Original Research Article

Efficacy of various chemical spray<u>s</u> on plant growth of chickpea (*Cicer arietinum* L.) in terminal heat stress conditions

ABSTRACT

Heat stress is now widely accepted as an important ecological factor influencing growth of plants and production. Rising temperatures as a result of global warming cause heat stress, reducing plant development and potential output throughout the entire globe. ~~Therefore, a~~<u>A</u>field experiment was carried out at ~~Student's Instructional Farm,~~ Chandra Shekhar Azad University of Agriculture & Technology<u>,</u> Kanpur, to minimize the heat stress induced-losses in chickpea plants with the foliar spray of chemicals during two consecutive years 2021-22 and 2022-23 at *Rabi* season <u>(</u>November-April<u>)</u>. Experimental treatments compris~~eing of~~ two chickpea varieties (RVG-202 and RVG-203) ~~were cultivated~~ <u>sown</u> on same ~~dates~~ <u>day</u> (15th November)~~ of sowing and~~<u>,</u>~~foliar~~ <u>foliar</u>spray of seven chemicals <u>at</u> ~~concentrations were applied as foliar spray treatments~~ at vegetative, anthesis and <u>at</u> both stage<u>s. The chemcials include</u>~~which were as~~ Salicylic acid @ 800 ppm, Salicylic acid @ 400 ppm, Ascorbic acid @ 10 ppm, Potassium chloride @ 1%, <u>T</u>hiourea @ 400 ppm, Cycocel @ 400 ppm and ~~including~~ <u>and</u>Control (~~without~~ <u>no</u> spray). Results suggested that heat stress severely reduced the chickpea growth and productivity. However, foliar application of salicylic acid and thiourea positively affected the plant growth attributes which ultimately increased the final productivity. ~~Conseisely~~<u>Concisely</u>, the foliar spray of chemicals particularly<u>,</u> salicylic acid and thiourea modulated the heat stress induced losses ~~to~~ <u>in</u>chickpea cultivar<u>s,</u> RVG-202 and RVG-203 by improving their antioxidant defense mechanism and enhanced the productivity.

Key word: chickpea, plant growth, salicylic acid, thiourea, terminal heat strees

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is an annual pulse of the legume family, ~~grown from~~ herbaceous, pod-producing plant~~s~~, in areas with a semiarid or temperate climate (Knights & Hobson, 2016; Wallace *et al.,* 2016). ~~The types of chickpeas that are produced nowadays are the only domesticated legumes of the *Cicer* genus and are thought to have been cultivated from the wild species, *Cicer reticulatum* (Ladizinsky & Adler, 1976; Sharma *et al.*, 2013). *Cicer arietinum* L. is the sole cultured species in the genus *Cicer* (43 species). It is a highly self-pollinated annual diploid (2n = 2x = 16) crop with a genome size of ~931 Mbps and an outcrossing rate of less than 1% (Rasheed *et al.*, 2021).~~ It is highly valued for its nutritional quality and health benefits and ability to improve soil fertility and sustainability of the cropping systems. Chickpea is an excellent source of protein, carbohydrate, dietary fibres, polyunsaturated fatty acids, minerals and vitamins (Jukanti, Gaur *et al.*, 2012). It is also considered as a high energy and protein feed in animal diets (Bampidis& Christodoulou, 2011).

Historically, Asia is a major producer of chickpeas, followed by Australia, Africa, America, and Europe. Globally, chickpea is grown in 150.04 lakh hectares area with a production of 158.71 lakh tonnes and productivity of 1057.8 kg/ha. India is the largest producer and consumer of pulses in the world. It has 36.8% of global area, 24.2% of global production and 27% of consumption (Anonymous, 2021). During 2021-22, India contributed 86% of total global chickpea production, with 137.50 lakh tonnes grown on 102.65 lakh hectares with a productivity of 1447 kg/hectare (agricoop.nic.in**)**. In India, Uttar Pradesh holds the fourth position with share of 5.7% in chickpea production. Uttar Pradesh produces 7.83 lakh tonnes in area of 5.94 lakh hectares with 1243 kg/hectare productivity in 2021-22.

Chickpea (*Cicer arietinum* L.) is a cool and dry season food legume largely grown on residual soil moisture after the rainy season. The chickpea crop is largely grown under rainfed conditions without irrigations. Thus, soil moisture deficit towards end of the crop season (terminal drought) is the most important abiotic stress in about two-thirds of the global chickpea area (Gaur *et al.* **2012**). The optimal temperatures for chickpea growth and reproductive phase range between 10°C and 30°C. High temperature during the reproductive stage causes a greater problem than at the seedling or vegetative phase. A few days of exposure to high temperatures (≥32°C) during reproductive phase can cause heavy yield losses. Chickpea suffers heavy yield losses when exposed to heat stress at reproductive (flowering and podding) stage (Gaur et al., 2012; Gaur et al., 2013 and Gaur *et al.* 2015).

Moisture stress at flowering and seed setting is most common and reported to reduce ~~seed~~ the seed yield significantly. Consequently, terminal drought stress, which occurs during the reproductive phase of the crop is common and critical (Anbessa and Bejiga, 2002).The frequency and severity of drought and heat stresses are further expected to increase due to increasing climatic variability and overall impacts of climate change. Varieties with enhanced tolerance to drought and heat stresses are needed for increasing and stabilizing chickpea production in the country. Salicylic acid is involved in water relations of plant cells in abiotic stress conditions and it is well known that SA diminishes the impairments arisen from water deficiency in plants (Hussain *et al.*, 2009). Salicylic acid (SA) plays a key role in regulation of plant growth, development, interactions with other organisms and responses to environmental stress (Miura and Tada, 2014). Ascorbic acid is found in the cytosol, chloroplasts, vacuoles and mitochondria of plant cells. It has a great effect on physiological processes such as cell division, plant growth and the biosynthesis of cell wall, metabolites and phytohormones. Moreover ascorbic acid plays a vital role in renovation of chloroplast and mitochondrion membranes (Barth *et al.*, 2004; Pavet*et al.*, 2005 and Barth *et al.*, 2006)

Foliar spray (~~Exogenous~~ exogenous) application of thiourea has been found effective in stress ~~alleviating~~ alleviation and ~~molecules including thiols that~~ are crucial for enhancing crop growth. Thiols are well known to maintain the redox state (-SH/-S-S-ratio) of the cell and its proper functioning under stress (Anjum *et al.*, 2011 and Perveen *et al.*, 2013). Improvement in plant growth and development under different stresses due to foliar spray of thiourea has been observed in maize (Sahu *et al.*, 1993), wheat (Sahu *et al.*, 2006), pearl millet (Parihar *et al.*, 1998) and cluster bean (Garg *et al.*, 2006).

MATERIAL AND METHODS

The experiments were carried out at Student's Instructional Farm and in the seed testing laboratory of Department of ~~seed~~ Seed Science and Technology, Chandra Shekhar Azad University of Agriculture & Technology Kanpur, during *Rabi* 2021-22 (Ist year) and 2022-23(IInd year). The experiment conducted with split plot design to ~~"Studies on~~study the influence of terminal heat stress on seed yield and seed quality in chickpea ~~(*Cicer arietinum* L.)"~~ consisted of two chickpea varieties namely RVG-202 (V_1) and RVG-203 (V_2). The experiment consisted of twenty two treatment combinations as mentioned below.

Main ~~plot~~ Plots- Varieties (V_1- RVG 202 and V_2 - RVG-203)

Sub ~~plot~~ Plots- Chemicals spray treatments: T_0-Control (~~Without~~ nospray), T_1- Salicylic acid @ 800 ppm at Vegetative, T_2- Salicylic acid @ 400 ppm at Vegetative, T_3- Ascorbic acid @ 10 ppm at Vegetative, T_4-KCl @ 1% at Vegetative, T_5-Thiourea @ 400ppm at Vegetative , T_6-KNO_3~~3~~ @ 0.3% at Vegetative, T_7-Cycocel @ 400 ppm at Vegetative, T_8- Salicylic acid @ 800 ppm at Anthesis, T_9- Salicylic acid @ 400 ppm on Anthesis, T_{10}- Ascorbic acid @ 10 ppm on Anthesis, T_{11}-KCl @ 1% at Anthesis, T_{12}-Thiourea @ 400ppm on Anthesis, T_{13}-KNO_3~~3~~ @ 0.3% at Anthesis, T_{14}-Cycocel @ 400 ppm at Anthesis, T_{15}- Salicylic acid @ 800 ppm at Vegetative + Anthesis, T_{16}- Salicylic acid @ 400 ppm on Vegetative + Anthesis, T_{17}- Ascorbic acid @ 10 ppm at Vegetative + Anthesis, T_{18}- KCl @ 1% at Vegetative + Anthesis, T_{19}-Thiourea @ 400ppm at Vegetative + Anthesis, T_{20}- KNO_3~~3~~ @ 0.3% on Vegetative + Anthesis and T_{21}-Cycocel @ 400 ppm at Vegetative + Anthesis.

The seeds were sown in three replications at spacing of 30 x 10 cm. ~~Two f~~ Foliar sprays at vegetative and reproductive stages~~after sowing~~ were given as per the treatments of subplot. Chemical spraying was done in morning or evening when wind speed were calm, at the rate of 200 ltr./ha or ac…please check (200 ml. per plot in 10 m^2 area). For the preparation of solution 1mg/ltr chemical were used for 1PPM solution. The observations were recorded on ten randomly selected plants from each plot on plant height and number of branches plant^{-1} at physiological maturity stage. The data analysis was carried out using ~~various~~ statistical techniques ~~were used for calculation of the data suggested by~~ followingCochran and Cox (1957).

RESULTS AND DISCUSSION

The terminal heat stress and foliar spray of chemicals had a significant influence on the plant growth characters (Plant height and number of branches plant^{-1}) and yield of chickpea. Plant height (cm) is an important determinant that decides the yield potential of any crop plant. The heat stress and foliar spray significantly influenced the plant height (cm) at physiological maturity stage in chickpea (Table-1).

Table- 1 Effect of varieties and chemicals~~'~~ sprays on plant height (cm) in chickpea

Treatments	Istyear			IIndyear			Pooled		
	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
T_0	44.33	33.67	39.00	43.33	33.35	38.34	43.83	33.51	38.67
T_1	52.00	44.00	48.00	51.33	44.33	47.83	51.67	44.17	47.92

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T_2	51.00	42.00	46.50	49.00	42.67	45.83	50.00	42.33	46.17
T_3	54.67	38.33	46.50	55.00	38.00	46.50	54.83	38.17	46.50
T_4	51.00	35.67	43.33	51.33	35.33	43.33	51.17	35.50	43.33
T_5	55.67	42.33	49.00	55.00	42.00	48.50	55.33	42.17	48.75
T_6	51.00	38.00	44.50	51.67	37.33	44.50	51.33	37.67	44.50
T_7	44.00	32.67	38.33	45.00	33.00	39.00	44.50	32.83	38.67
T_8	51.00	38.33	44.67	50.33	41.00	45.67	50.67	39.67	45.17
T_9	49.67	36.67	43.17	48.33	39.67	44.00	49.00	38.17	43.58
T_{10}	52.00	37.67	44.83	52.33	38.00	45.17	52.17	37.83	45.00
T_{11}	49.00	35.00	42.00	48.67	35.33	42.00	48.83	35.17	42.00
T_{12}	54.33	41.00	47.67	54.67	40.33	47.50	54.50	40.67	47.58
T_{13}	47.33	34.67	41.00	47.67	35.00	41.33	47.50	34.83	41.17
T_{14}	45.33	35.00	40.17	47.00	34.67	40.83	46.17	34.83	40.50
T_{15}	54.67	47.00	50.83	54.33	46.33	50.33	54.50	46.67	50.58
T_{16}	53.33	44.67	49.00	53.00	44.00	48.50	53.17	44.33	48.75
T_{17}	55.67	39.33	47.50	54.67	38.67	46.67	55.17	39.00	47.08
T_{18}	51.33	36.67	44.00	52.00	36.33	44.17	51.67	36.50	44.08
T_{19}	62.00	43.67	52.83	61.33	43.00	52.17	61.67	43.33	52.50
T_{20}	50.67	39.67	45.17	50.00	39.00	44.50	50.33	39.33	44.83
T_{21}	43.33	32.00	37.67	44.00	32.34	38.17	43.67	32.17	37.92
Mean	**51.06**	**38.55**		**50.91**	**38.62**		**50.98**	**38.58**	
Factors	SE(d)	C.D.at 5%		SE(d)	C.D.at 5%		SE(d)	C.D.at 5%	
V	0.63	2.71		0.55	2.67		0.59	2.69	
T	1.09	2.16		0.98	1.96		1.03	2.05	
VxT	1.54	3.05		1.38	2.74		1.46	2.90	
CV (%)	4.19			3.77			3.98		

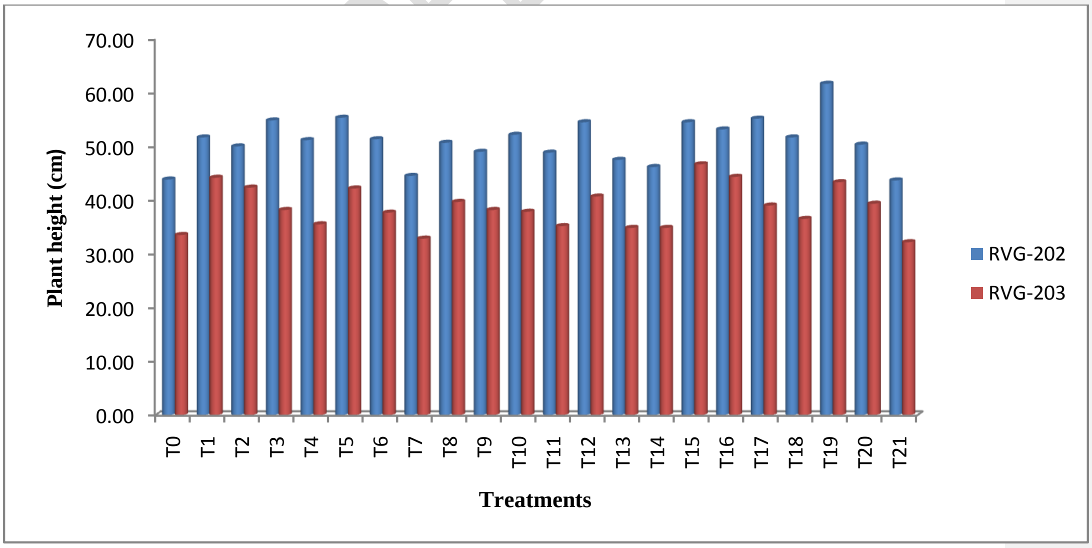

Fig.1 Effect of varieties and chemicals' sprays on plant height (cm) in chickpea

Table- 2 Effect of varieties and chemicals' sprays on branches plant^{-1} in chickpea

Treatments	Istyear			IIndyear			Pooled		
	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
T_0	6.89	5.83	6.36	6.67	5.83	6.25	6.78	5.83	6.31
T_1	11.78	11.22	11.50	11.83	11.33	11.58	11.81	11.28	11.54
T_2	10.89	10.50	10.70	10.83	10.50	10.67	10.86	10.50	10.68
T_3	10.00	8.78	9.39	10.33	8.78	9.56	10.17	8.78	9.47
T_4	8.83	8.07	8.45	9.00	8.50	8.75	8.92	8.29	8.60
T_5	9.67	8.78	9.23	10.00	9.11	9.56	9.84	8.95	9.39
T_6	9.40	8.44	8.92	10.33	9.17	9.75	9.87	8.81	9.34
T_7	11.52	10.70	11.11	11.67	10.67	11.17	11.60	10.69	11.14
T_8	10.89	10.11	10.50	10.00	9.44	9.72	10.45	9.78	10.11
T_9	10.73	9.78	10.26	9.67	9.83	9.75	10.20	9.81	10.00
T_{10}	9.44	7.50	8.47	9.33	7.37	8.35	9.39	7.44	8.41
T_{11}	7.67	6.89	7.28	7.89	6.78	7.34	7.78	6.84	7.31
T_{12}	8.72	8.50	8.61	10.22	9.24	9.73	9.47	8.87	9.17
T_{13}	8.50	7.78	8.14	8.33	9.00	8.67	8.42	8.39	8.40
T_{14}	10.56	9.57	10.07	10.00	9.50	9.75	10.28	9.54	9.91
T_{15}	14.83	12.83	13.83	14.33	12.57	13.45	14.58	12.70	13.64
T_{16}	12.85	11.74	12.30	12.67	12.00	12.34	12.76	11.87	12.32
T_{17}	8.72	7.78	8.25	8.67	8.33	8.50	8.70	8.06	8.38
T_{18}	9.94	9.11	9.53	9.33	8.83	9.08	9.64	8.97	9.30
T_{19}	9.67	8.57	9.12	9.22	8.67	8.95	9.45	8.62	9.03
T_{20}	10.44	9.28	9.86	10.11	9.50	9.81	10.28	9.40	9.83
T_{21}	13.67	12.50	13.09	12.78	11.44	12.11	13.23	11.97	12.60
Mean	**10.26**	**9.28**		**10.15**	**9.38**		**10.21**	**9.33**	
Factors	SE(d)	C.D.at 5%		SE(d)	C.D.at 5%		SE(d)	C.D.at 5%	
V	0.30	0.68		0.15	0.71		0.23	0.70	
T	0.17	0.34		0.27	0.54		0.22	0.44	
VxT	0.24	0.87		0.39	0.91		0.31	0.89	
CV (%)	9.30			8.87			9.08		

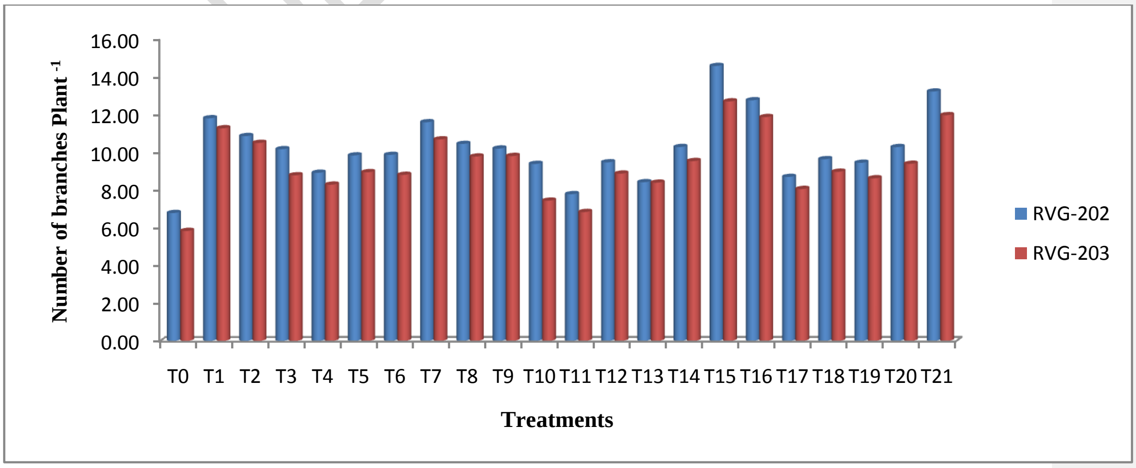

Fig.2 Effect of varieties and chemicals' sprays on number of branches plant^{-1} in chickpea

From the perusal of data (Table-1), it is clear that significant differences were observed between the two varieties in terms of plant height at physiological maturity. The variety RVG-202 (V_1) attained more plant height (50.98 cm) as compared to the variety RVG-203 (V_2) which exhibited 38.58 cm.plant height at physiological maturity. From the analysis, it is also perceptible that V_1 scored 32.14% more plant height as compared to V_2.

The overall mean data presented in Table-1 reveal that plant height varied significantly in all the applied treatments. Among the different treatments, T_{19} (Thiourea spray at vegetative + anthesis stage @ 400 ppm) documented resulted in maximum plant height (52.50 cm) followed by T_{15} (Salicylic acid spray at vegetative + anthesis stage @ 800 ppm). Also among allthe The treatment,s T_{21} (Cycocel spray at vegetative + anthesis stage @ 400 ppm) exhibited the shortest plant height at 37.92 cm.

The interaction of variety × treatment (V×T) had significant effect on plant height. The least plant height (32.17 cm Fig.1) was observed in the treatment combination of $V_2 \times T_{21}$ which did not statistically differ from the interaction of $V_2 \times T_{0,}$ $V_2 \times T_7$ $V_2 \times T_{13}$ &$V_2 \times T_{14}$ (Table 1). The interaction $V_1 \times T_{19}$ exhibited the highest plant height (61.67 cm Fig 1) which showed significant difference from rest of the treatment combinations (Table 1).

The data recorded on number of branches plant^{-1}at physiological maturity are given in Table 2 and depicted graphically in Figure 2, clearly indicates that both the varieties and treatments both hadsignificant effect on number of branches plant^{-1} in chickpea. From the perusal of data (Table 2), it is clear that significant differences difference- were wasobserved between the two varieties in terms of number of branches plant^{-1} at physiological maturity. The variety RVG-202 (V_1) attained more number of branches plant^{-1}(10.21) as compared to the variety RVG-203 (V_2) which exhibited 9.33 number of branches plant^{-1}at physiological maturity. From the analysis it is also perceptible that V_1 scored 8.61 % more plant height as compared to V_2.

The overall mean data presented in Table 2 reveal that number of branches plant^{-1} varied significantly in all the applied treatments. Among the different treatments, T_{15} (Salicylic acid spray at vegetative + anthesis stage @ 800 ppm) documented registeredmaximum number of branches plant^{-1}(13.64) followed by T_{16} (Salicylic acid spray at vegetative + anthesis stage @ 400 ppm) while the minimum number of branches plant^{-1} (6.31) was recorded in T_0 (Control) (Fig 2).

The interaction of variety × Treatment (V×T) had significant effect on number of branches plant^{-1}. The least number of branches plant^{-1} (5.83, Fig. 2) was observed in the treatment combination of $V_2 \times T_0$ which showed significant difference from rest of the treatment combinations. The interaction of $V_1 \times T_{15}$ exhibited the highest number of branches plant^{-1} (14.58 Fig. 2) which showed significant difference from rest of the treatment combination.

Similar results were reported by He et al., 2005; Khan et al., 2014; Sahu *et al.*, 1993; Sahu *et al.*, 2006; Parihar *et al.*, 1998 and Garg *et al.*, 2006. Accordingly, it It was found that the application of thiourea and salicylic acid in the form of foliar spray regulates the plant growth as reported by He et al., 2005; Khan et al., 2014; Sahu *et al.*, 1993; Sahu *et al.*, 2006; Parihar *et al.*, 1998 and Garg *et al.*, 2006. Salicylic acid regulates the stomatal openings, ions and nitrogen uptakes. Itand regulates the enzymes activities which lead to an enhanced plant growth. Two f Foliar sprays of thiourea under moisture stress during flowering and seed setting recorded significantly higher plant height. (reported byDoddagoudar *et al.*, 2021; *Jat et al.2014* and Ahmed*et al.* 2021).

CONCLUSION

Based on present study, it It is was concluded that the foliar spray of thiourea spray at vegetative + anthesis stage @ 400 ppm and Salicylic acid spray at vegetative + anthesis stage @ 800 ppm both chemicals has been have significant influence on chickpea plant growth under heat stress conditions, in terms of . Thiourea and Salicylic acid sprays at vegetative and one at reproductive stage resulted in good plant growth (plant height and number of branches plant^{-1})of chickpea and it was The chemical treatments have been found most remunerative as compared with the to other treatments and control. This could have the utility against different stresses and offered as a solution to the problem faced with terminal heat stress. …..supportive data on physiological characters and cost benefit ratio shall be given for justification of this statement

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