madhuri (16.13) and Phule Madhu (12.53). However the minimum cob girth was observed in the treatment T_6 (20 ppm) in both varieties Madhuri (11.53) & Phule Madhu (9.73).

4) **Green Cob weight (g/plant^{-1}):** Result revealed that Green Cob weight was the maximum in treatment T_2 (100 ppm) in both varieties Madhuri (112.57) and Phule Madhu (48.37). However the minimum Green Cob weight was observed in the treatment T_6 (20 ppm) in both varieties Madhuri (81.63) & Phule Madhu (31.77).

Discussion

Plant height, days of flowering & tasseling, no. leaf, root length, leaf area, chlorophyll content, no. of cob. Cob length, cob girth, cob yield and was increased in treatment having vanadium in low concentration and decreases at concentration.

Similar finding for plant height, no. leaf, root length, leaf area and yield was observed by Vachirapatama *et al.,* (2011) where it was reported that low concentration of vanadium increases the plant growth parameters of chines cabbage and tomato. This effect may be due to the fact that V at this concentration can help increase nitrogen in the form of ammonium compound activating the rice growth. Vanadium is a crucially important element for photosynthesis and phytoplankton growth Nalewajko *et al.,* (1995). It is also essential for some species of nitrogen fixing bacteria, algae, and fungi. V plays a pivotal role in the formation of the holo-enzyme of peroxidase of bromine, iodine, and chlorine Hector *et al.,* (2017) [3]. Kasai *et al.,* (1999) [5]. also reported that V is an essential element for the growth of the green alga (*Scenedesmus obliquus*) in V is required at concentration 0.1 g/ml V in nutrient medium. by above 25mg V + RDF This result was due to inhibition of growth & death of cell of plant. Meisch *et al*., (1977) [7]. Signifying amount of V in soil water have shows to have inhibitory effect on plant some enzymes, growth & photosynthesis Kasim *et al*., (1999). The increase of proline content was might associated with the development of AMF hypha which assisted the plant to extract water as well as nutrients from the dry soil. Kandowangko *et al*., (2009) [4]. Signifying amount of V in soil water we can shows to have inhibitory effect on plant some enzymes, growth & photosynthesis Kasim *et al*., (1999). Similar finding was given by, the obtained result was yield decreases with increases the rate of vanadium because toxicity symptom in roots are club shaped, secondary root number reduction & necrosis Gil *et al*., (2008). Signifying amount of V in soil water we can shows to have inhibitory effect on plant some enzymes, growth & photosynthesis Kasim *et al*., (1999). Similar finding was given by, the obtained result was yield decreases with increases the rate of vanadium because toxicity symptom in roots are club shaped, secondary root number reduction & necrosis Gil *et al*., (2008). Signifying amount of V in soil water we can shows to have inhibitory effect on plant some enzymes, growth & photosynthesis Kasim *et al*., (1999). Similar finding was given by, the obtained result was yield decreases with increases the rate of vanadium because toxicity symptom in roots are club shaped, secondary root number reduction & necrosis Gil *et al*., (2008).

Table 1: Mean table of Morphological character of sweet corn Madhuri (V_1) and Phule Madhu (V_2).

Treatment	Plant Height (cm)		Days of Tasseling		Days of Silking		Leaf Area (dm²)		No. of Leaf		Root Length (cm)	
	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2
Control	100.03	22.10	65.67	40.53	82.00	72.67	1051.74	83.33	9.33	431.93	25.60	6.67
RDF	105.57	26.40	61.33	44.53	76.67	68.67	1272.10	80.33	10.00	538.70	38.03	8.00
RDF+V(20 ppm)	122.70	60.60	55.67	80.43	70.00	63.33	2427.96	73.67	13.00	1006.83	69.50	10.67
RDF+V(40ppm)	117.63	50.47	58.00	72.43	71.00	64.00	1991.57	75.00	11.67	928.37	63.03	10.33
RDF+V(60ppm)	114.87	48.93	60.00	70.47	72.00	65.00	1627.52	75.33	10.33	799.23	55.43	10.33
RDF+V(80ppm)	112.60	46.00	60.67	66.33	72.67	66.33	1686.15	76.33	11.00	739.80	45.67	9.33
RDF+V(100ppm)	109.47	42.70	62.00	64.13	74.00	65.33	1489.95	77.33	10.00	686.37	38.60	9.00
Gen. Mean	111.84	42.46	60.48	62.70	74.05	66.48	1649.57	77.33	10.76	733.03	47.98	9.19
MIN.	100.03	22.10	65.67	40.53	82.00	72.67	1051.74	83.33	9.33	431.93	25.60	6.67
MAX.	122.70	60.60	55.67	80.43	70.00	63.33	2427.96	73.67	13.00	1006.83	69.50	10.67
C.V.	1.91	4.41	1.91	4.10	1.89	2.32	9.70	1.47	7.85	13.00	2.18	7.87
S.E.M.	1.23	1.08	0.67	1.48	0.81	0.89	92.38	0.65	0.49	55.04	0.60	0.42
C.D. 5%	3.74	3.28	2.02	4.50	2.45	2.70	280.22	1.99	1.48	166.93	1.83	1.27

Table 2: Mean table of Biochemical character of sweet corn Madhuri (V_1) and Phule Madhu (V_2).

Treatment	Chlorophyll a (mg/g/Fr. Wt.)		Chlorophyll b (mg/g/Fr. Wt.)		Total Chlorophyll (mg/g/Fr. Wt.)		Carotenoids (mg/g/Fr. Wt.)		Proline Content (µg/g/ Fr. Wt.)	
	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2
Control	1.92	0.55	1.47	0.39	1.30	0.34	0.65	0.14	0.02	0.01
RDF	2.10	0.97	2.17	0.11	1.93	0.86	0.67	0.33	0.03	0.01
RDF+V(20 ppm)	2.71	2.40	1.43	2.27	2.39	2.01	1.09	0.82	0.04	0.04
RDF+V(40ppm)	2.64	1.75	2.41	1.94	2.18	1.69	0.98	0.57	0.05	0.07
RDF+V(60ppm)	2.58	1.67	2.34	1.79	2.08	1.54	0.96	0.56	0.06	0.15
RDF+V(80ppm)	2.55	1.46	2.17	1.58	1.83	1.40	0.91	0.49	0.10	0.19
RDF+V(100ppm)	2.51	1.27	2.06	0.97	1.26	0.98	0.95	0.47	0.14	0.19
Gen. Mean	2.43	1.44	2.09	1.44	1.85	1.26	0.89	0.48	0.06	0.09
MIN.	1.92	0.55	1.47	0.39	1.30	0.34	0.65	0.14	0.02	0.01
MAX.	2.71	2.40	1.43	2.27	2.39	2.01	1.09	0.82	0.04	0.04
C.V.	0.11	0.08	0.08	0.01	0.12	0.13	0.55	0.58	0.43	0.10
S.E.M.	0.15	0.06	0.01	0.01	0.02	0.01	0.02	0.01	0.01	0.02
C.D. 5%	0.47	0.21	0.32	0.31	0.04	0.03	0.08	0.04	0.05	0.01

Table 3: Mean table of yield character of sweet corn Madhuri (V_1) and Phule Madhu(V_2).

Treatment	Number of Cobs/Plant		Cob Length (cm)		Cob Girth (cm)		Green Cob Weight (gm/plant)	
	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2
Control	1.00	1.00	15.23	3.40	7.23	2.47	47.43	2.07
RDF	1.00	1.00	16.57	8.23	10.40	5.17	62.57	13.77
RDF+V(20 ppm)	2.00	1.67	20.33	16.47	16.13	12.53	112.57	48.37
RDF+V(40ppm)	1.33	1.33	18.90	15.73	14.87	11.50	93.57	45.87
RDF+V(60ppm)	1.00	1.00	18.03	14.93	13.87	10.60	90.00	41.27
RDF+V(80ppm)	1.00	1.00	17.27	14.30	12.80	10.10	86.80	39.37
RDF+V(100ppm)	1.00	1.00	16.87	13.93	11.53	9.73	81.63	31.77
Gen. Mean	1.19	1.14	17.60	12.43	12.40	8.87	82.08	31.78
MIN.	1.00	1.00	15.23	3.40	7.23	2.47	47.43	2.07
MAX.	2.00	1.67	20.33	16.47	16.13	12.53	112.57	48.37
C.V.	18.33	27.00	2.13	28.25	5.80	8.45	2.19	15.43
S.E.M.	0.13	0.18	0.22	2.03	0.42	0.43	1.04	2.83
C.D. 5%	0.38	0.01	0.66	6.15	1.26	1.31	3.15	8.59

Conclusion

It is the concluded from studies, on vanadium 20 ppm was found as best treatment to increases the yield of sweet corn in pot experiment. The result of current study also indicated that the higher dose of vanadium shows reverse effect on the morphological, biochemical and yield contributing character of the sweet corn.

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