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EFFECT OF FOLIAR APPLICATION OF POTASSIUM NITRATE AND SALICYLIC ACID ON YIELD, YIELD ATTRIBUTES AND ECONOMICS OF WHEAT (*Triticum aestivum* L.)

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ABSTRACT

A field experiment was carried out during the *rabi* season of 2020-21 to study the effect of potassium nitrate and salicylic acid on yield, yield attributes and economics of wheat (*Triticum aestivum* L.). The field experiment was conducted at the Student's Research Farm, Khalsa College, Amritsar-143 001, Punjab, India. The experiment was laid out in split plot design with five foliar applications *viz.*,F_1 (potassium nitrate 1%), F_2 (potassium nitrate 2%), F_3 (salicylic acid 50 ppm), F_4 (salicylic acid 100 ppm) and F_5 (control) in main plots and three sub plots *viz.*,S_1 (booting stage), S_2 (booting + anthesis) and S_3 (booting + milking) and they were replicated thrice. The results showed that foliar applications of 2% potassium nitrate (F_2) recorded maximum effective tillers (63.42), number of grains spike^{-1} (45.64), 1000-grain weight (40.07), grain yield (44.98 q ha^{-1}) as well as B:C ratio (2.59) which was at par with F_4(salicylic acid 100 ppm) and F_1(potassium nitrate 1%) and significantly higher than rest of the treatments. Among the growth stages, S_2 (booting + anthesis) enhanced the yield attributes *viz.,* effective tillers, ear length, number of grains spike^{-1}, 1000-grain weight, yield and benefit: cost ratio of wheat which was at par with S_3 (booting + milking) but significantly better than S_1 (booting) treatment. The maximum yield (43.66 q ha^{-1}), net returns (Rs.65285 ha^{-1}) and B:C ratio (2.53) was achieved by S_2 (booting + anthesis) treatment. From the above findings, it may be concluded that foliar application of 2% potassium nitrate and 100 ppm salicylic acid at booting + anthesis stage resulted higher grain yield, yield attributes and economics of wheat

(Keywords: Economics, grain yield, potassium nitrate, salicylic acid, wheat and yield attributes)

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the most cultivated food crop worldwide due to its wider adaptability to different agro-climatic and soil conditions.Wheat grain contains more protein than other cereals and it has a relatively high content of niacin and thiamine. It is consumed in the form of flour, breads, biscuits, pasta, noodles and macaroni. Wheat straw is also used for the animal feed as fodder and for packaging materials. The wheat contains nearly 70% carbohydrates, 12% protein, 1.7% fat, 2.7% minerals,2% fiber and 12% moisture (Anonymous, 2019).China ranks first in terms of production followed by India, Russia and the USA. In India, wheat is second most important cereal crop after rice.The major wheat producing states are Uttar Pradesh, Punjab, Haryana, Tamilnadu, Maharashtra, Madhya Pradesh, Gujarat, Rajasthan and Karnataka. Under Punjab wheat is grown on an area of 3.52 million hectares with the production of 18.26 million tonnes and hectare^{-1} yield of 51.88 q ha^{-1}(Anonymous,2020).

Temperature stresses are the major environmental factors which affecting the plant growth, development and also its metabolic process. Most of the world crops including wheat have an optimal range of temperature. Exposure to higher than the optimal temperature reduced yield and decreased quality of wheat grain. Over 7 million hectares of wheat grown in approximately 50 countries are subjected to continual heat stressing environment and adversely affects wheat growth in many important production regions and is a major limitation to wheat productivity worldwide. Wheat growth and yield are adversely affected due to high temperature during reproductive phases. In wheat, high temperature (>31^{0}C) can decrease the rate of grain filling (Wardlaw and Moncur, 2002). Temperature above the optimum for growth can be deleterious, causing injury which is generally called heat stress. The north Indian states like Uttar Pradesh, Punjab, Haryana, Uttarakhand and Himachal Pradesh are some of the major producing states where crop is more susceptible to heat stress where 1^{0}C rise in temperature resulting in reduction of wheat yield (Singh *et al*., 2011).Grain filling duration is shortened by elevated temperature during anthesis to grain maturity which leads to considerable reduction in grain yield (Farooq *et al*., 2011). According to a report of the Intergovernmental panel on climate change (IPCC2014) the global climate predict an

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increase in mean ambient temperature between 3.7 to 4.8^{0}C by the end of century. This change in global temperature may alter the geographical distribution and growing season of agricultural crops.

To reduce the effect of high temperature on wheat crop, some phyto hormones are used. Recently spray of Osmo-protectants has been proposed to mitigate the effect of temperature and water stress. Foliar application of osmo-protectants like potassium nitrate and salicylic acid are used to mitigate the effect of heat stress in wheat. Application of potassium nitrate (KNO_3) may be considered as an option through its effect on water uptake, root growth, transpiration and stomatal behavior. Besides, crop growth can also be enhanced through nitrogen and potassium nutrition as N and K play a unique role in metabolic, physiological and biochemical functions of plants.Also potassium nitrate increased the quality parameters of tuberose were observed by (Ladhi *et al.,* 2021, Mahajan *et al*., 2012).Salicylic acid (SA) is a phenolic compound involved in the regulation of growth and development of plants and their responses to biotic and abiotic stress factors (Khan *et al.,*2013, Miura and Tada, 2014). Salicylic acid can also play a significant role in plant water relations under abiotic stress conditions. It is an endogenous growth regulator, which contributes in the regulation of physiological, biochemical and molecular processes and therefore, it affects the plant growth, development and productivity (Hayat *et al.,* 2010).

MATERIALS AND METHODS

A field experiment was carried out during *rabi* season of 2020-21 at the Student's Research Farm, Department of Agriculture, Khalsa College, Amritsar-143001, Punjab, India. The soil of the experimental field was categorized as sandy loam in texture. The soil was tested low in organic carbon (0.39%) and available nitrogen (179 kg ha^{-1}). However, available phosphorus (22 kg ha^{-1}) and potassium (296 kg ha^{-1}) were in medium category. The soil pH (8.4) and electrical conductivity (0.21 dS m^{-1}) values were within the normal range.The field experiment was laid out in split plot design (SPD) which consisted of main plot treatments such as potassium nitrate 1% (F_1), potassium nitrate 2% (F_2), salicylic acid 50 ppm (F_3), salicylic acid 100 ppm (F_4) and control (F_5) and sub plot treatments such as booting stage (S_1), booting + anthesis (S_2) and booting + milking (S_3) with three replications. The observations like yield attributes *viz.,* effective tillers $meter^{-1}$ row length, ear length, number of grains $spike^{-1}$, 1000-grain weight, yield and economics *viz.,* cost of cultivation, net returns and B: C ratio were recorded. The crop was raised as per the package of practices of Punjab Agricultural University, Ludhiana. Statistical analysis of the data recorded was done as per split plot (Cochran and Cox 1967) design using CPCS-1 software developed by the Department of Mathematics and Statistics, PAU, Ludhiana. Critical difference (CD) at 5% probability was used to compare the differences among treatments.

RESULTS AND DISCUSSION

Effect of potassium nitrate and salicylic acid on yield and yield attributes of wheat

Effective tillers $meter^{-1}$ row length

The number of effective tillers has a direct effect on the grain yield because it contributes to more number of grains to increase the yield. The data regarding the effective tillers $meter^{-1}$ row length are presented in Table 1.The highest number of effective tillers (63.42) was recorded in treatment KNO_3 (2%) and it was statistically at par with salicylic acid (100 ppm) and KNO_3 (1%) but significantly higher than salicylic acid (50 ppm) and control. These results were confirmed by the findings of Gul *et al.* (2011), who reported that number of tillers increased with foliar application of potassium.Similarly Shabnam *et al.* (2019) also reported that foliar spray of potassium nitrate increased the number of effective tillers. Among growth stages, maximum number of effective tillers (61.77) was observed in booting + anthesis stage followed by booting + milking stage but significantly higher than booting stage.

Length of spike (cm)

The length of spike indicates the number of spikelets which in turn affect the number of grains and ultimately the grain yield of wheat crop.The data presented in Table 1 revealed that foliar application of KNO_3 (2%) was highest spike length (10.72 cm) which was statistically at par with salicylic acid (100 ppm) and KNO_3 (1%) but significantly higher than salicylic acid (50 ppm) and control. This might be due to potassium foliar application may be ascribed to the role of potassium improving many physiological growth processes and delay plant leaves senescence as well as increasing photosynthetic activity. Among growth stages, maximum spike length (10.53 cm) was recorded in booting + anthesis stage which was statistically at par with booting + milking stage and significantly higher than booting stage. Similar results were obtained by Youssef *et al.* (2012), who recorded that increase in spike length with foliar application of potassium.

Number of grains $spike^{-1}$

Number of grains $spike^{-1}$ is important yield attribute which determine the yield potential of a crop. More the number of grains $spike^{-1}$ more will be the yield. The data on number of grains $spike^{-1}$ have been presented in Table 1.The maximum (45.64) number of grains $spike^{-1}$ was recorded in KNO_3 (2%) which was statistically at par with salicylic acid (100 ppm) and KNO_3 (1%), but significantly higher than salicylic acid (50 ppm) and control. This might be due to enhanced photosynthetic activity and translocation of photosynthates by potassium and nitrate. Among growth stages, maximum number of grains $spike^{-1}$ (44.72)was recorded in booting + anthesis stage which at par with booting + milking stage but significantly higher than booting stage. Similar results were obtained by Arif *et al.* (2006), who reported that number of grains $spike^{-1}$ increased with foliar nutrition.Azimi *et al.* (2013) in Iran also reported increased in number of grains spike^{-1} with salicylic acid application.

1000- grain weight (g)

The 1000-grain weight is most important yield attribute, which determines the yield contribution of individual grain as well as quality appearance of grain. More the 1000-grain weight, more grain looks bolder in appearance. The 1000-grain weight determines the ability of the plant to translocate the photo assimilates to sink. Data on 1000-grain weight have been presented in Table 1.The highest 1000-grain weight (40.07 g) was observed in KNO_3 (2%) and it was statistically at par with salicylic acid (100 ppm) and KNO_3 (1%), but significantly higher 1000-grain weight than salicylic acid (50 ppm) and control. This might be due to increased grain filling duration resulted in higher 1000-grain weight. Among growth stages, the maximum 1000-grain weight (39.41 g) was recorded at booting + anthesis stage followed by booting + milking stage but significantly higher than booting stage.These results were confirmed by the findings of Gosavi *et al.* (2017), who reported that increased in 1000-grain weight with foliar application of nutrients.Singh *et al.* (2013) in Jaipur (Rajasthan) also reported an increase in 1000-grain weight with salicylic acid application.

Grain yield (q ha^{-1})

Foliar applications of potassium nitrate and salicylic acid significantly affected the grain yield of wheat. The higher grain yield (44.98 q ha^{-1}) was recorded in foliar applied KNO_3 (2%) which was statistically at par with salicylic acid (100 ppm) and KNO_3 (1%) but significantly higher with salicylic acid (50 ppm) and control. Among growth stages, the maximum grain yield (43.66 q ha^{-1}) was observed in booting + anthesis stage which was statistically at par with booting + milking stage but significantly higher than booting stage. Higher grain yield in KNO_3 (2%) and salicylic acid (100 ppm) might be due to more translocation of photo assimilates and stored food reserve to sink (grains) and significantly increase the grain yield of wheat. Increase in grain yield with KNO_3 and salicylic acid application was attributed to higher grain setting and 1000-grain weight. Similar results of increase in grain yield were recorded by Mahajan*et al.* (2012), who reported that grain yield can be improved with single spray of 1% KNO_3 at flowering stage in transplanted rice and Singh *et al.* (2013) observed maximum grain yield with 100 ppm salicylic acid at jointing and ear emergence stage.

Economic analysis

Gross returns (Rs. ha^{-1})

Gross returns are total returns from the crop including from grain and from straw. The data pertaining to the gross returns are presented in Table 2. Foliar application of potassium nitrate and salicylic acid resulted in significantly increased gross returns. KNO_3 (2%) gave highest gross returns (Rs.110697 ha^{-1}) followed by (Rs.107550 ha^{-1}) in salicylic acid (100 ppm) and (Rs.106155 ha^{-1}) in KNO_3 (1%), (Rs.103464 ha^{-1}) in salicylic acid (50 ppm) and minimum (Rs.97252 ha^{-1}) in control. Among growth stages, the maximum (Rs.107871 ha^{-1}) gross returns were recorded in booting + anthesis stage followed by (Rs.104941 ha^{-1}) in booting + milking stage and minimum (Rs.102253 ha^{-1}) in booting stage.Similar results were found by Singh *et al.* (2020), who recorded that maximum gross return with foliar application of 0.5% KNO_3 at booting and anthesis stage.

Net returns (Rs. ha^{-1})

Net returns are the benefit from crop after deducting the cost of cultivation. Potassium nitrate application significantly increased the net return as compared to control. The highest net return (Rs.68101 ha^{-1}) was observed in KNO_3 (2%) application followed by (Rs.65074 ha^{-1}) in salicylic acid (100 ppm),(Rs.63709 ha^{-1}) in KNO_3 (1%), (Rs.61078 ha^{-1}) in salicylic acid (50 ppm) and minimum (Rs. 55456 ha^{-1}) in control. In growth stages, the highest net returns (Rs.65285 ha^{-1}) were recorded in booting + anthesis stage followed by booting + milking stage (Rs.62355 ha^{-1}) and minimum (Rs.60407 ha^{-1}) in booting stage.The results corroborated with the findings of Singh *et al.* (2021), who recorded that maximum net returns with foliar application of 0.5% KNO_3 at booting and anthesis stage. Similarly, Kaur *et al.* (2015) also showed that the higher net returns were recorded under salicylic acid spray at 50 mg l^{-1} as compared to water spray.

Benefit: cost ratio

The data regarded to benefit : cost ratio are presented in Table 2. Foliar application of KNO_3 (2%) recorded the maximum (2.59) benefit cost ratio followed by (2.53) in salicylic acid (100 ppm), (2.50) in KNO_3 (1%), (2.44) in salicylic acid (50 ppm) and minimum (2.32) in control. Benefit: cost ratio varied among different growth stages. The maximum benefit: cost ratio (2.53) was recorded in booting + anthesis stage followed by (2.46) in booting + milking and (2.44) in booting stage, respectively. The results are also supported with findings of Singh *et al.* (2020), who reported that, higher B: C ratio with foliar application of 0.5% KNO_3 at booting and anthesis stage.Siddagangamma *et al.* (2018) showed that foliar application of 100 ppm salicylic acid at 35 DAS and 50 DAS recorded higher B: C ratio as compared to the rest treatments in sesame.

From the above findings, it may be concluded that foliar applications of potassium nitrate and salicylic acid had significant effect on yield attributes, yield and economics of wheat. Foliar application of 2% potassium nitrate and 100 ppm salicylic acid at booting + anthesis stage resulted higher grain yield, yield attributes and economics of wheat.

Table 1. Effect of potassium nitrate and salicylic acid on yield attributes and yield of wheat at different growth stages

Treatments	Effective tillers $meter^{-1}$ row length	Length of spike (cm)	No. of grains $spike^{-1}$	1000 grain weight (g)	Grain yield (q ha^{-1})
Foliar applications					
KNO_3 (1%)	59.32	10.27	43.25	38.10	42.90
KNO_3 (2%)	63.42	10.72	45.64	40.07	44.98
SA (50 ppm)	57.59	10.21	42.65	37.54	41.80
SA (100 ppm)	61.43	10.36	43.75	38.36	43.49
Control	54.36	9.92	39.46	36.26	39.12
S E (m)±	1.43	0.16	0.84	0.67	0.99
CD (p=0.05)	4.28	0.49	2.53	2.01	2.98
Growth stages					
Booting stage	56.74	10.15	41.14	36.66	41.26
Booting + Anthesis	61.77	10.53	44.72	39.41	43.66
Booting + Milking	59.17	10.20	42.98	38.12	42.45
S E (m)±	1.09	0.12	0.61	0.50	0.57
CD (p=0.05)	3.27	0.36	1.82	1.51	1.72

Table 2. Effect of potassium nitrate and salicylic acid on cost of cultivation, gross return, net return and benefit : cost ratio

Treatments	Cost of Cultivation (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B:C ratio
Foliar sprays				
KNO_3 (1%)	42446	106155	63709	2.50
KNO_3 (2%)	42596	110697	68101	2.59
SA (50 ppm)	42386	103464	61078	2.44
SA (100 ppm)	42476	107550	65074	2.53
Control	41796	97252	55456	2.32
Growth stages				
Booting stage	41846	102253	60407	2.44
Booting + Anthesis	42586	107871	65285	2.53
Booting + Milking	42586	104941	62355	2.46

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