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Effect of foliar nutrition of water soluble fertilizer and growth regulator on content and uptake of micronutrients by black gram (*Vigna mungo* L. Hepper)

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Abstract
The experimental soil was clay texture, moderately calcareous in nature and slightly alkaline in reaction and normal in salt content. A field experiment was conducted to study the "Effect of water soluble fertilizer with growth regulator on growth, yield and quality of black gram grown on Vertisol" at the farm of Department of Soil Science and Agril. Chemistry, College of Agriculture, Badnapur during *kharif* 2019-2020. The experiment comprised of ten treatments with three replication which included the foliar spray of water soluble fertilizer and growth regulator and RDF application through soil at the time of sowing. The results emerged out clearly indicated that the foliar application of water soluble fertilizer and growth regulator was influenced the total micronutrient content in seed and straw and also total uptake of micronutrient. The Fe concentration in black gram grain was observed to be higher in treatment T_6 (RDF + 00:52:34 @ 0.5% + SA @ 50 ppm 45 DAS) 111.67 mg kg^{-1} and Fe concentration in black gram straw was observed to be higher in treatment T_9 (RDF + 00:52:34 @ 0.5%+ GA + SA @ 50 ppm each 27 DAS) 60.67 mg kg^{-1}. The highest Fe uptake (1900.16 g ha^{-1}) was observed in treatment T_9 RDF + 00:52:34 @ 0.5%+ GA + SA @ 50 ppm each 27 DAS. Mn concentration in black gram grain and straw was significantly higher in the treatment T_9 (RDF + 00:52:34 @ 0.5%+ GA + SA @ 50 ppm each 27 DAS) 49.38 mg kg^{-1} and 23.10 mg kg^{-1}.The highest Mn uptake was 816.79 g ha^{-1} observed in treatment T_9 (RDF + 00:52:34 @ 0.5%+ GA + SA @ 50 ppm each 27 DAS).

Keywords: Black gram, water soluble fertilizer, growth regulator, vertisol, micronutrient and uptake

Introduction
Black gram (*Vigna mungo* L. Hepper) is one of the most important pulse crop grown throughout the India. Black gram is excellent source of protein as well as carbohydrates. It is also known as "Mash bean and urdbean". Black gram is third important pulse crop of India which is cultivated all over a wide range of agro-climatic zones of the country. It is mainly a day neutral warm season crop commonly grown in semi-arid to sub-humid low land tropics and sub- tropics. In India, black gram traditionally grown in Kharif season, but in south it also grown as rabi crop. It is grown in area at which received annual rainfall is 800 mm. It is a hardy and drought resistant plant. Black gram protein content is more than twice that of cereals reported by Thesiya *et al*. 2013 [4]. The legume crop improves soil fertility by symbiotic fixation of atmospheric nitrogen in root nodules Suradkar *et al*. 2022 [3]. Throughout the India, black gram is used for different purpose. The major portion is utilized in making dal, soup, curries, sweet, snacks, idle and dosa. The food values of black gram in its high and easily digestible protein. Its seed contain approximately 25-28 percent protein, 1-1.5 percent oil, 3.5-4.5 percent fiber, 4.5-5 percent ash and 62-65 percent carbohydrates on dry weight basis (Anonymous 2017) [1]. Yield is the culmination of several comprehensive phases which starts at germination and end at harvest, encompassing through shoot growth, leaf development, photosynthesis, flowering, pollination and seed set. Foliar nitrogen nutrition may induce drought tolerance in crop. Increase in plant height was due to availability of nitrogen and potassium to plants through foliar spray. Potassium regulates the osmotic turgor of cells and water balance which is driving force for cell division and elongation. Potassium nitrate (KNO_3) be consider the best option because it also provide potassium which influence water economy and crop growth, through its effect on water uptake, root growth, maintenance of turgor pressure, transpiration and stomata behavior. Foliar application of KNO_3 contribute in dry matter production (up to some extent) as indicated by delayed flowering.

KNO_3 @ 1 percent spray recorded maximum photosynthetic rate. The reason for the enhanced need for K by plants suffering from environmental stress like drought appears to be related to the fact that K is required for maintenance of photosynthetic and CO_2 fixation. Application of salicylic acid as 100 ppm concentration increase number of pod per plant, number of seed per pod, seed weight per plant and yield per hectare.

Foliar spray technique helps the nutrient to reach the site of food synthesis directly leading to no wastage and quick supply of food and therefore reduce the requirement of fertilizer. Foliar nutrient can hasten the growth of crop suddenly. Presently black gram yield is very low because the fact that the crop is mainly grown in rainfed condition with poor management practices and also due to various physiological, biochemical as well as inherent factors associated with the crop. Apart from the genetic makeup, the physiological factor *viz*., insufficient portioning assimilates, poor pod setting due to the flower abscission and lack of nutrients during critical stage of crop growth, coupled with a number of disease and pest constitute the major constraints for the poor yield. The productivity of black gram in our country is very low. Hence, there is need for enhancement of the productivity of black gram by proper agronomic and nutrient management practices. One among them is foliar application of organic and inorganic sources of nutrients for exploiting genetic potential of the crop. This is considered to be an efficient and economic method of supplementing part of nutrients requirements at critical stages. Foliar application is credited with the advantage of quick and efficient utilization of nutrients, elimination of losses through leaching, fixation and regulating the uptake of nutrients by plant (Manonmani and Srimathi 2009) [2].

Materials and Methods

A field experiment was conducted during Kharif, 2019-2020 in Vertisol at departmental farm of Soil Science and Agril. Chemistry, College of Agriculture, Badnapur. The experimental soil was clay texture, moderately calcareous in nature and slightly alkaline in reaction and normal in salt content. At sowing of experiment the soil exhibit pH 7.86 (slightly alkaline in reaction), electrical conductance 0.23 dSm^{-1}, organic carbon content 0.75% (moderately high) and free $CaCO_3$ content was 5.22% respectively. The soil sample was low in available nitrogen (180.36 kg ha^{-1}), moderate in available phosphorus (14.36 kg ha^{-1}), high in available potassium (460.59 kg ha^{-1}). The experimental design used was Randomized Block design (RBD) with three replications consisting ten different treatments *viz.* T1= Control, T2 =RDF, T3=RDF + 00:52:34 @ 0.5% +GA @ 50 ppm 27 DAS, T4=RDF + 00:52:34 @ 0.5% + SA @ 50 ppm 27 DAS, T5 = RDF + 00:52:34 @ 0.5% + GA @ 50 ppm 45 DAS, T6 = RDF + 00:52:34 @ 0.5% + SA @ 50 ppm 45 DAS, T7 = RDF + 13:00:45 @ 0.5% + GA @ 50 ppm 27 DAS, T8= RDF + 13:00:45 @ 0.5% + SA @ 50 ppm 27 DAS, T9= RDF + 00:52:34 @ 0.5%+ GA + SA @ 50 ppm each 27 DAS and treatment T10= RDF + 13:00:45 @ 0.5%+ GA + SA @ 50 ppm each 45 DAS.

Result and Discussion

Effect of water soluble fertilizer and growth regulator on total micronutrient content

Total Fe content and uptake

The data on Fe content and uptake by black gram as influenced by foliar application of water soluble fertilizer and growth regulator are presented in table 01. The effect of foliar application of water soluble fertilizer and growth regulator on Fe concentration in seed and straw was statistically non-significant. The grain and straw concentration of black gram ranged between 94.37 mg kg^{-1} to 111.67 mg kg^{-1} and 54.67 mg kg^{-1} to 60.67 mg kg^{-1} respectively.

Table 1: Effect of foliar application of water soluble fertilizer and growth regulator on Fe content in seed, straw and total uptake by Black gram

Treatments	Fe content (mg kg^{-1})		Total Uptake Fe (gha^{-1})
	Seed	Straw	
T_1: Control	94.37	54.67	488.43
T_2: RDF	105.00	57.00	1356.56
T_3: RDF + 00:52:34 @ 0.5% +GA @ 50 ppm 27DAS	102.00	55.33	1772.36
T_4: RDF + 00:52:34 @ 0.5% + SA @ 50 ppm 27 DAS	101.33	57.33	1791.04
T_5: RDF + 00:52:34 @ 0.5% + GA @ 50 ppm 45DAS	109.33	54.67	1439.39
T_6: RDF + 00:52:34 @ 0.5% + SA @ 50 ppm 45 DAS	111.67	57.00	1421.20
T_7: RDF + 13:00:45 @ 0.5% + GA @ 50 ppm 27 DAS	106.67	59.67	1871.52
T_8: RDF + 13:00:45 @ 0.5% + SA @ 50 ppm 27 DAS	102.67	51.22	1484.19
T_9: RDF + 00:52:34 @ 0.5%+ GA + SA @ 50 ppm each 27 DAS	103.67	60.67	1900.16
T_{10}: RDF + 13:00:45 @ 0.5%+ GA + SA @ 50 ppm each 45 DAS	106.67	53.65	1464.86
SEm±	9.37	4.78	56.34
C.D.@5%	NS	NS	NS

The Fe concentration in black gram grain was observed to be higher in treatment T_6 RDF + 00:52:34 @ 0.5% + SA @ 50 ppm 45 DAS (111.67 mg kg^{-1}) and straw was observed to be higher in treatment T_9: RDF + 00:52:34 @ 0.5%+ GA + SA @ 50 ppm each 27 DAS (60.67 mg kg^{-1}) respectively. The lowest Fe content in black gram grain and straw was observed in treatment T_1 Control (94.37 mg kg^{-1}) and (54.67 mg kg^{-1}) respectively. The nutrient uptake is a function of biomass and nutrient concentration in plant. The effect of foliar application of water soluble fertilizer and growth regulator on total uptake of Fe was statistically non-significant. The highest Fe uptake was observed in treatment T_9 RDF + 00:52:34 @ 0.5%+ GA + SA @ 50 ppm each 27 DAS (1900.16 g ha^{-1}). Results indicate the effect of the water soluble fertilizer and growth regulator foliar application in increasing Fe uptake.

Total Mn content and uptake

The effect of foliar application of water soluble fertilizer and growth regulator on total uptake of Mn was statistically non-significant. The highest Mn uptake was observed in treatment T_9 RDF + 00:52:34 @ 0.5%+ GA + SA @ 50 ppm each 27 DAS (816.79 g $ha^{-1)}$. Presented data clearly indicates the effect of water soluble fertilizer and growth regulator foliar application on increase in Mn uptake by black gram. Foliar

application resulted in greater absorption, assimilation and translocation of nutrients for increased photosynthesis which results in increase uptake of micronutrients. The effect of foliar application of water soluble fertilizer and growth regulator on Mn concentration in seed and straw was statistically non-significant. Mn concentration in black gram grain was significantly higher in the treatment T9 RDF + 00:52:34 @ 0.5%+ GA + SA @ 50 ppm each 27 DAS (49.38 mg kg-^{1}). The black gram straw concentration was higher in the treatment T9 RDF + 00:52:34 @ 0.5%+ GA + SA @ 50 ppm each 27 DAS (23.10 mg kg^{-1}). The nutrient uptake is a function of biomass and nutrient concentration in plant.

Total Zn content and uptake

The data on Zn content and uptake by black gram as influenced by foliar application of water soluble fertilizer and growth regulator are presented in table. The effect of foliar application of water soluble fertilizer and growth regulator on Zn concentration in seed was statistically non-significant. Zn concentration in black gram grain was significantly higher in the treatment T_7 RDF + 13:00:45 @ 0.5% + GA @ 50 ppm 27 DAS (35.45 mg kg^{-1}). Similarly the effect of foliar application of water soluble fertilizer and growth regulator on Zn concentration in straw was statistically non-significant. Zn content in the black gram straw content was significantly higher in the treatment T_9 RDF + 00:52:34 @ 0.5%+ GA + SA @ 50 ppm each 27 DAS (17.22 mg kg^{-1}). The nutrient uptake is a function of biomass and nutrient concentration in plant. The effect of foliar application of water soluble fertilizer and growth regulator on total uptake of Zn was statistically non-significant. The highest Zn uptake was observed in treatment T_9 RDF + 00:52:34 @ 0.5%+ GA + SA @ 50 ppm each 27 DAS (582.92 g ha^{-1}). Presented data clearly indicates the effect of water soluble fertilizer and growth regulator application on increase in Zn uptake by black gram. Foliar application resulted in greater absorption, assimilation and translocation of nutrients for increased photosynthesis which results in increase uptake of micronutrients.

Table 2: Effect of foliar application of water soluble fertilizer and growth regulator on Mn content in seed, straw and total uptake by Black gram

Treatments	Mn content(mg kg^{-1})		Total Uptake Mn (g ha^{-1})
	Seed	Straw	
T_1: Control	46.02	21.69	469.15
T_2: RDF	47.78	20.46	564.79
T_3: RDF + 00:52:34 @ 0.5% +GA @ 50 ppm 27 DAS	48.11	21.83	774.43
T_4: RDF + 00:52:34 @ 0.5% + SA @ 50 ppm 27 DAS	48.75	21.76	777.89
T_5: RDF + 00:52:34 @ 0.5% + GA @ 50 ppm 45DAS	48.44	21.71	609.39
T_6: RDF + 00:52:34 @ 0.5% + SA @ 50 ppm 45 DAS	49.02	22.71	598.85
T_7: RDF + 13:00:45 @ 0.5% + GA @ 50 ppm 27 DAS	48.14	22.42	779.79
T_8: RDF + 13:00:45 @ 0.5% + SA @ 50 ppm 27 DAS	48.24	22.75	681.07
T_9: RDF + 00:52:34 @ 0.5%+ GA + SA @ 50 ppm each 27 DAS	49.38	23.10	816.79
T_{10}: RDF + 13:00:45 @ 0.5%+ GA + SA @ 50 ppm each 45 DAS	49.28	22.70	302.24
SEm±	3.79	1.78	52.23
C.D.@5%	NS	NS	NS

Total Cu content and uptake

The effect of foliar application of water soluble fertilizer and growth regulator on Cu concentration in seed and straw was statistically non-significant. Cu concentration in black gram grain was significantly higher in the treatment T9 RDF + 00:52:34 @ 0.5%+ GA + SA @ 50 ppm each 27 DAS (14.73 mg kg^{-1}). The black gram straw content Cu was significantly higher in the treatment T9 RDF + 00:52:34 @ 0.5%+ GA + SA @ 50 ppm each 27 DAS (8.33 mg kg^{-1}). Total content of Cu it was statistically non-significant. The effect of foliar application of water soluble fertilizer and growth regulator on total uptake of Cu was statistically non-significant. The highest Cu uptake was observed in treatment T_9 RDF + 00:52:34 @ 0.5%+ GA + SA @ 50 ppm each 27 DAS (264.63 g ha^{-1}). Presented data clearly indicates the effect of water soluble fertilizer and growth regulator foliar application on decreases in Cu uptake by black gram. Foliar application resulted in greater absorption, assimilation and translocation of nutrients for increased photosynthesis which results in decreases uptake of micronutrients.

Table 3: Effect of foliar application of water soluble fertilizer and growth regulator on Zn content in seed, straw and total uptake by Black gram

Treatments	Zn content (mg kg^{-1})		Total Uptake Zn (g ha^{-1})
	Seed	Straw	
T_1: Control	34.38	11.00	304.00
T_2: RDF	34.27	14.33	394.10
T_3: RDF + 00:52:34 @ 0.5% +GA @ 50 ppm 27 DAS	34.12	15.67	551.94
T_4: RDF + 00:52:34 @ 0.5% + SA @ 50 ppm 27 DAS	35.22	15.03	552.04
T_5: RDF + 00:52:34 @ 0.5% + GA @ 50 ppm 45 DAS	34.40	13.82	414.73
T_6: RDF + 00:52:34 @ 0.5% + SA @ 50 ppm 45 DAS	34.99	14.67	410.79
T_7: RDF + 13:00:45 @ 0.5% + GA @ 50 ppm 27 DAS	35.45	15.42	558.71
T_8: RDF + 13:00:45 @ 0.5% + SA @ 50 ppm 27 DAS	34.22	15.33	473.13
T_9: RDF + 00:52:34 @ 0.5%+ GA + SA @ 50 ppm each 27 DAS	34.14	17.22	582.92
T_{10}: RDF + 13:00:45 @ 0.5%+ GA + SA @ 50 ppm each 45 DAS	34.65	15.55	453.73
SEm±	2.78	1.32	53.32
C.D.@5%	NS	NS	NS

Table 4: Effect of foliar application of water soluble fertilizer and growth regulator on Cu content in seed, straw and total uptake by Black gram

Treatments	Cu content (mg kg^{-1})		Total Uptake (g ha^{-1})
	Seed	Straw	
T_1: Control	10.67	5.74	114.82
T_2: RDF	14.33	7.33	180.34
T_3: RDF + 00:52:34 @ 0.5% +GA @ 50 ppm 27 DAS	13.33	7.33	232.59
T_4: RDF + 00:52:34 @ 0.5% + SA @ 50 ppm 27 DAS	10.00	6.48	148.35
T_5: RDF + 00:52:34 @ 0.5% + GA @ 50 ppm 45 DAS	12.00	7.37	173.44
T_6: RDF + 00:52:34 @ 0.5% + SA @ 50 ppm 45 DAS	11.00	6.33	147.73
T_7: RDF + 13:00:45 @ 0.5% + GA @ 50 ppm 27 DAS	12.00	7.00	214.66
T_8: RDF + 13:00:45 @ 0.5% + SA @ 50 ppm 27 DAS	10.67	6.67	170.90
T_9: RDF + 00:52:34 @ 0.5%+ GA + SA @ 50 ppm each 27 DAS	14.73	8.33	264.63
T_{10}: RDF + 13:00:45 @ 0.5%+ GA + SA @ 50 ppm each 45 DAS	11.96	6.57	170.40
SEm±	1.08	0.59	25.78
C.D.@5%	NS	NS	NS

Conclusion

Application of RDF + 00:52:34 @ 0.5%+ GA + SA @ 50 ppm each 27 DAS significantly increases growth and growth parameters and also yield and yield parameters due to overcome of water/nutrient stress during early growth and flowering stage. The application of foliar nutrition helps to overcome the specific occurrence of stress and as a result of maximum vegetative growth due to optimized nutrition of the plant. Foliar application of water soluble fertilizer and growth regulator influenced total micronutrient content in seed and straw and also total uptake of micronutrient. It also increases nutrient uptake of phosphorus, potassium significantly and increases nutrient content and uptake of Fe, Mn, Zn and Cu.

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