Plant Archives Vol. 24, No. 2, 2024 pp. 2769-2774 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org

DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2024.v24.no.2.393

INFLUENCE OF GLYCINE BETAINE AND SALICYLIC ACID FOLIAR SPRAY ON PERFORMANCE OF LATE SOWN WHEAT

Devesh Sanjay Pardhi[1], A.S. Chandan[2]*, Okram Ricky Devi[3], I. Mahamed Ashiq[4] and Tapan Senchowa[5]

[1]Department of Crop Physiology, ANDUA&T, Kumarganj, Ayodhya, U.P., India.

[2,5] Department of Crop Physiology, Assam Agricultural University, Jorhat - 785 013, Assam, India.

[3]Department of Agronomy, Assam Agricultural University, Jorhat - 785 013, Assam, India.

[4]Department of Biotechnology, College of Agriculture, UAS, Dharwad - 580 005, Karnataka, India.

*Corresponding author E-mail : chandan.a.s456@gmail.com

(Date of Receiving-16-06-2024; Date of Acceptance-24-08-2024)

ABSTRACT

A field experiment was conducted at College of Research, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya, University in Faizabad, Uttar Pradesh, India during the year 2021-2022 to study the effect of glycine betaine and salicylic acid foliar spray on performance of wheat under late sown condition. The findings indicated that glycine betaine @ 100mM followed by salicylic acid @ 250ppm foliar application treatments significantly enhanced the grain yield, straw yield and biological yield of wheat variety PBW-343 (15.00g/plant, 18.92g/plant, 33.92g/plant, respectively). Yield attributing characters *viz*., number of filled grains/spike (44.13), spike length (12.81cm), total number of grains/spike (47.66) and test weight (43.34g) were also found in the treatments having glycine betaine @ 100mM and salicylic acid @ 250ppm foliar application.

Key words : Foliar application, Growth, Glycine betaine, Salicylic.

Introduction

Wheat is the main staple food crop of the world and production is 778.6 MMT during the year 2021-22. The top wheat producing countries in the world are European Union (1,38,900 MT), China (1,36,946 MT), India (1,09,520 MT), Russia (75,500 MT), United States (44,790 MT) for the year 2021-22 (Statistica, 2022). It constitutes a significant amount in food security worldwide. With 14.0% area contribution and 13.6% output share, India is the world's second-largest producer of wheat (Devi *et al*., 2024). The area, yield and production of wheat in India were 31,357 thousand hectares, 3.4 MT/hectare, 107,860 thousand metric tons respectively in year 2020-21 (USDA, 2022). It makes up a substantial portion of global food security. In India, wheat is mainly cultivated in states of Uttar Pradesh, Madhya Pradesh, Punjab, Rajasthan, Haryana. Wheat has been grown since prehistoric- time, all available evidences suggest that origin of wheat from North-East where wild form of wheat is cultivated. Wheat is annual plant of Poaceae (Gramineae) family it belongs to genus *Triticum*. The economically important species of wheat cultivated are *Triticum aestivum, Triticum durum, Triticum dicoccum* in India. The chromosome number of wheat is 2n= 14, 28, 42 depending upon ploidy level of species. Fruit type of wheat is Caryopsis and inflorescence is called Spikelet. Wheat is a long day plant. The ideal wheat climate has winter temperature 10 to 15°C and summer temperature varying from 21 to 26°C. Wheat contains energy 1368kJ (327 Kcal), carbohydrates 71.18g, sugar 0.41gm, dietary fiber's 12.29g, fat 1.54 g, protein 12.61g, water 13.1g and also contains various vitamins and minerals in 100g whole wheat.

High-temperature stress adversely affects plant physio-biochemical and molecular characteristics, resulting in poor plant growth and development. In India, main cause of low yield is late sowing due to poor crop establishment. Crop establishment is an important factor depends upon optimum plant population and uniform emergence. Proper crop establishment depends upon quality of the seed in terms of its germination and seedling vigour (Devi *et al*., 2022). Sowing date affects the growth and yield of wheat crop. Wheat is predominantly grown during *rabi* season and has more wider planting window. In the north western plain zone of India, it is planted in second fortnight of October as early planting, first to third week of November as optimum sowing time (Devi *et al*., 2023). Due to its sensitivity to heat stress, wheat productivity is thought to decline globally by 6% for every 1% increase in temperature. High temperatures in wheat affect a number of physiological, biological and biochemical processes, therefore even a 1°C rise in mean temperature during the reproductive stage may result in increased loss and grain output. Heat stress causes poor germination, decrease in grain filling duration, reduction in grain number, deactivation of Rubisco enzyme, decrease in photosynthetic capacity, reduction in rate of assimilate translocation, premature leaf senescence, decrease chlorophyll content, ultimately decreases yield, heat stress also effect the starch and protein content in grain. Heat stress induces production of reactive oxygen species, which cause change in membrane stability along with lipid peroxidation, protein oxidation, and damage to nucleic acids (Poudel and Poudel, 2020).

Salicylic acid (SA) is an endogenous plant hormone of phenolic nature that possess an aromatic ring with a hydroxyl group and plays a vital role in plant growth, ion uptake and transport (Laishram *et al*., 2023; Klessig *et al*., 2018). It acts as endogenous signaling molecule and plays important role in growth and development regulation of plant and also involved in interaction with other organism and response to several abiotic stresses. It plays miscellaneous physiological roles in plants together with thermogenesis, flower initiation, nutrient uptake, ethylene biosynthesis, stomatal movements, photosynthesis and enzyme action. It increases heat tolerance capacity of plant under environment extremes. It enhances root growth by increasing cell division in apical meristems in wheat seedlings which help in better growth of plants under stress condition (Kumar *et al.*, 2021). Exogenously applied salicylic acid to stressed plant by various approaches was reported to induce major abiotic stress tolerance-mechanisms (Horvath *et al*., 2007; Khan *et al*., 2014; Anwar *et al.*, 2013). It mediated tolerance to heat stress has also been evaluated (He *et al.*, 2002; Wang *et al*., 2010; Khan *et al*., 2013).

Glycine betaine is a compatible osmolyte that likely plays an important role in osmoregulation in plants subjected to extreme environmental cues, including high-temperature stress. Additionally, it is likely that glycine betaine activates signaling molecules such as calcium-dependent protein kinases (CDPKs) and mitogen-activated protein kinases (MAPKs) (Hemantarajan *et al*., 2014), which could activate stress-responsive and heat-shock transcription factor (HSF) genes. The activated stress-responsive genes may boost the natural defense system by enhancing the activities of enzymatic antioxidants, such as superoxide dismutase (SOD), catalase (CAT) and peroxidase (POD), which may alleviate the negative impact of uncontrolled ROS causing oxidative damage triggered by heat stress. The elimination/reduction of ROS may keep biological membranes intact. Furthermore, activated HSF genes may lead to the synthesis and activation of HSPs. Most HSPs can also act as chaperones, which can prevent heat-induced aggregation of proteins (Jacob *et al*., 2017). The role of HSPs in plant thermotolerance has been elucidated in several comprehensive reviews.

Exogenous application of glycine betaine improves thermotolerance in many plants by enhancing their growth and yield via counteracting metabolic maladjustments caused by HS. For example, while appraising the role of exogenous glycine betaine application on heat-stressed tomato plants, Li *et al*. (2014) reported enhanced seed germination, expression of heat shock genes, and accumulation of heat-shock protein 70 (HSP70). Likewise, exogenous glycine betaine supplementation likely controls many other key metabolic processes in heat-stressed plants.

Materials and Methods

Experimental site

A field experiment was conducted during *rabi* season of 2021-22 at College of Research, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya University in Faizabad, Uttar Pradesh, India (Fig.1). The experimental plot is situated at latitude of 24.4^0 to 26.56^0 N and longitude of 82.12^0 to 83.98^0E on an elevation of 113 meters in the gangetic alluvium of eastern Uttar Pradesh.

Weather conditions during the crop season

The meteorological data on weather conditions prevailing during *rabi* season of year 2021-22 have been illustrated in Fig. 2.

Experimental details

The experiment was conducted in field containing silt loam soil with two wheat varieties PBW-343 and Halna. Three replications of the experiment were conducted using a factorial randomized block design

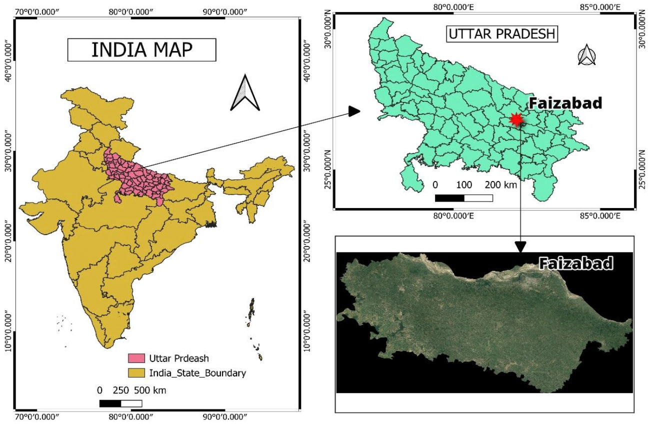

Fig. 1 : Map of the experimental area, Faizabad, Uttar Pradesh, India.

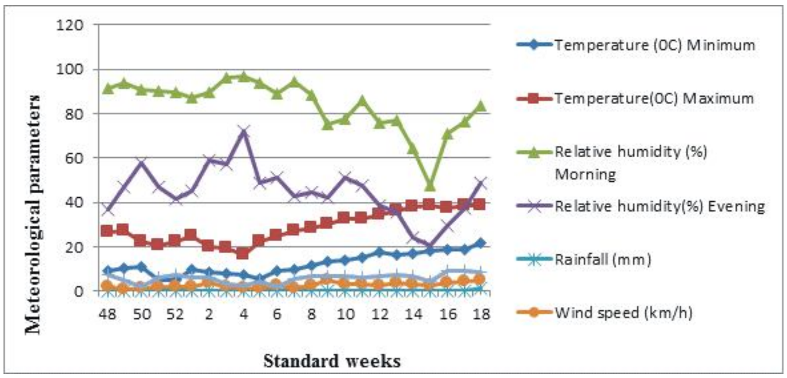

Fig. 2 : Meteorological data during the crop season (2021-22).

(RBD) (Rangaswamy, 1995). The study comprised of following treatments as below:

Factor A: Foliar application

T_1 (Control)

T_2 (glycine betaine 50milli molar)

T_3 (glycine betaine 100milli molar)

T_4 (glycine betaine 150milli molar)

T_5 (salicylic acid 150ppm)

T_6 (salicylic acid 250ppm)

T_7 (salicylic acid 350ppm)

Factor B: Variety

V_1 (PBW-343)

V_2 (Halna)

Soil fertility

Nitrogen, phosphorus and potash were added @ of 120, 60 and 40 kg/ha through urea, DAP and muriate of potash, respectively. Half of the nitrogen, total phosphorus and total potash were added as a basal dose before sowing of seeds. Remaining nitrogen was added in two equal split doses, one at tillering stage and the other at the time of flowering. Standard cultural practices were adopted for normal plant growth.

Sowing

Wheat cultivar PBW-343 and Halna, were sown on 20th Dec, 2020 in rows spacing 20 cm at depth of 5-7 cm in soil. The seeds were obtained from the Crop Physiology Department, ANDUA&T, Kumarganj, Ayodhya (U.P.) , India.

Preparations of solutions of salicylic acid and glycine betaine for foliar application

The different concentrations of salicylic acid were prepared in desired volume of water to make 150ppm, 250ppm, 350ppm respectively. In order to improve spray retention sticky agent teepol was mixed into the spray solution @ 0.5ml/litre. Similarly different concentration of glycine betaine was prepared in one litre of water to make 50mM, 100mM and150mM solution. Foliar application was done with the help of knapsack sprayer at 50 days after sowing.

Observations

Observations on yield and yield components were taken at the time of harvesting on five plants per plot.

Number of filled grains/spike

The numbers of grains were counted in five randomly selected ears for one replication and values were averaged to express number of filled grains per spike.

Spike length (cm)

Five ears per replication were carefully measured for length using a meter scale, measuring from the neck node to the tip of the ear. An average of the measurements was then computed and reported in centimeters.

Total number of grains/spike

The number of grains was counted from five plants and values were averaged to express number of grains/ plant.

Test weight (1000-grains) (g)

1000 well filled grains having moisture content 12-15% were selected and counted from the samples of each treatment. These counted grains were weighted and recorded as test weight.

Grain yield/plant (g)

The grain weight from the five sampled plants was taken and calculated values were expressed as grain yield/plant.

Biological yield/plant (g)

The sum of grain weight and straw weight from the five sampled plants and the calculated values was expressed as biological yield/plant.

Straw yield/plant (g)

Straw yield was calculated by subtracting the grain yield from biological yield.

Harvest index (%)

The harvest index (HI) was calculated as per formula as follows. It is expressed in percent

$$\text{Harvest index (\%)} = \frac{\text{Economical yield}}{\text{Biological yield}} \times 100$$

Statistical analysis

Data recorded on various growth and yield attributes were subjected to statistical analysis by Fisher method of analysis of variance (Fisher and Yates, 1949). The significance of various treatments was judged by comparing calculated, F' value with Fisher's, F' value at 5 percent level, incorporate in tables, were also calculated to compare the relative performance of various treatments by using the following formula:

$$\text{SEm}\pm = \sqrt{\frac{\text{EMS}}{\text{N}}}$$

Where,

EMS is mean sum of square of error

N = total number of experimental units

Level of factors

$$\text{CD} = \sqrt{\frac{2\text{EMS}}{\text{N}}} \times t\,(5\%)$$

Where,

Value of 't' from Fisher's table at error degree of freedom on 5% level of significance.

Results

Number of filled grains/spike

The data presented in Table 1 and depicted that the maximum number of filled grains/spike (44.13) was recorded with foliar application of glycine betaine 100mM (T_3) followed by foliar application of salicylic acid 250ppm (T_6) than rest of treatments. As far as varieties are concerned variety V_1-PBW343 (42.26) showed higher number of filled grains/panicle as compared to V_2-Halna (40.99).

Spike length (cm)

The data with respect to spike length presented in Table 1. divulged that the maximum spike length (12.81cm) was recorded with foliar application of glycine betaine 100mM (T_3) followed by foliar application of salicylic acid 250ppm (T_6) than rest of treatments. As far as varieties are concerned variety V_1-PBW343 (10.89cm) showed higher spike length as compared to V_2-Halna (10.54cm).

Total number of grains/spike

The data pertaining to Table 1 revealed that the maximum total number of grains/ spike (47.66) was recorded with foliar application of glycine betaine 100mM (T_3) followed by foliar application of salicylic acid 250ppm (T_6) than rest of treatments. Among variety, V_1-PBW343 (45.64) showed statistically higher as compared to V_2-Halna (44.27).

Test weight (g)

Test weight presented in Table 1 depicted out that the maximum test weight (43.34g) was recorded with foliar application of glycine betaine 100mM (T_3) followed by foliar application of salicylic acid 250ppm (T_6) than other treatments. Amongst the variety, V_1-PBW343 (41.43g) showed higher test weight as compared to V_2-Halna (40.19g).

Yield

Perusal of data revealed that application of glycine betaine and SA significantly increased the grain, stover and biological yield of late sown wheat (Table 2).

The maximum grain yield (15 g/plant) was recorded with foliar application of glycine betaine 100mM (T_3) followed by foliar application of salicylic acid 250ppm (T_6) than rest of treatments. As far as varieties are concerned variety V_1-PBW343 (13.14g/plant) showed higher yield as compared to V_2-Halna (12.70/plant).

Similarly, the maximum straw yield (18.92g/plant) was recorded with foliar application of glycine betaine 100mM (T_3) followed by foliar application of salicylic acid 250ppm (T_6) than rest of treatments. As far as varieties are concerned, V_1-PBW343 (17.83/plant) showed higher straw yield as compared to V_2-Halna (15.74/plant).

Biological yield also followed same trend. The maximum biological yield (33.92g/plant) was recorded with foliar application of glycine betaine 100mM (T_3) followed by foliar application of salicylic acid 250ppm (T_6) among all the treatments. While among variety, V_1-PBW343 (30.97g/plant) showed higher biological yield as compared to V_2-Halna (28.29g/plant).

Harvest index (%)

The data with respect to harvest index presented in

Table 1 : Effect of foliar application of glycine betaine and salicylic acid on yield and yield attributes at harvesting stage of late sown wheat varieties.

Treatments	No. of filled grains/spike		Spike length (cm)		Total no of grains/ spike		Test weight (g)	
	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2
T_1	40.00	38.80	8.00	7.76	43.20	41.90	38.00	36.86
T_2	42.00	40.74	9.95	9.65	45.36	44.00	41.00	39.77
T_3	44.80	43.46	13.00	12.61	48.38	46.93	44.00	42.68
T_4	41.00	39.77	10.12	9.82	44.28	42.95	42.00	40.74
T_5	43.00	41.71	11.22	10.68	46.44	45.05	41.00	39.77
T_6	44.00	42.68	12.95	12.56	47.52	46.09	44.00	42.68
T_7	41.00	39.77	11.00	10.67	44.28	42.95	40.00	38.80
Mean	42.26	40.99	10.89	10.54	45.64	44.27	41.43	40.19
Factors	SE±m	CD	SE±m	CD	SE±m	CD	SE±m	CD
Variety	0.39	1.15	0.10	0.29	0.42	1.24	0.37	1.10
Treatments	0.74	2.16	0.19	0.55	0.79	2.33	0.70	2.07
V × T	1.04	NS	0.26	NS	1.12	NS	1.00	NS

Table 2 : Effect of foliar application of glycine betaine and salicylic acid on yield and yield attributes at harvesting stage of late sown wheat varieties

Treatments	Grain yield (g/plant)		Straw yield (g/plant)		Biological yield (g/plant)		Harvest index (%)	
	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2
T_1	11.00	11.20	15.76	12.16	26.76	22.30	41.14	45.48
T_2	12.00	13.30	15.96	15.86	27.96	29.16	42.91	45.61
T_3	15.25	14.75	20.45	17.39	35.70	32.14	42.72	45.89
T_4	12.90	11.70	17.68	17.22	30.58	28.92	42.19	40.45
T_5	13.70	12.50	17.76	16.52	31.46	29.02	43.56	43.11
T_6	14.20	13.48	19.87	17.22	34.07	30.70	41.66	43.89
T_7	12.95	12.00	17.30	13.81	30.25	25.81	42.85	46.51
Mean	13.14	12.70	17.83	15.74	30.97	28.29	42.43	44.42
Factors	SE(m)	C.D.	SE(m)	C.D.	SE(m)	C.D.	SE(m)	C.D.
Variety	0.17	0.52	0.27	0.79	0.38	1.12	0.40	1.18
Treatments	0.33	0.97	0.51	1.49	0.71	2.09	0.75	2.21
V × T	0.47	NS	0.72	NS	1.01	NS	1.07	NS

Table 2 revealed that the maximum harvest index (45.03%) was recorded with foliar application of glycine betaine 100mM (T_3) followed by foliar application of Salicylic acid 250ppm (T_6) than rest of treatments. While variety V_1-PBW343 (44.42%) showed higher harvest index as compared to V_2-Halna (42.43%).

Discussion

It was determined that the yield increase and yield-attributing characters were statistically superior. in foliar application treatments wiith glycine betaine 100mM (T_3) followed by foliar application of SA 250ppm (T_6) under stressed wheat. Better net photosynthetic assimilation, increased PS-II photoinhibition tolerance, antioxidant enzyme activation, thylakoid membrane stabilization, and reduced chlorophyll degradation could all be contributing factors. In addition to osmoregulation, glycine betaine also play role in ion homeostasis, stabilization of membranes and proteins (RUBISCO), modification of chloroplast ultrastructure, maintenance of gas exchange and photosynthesis, acceleration of antioxidant enzyme activities to scavenge ROS, accumulation of other osmolytes (proline, soluble sugars, etc.) and thus contributed to increase in yield and yield attributing characters. Application of SA and significantly increased the grain, stover and biomass, scaling up of SA up to 200 ppm caused significant enhancement in grain yield (1022.91 kg/ha), stover yield (1714.87 kg/ha) and biomass yield (2737.77 kg/ha) of lentil (Laishram *et al.*, 2023). This finding is in line with our present study. Increased in yield might be due to the growth promoting effect of SA which increased the level of cell division within the apical meristem of seedling root and caused higher plant growth and increased the dry matter production (Laishram *et al.*, 2020). It has also been reported that SA mitigate the deleterious effects of several environmental stresses on plants including low temperature and chilling, high temperature and drought (Senaratna *et al.*, 2000).

Conclusion

The significant improvement in plant growth by applying glycine betaine topically 100mM, followed by salicylic acid 250ppm over rest of treatments was found in the present study. This study highlights the pivotal role played by osmolytes and PGRs on yield as well as yield characteristics. Thus, exogenous foliar treatment of 250 ppm salicylic acid and 100 mM glycine betaine may be a possibility for enhancing late-sown wheat's heat tolerance and grain output.

References

Anwar, J. Khan, Rasul S.B., Zulkiffal I.M. and Hussain M. (2013). Effect of sowing dates on yield and yield components in wheat using stability analysis. *Int. J. Agric. Biol.*, **9(1)**, 129-132.

Devi, O.R., Verma O., Halder R., Pandey S.T. and Chaturvedi P. (2022). Effect of Seed Priming with Liquid Organic on Germination, Seedling Development and Enzymatic activity of Wheat (*Triticum aestivum* L.). *Environ. Ecol.*, **40(3C)**, 1720-1725.

Devi, O.R., Harish B.M., Doggalli G., Laishram B., Verma O., Sharma A. and Ojha N. (2024). Effect of liquid fermented organic manure concoctions and their foliar spray under different dose of nutrients on chlorophyll content of late sown wheat. *Plant Archives*, **24(1)**, 1244-1248.

Devi, O.R., Verma O., Pandey S.T., Laishram B., Bhatnagar A. and Chaturvedi P. (2023). Correlation of germination, seedling vigour indices and enzyme activities in response to liquid organic Kunapajala to predict field emergence in late sown wheat. *Environ. Ecol.*, **41(3B)**, 1694—1698.

Fisher, R.A. and Yates F. (1949). Statistical tables for biological, agricultural and medical research.

Hasanuzzaman, M., Hossain M.A., da Silva J.A.T. and Fujita M. (2012). Plant responses and tolerance to abiotic oxidative stress: antioxidative system is a key factor. In: Bandi, V., Shanker A.K., Shanker C., Mandapaka M. (eds). Crop stress and its management: Perspectives and Strategies. *Springer;* Berlin, Germany : 261-316.

He, Y., Liu Y., Cao W., Huai M., Xu B. and Huang B. (2005). Effect of salicylic acid on heat tolerance associated with antioxidant metabolism in Kentucky blue grass. *Am. J. Crop. Sci*., **45**, 988-995.

Horvath, E., Pal M., Szalai G., Paldi E. and Janda T. (2007). Exogenous 4-hydroxybenzoic acid and salicylic acid modulate effect of short term drought and freezing stress on wheat plants. *Biol. Plant*, **51**, 480-487.

Jacob, P., Hirt H. and Bendahmane A. (2017). The heat shock protein/chaperone network and multiple stress resistance. *Plant Biotechnol. J.*, **15(4**), 405-414.

Khan, M.I.R,, Asgher M, and Khan N.A. (2014). Allevation of salt induced photosynthesis and growth inhibition by salicylic acid involves glycine betaine and ethylene in mung bean (*Vigna radiata* L.). *Plant Physiol. Biochem*., **80**, 67-74.

Klessig, D.F., Choi H.W. and Dempsey D.A. (2018). Systemic acquired resistance and salicylic acid: past, present and future. *Mole. Plant-microbe Interactions*, **31(9)**, 871-888.

Kumar, A., Rai A.C., Rai A., Rai K.K. and Rai V.P. (Eds.). (2021). *Stress Tolerance in Horticultural Crops: Challenges and Mitigation Strategies*. Woodhead Publishing.

Laishram, B., Singh T.B., Devi O.R., Khumukcham P.S. and Ngairangbam H. (2023). Yield, economics, nutrient uptake and quality of lentil (*Lens culinaris* L.) as influence by salicylic acid and potassium nitrate under rainfed condition. *Environ. Ecol.*, **41(3A)**, 1591—1596.

Laishram, B., Singh B.T., Kalpana A., Wangkheirakpam M., Chongtham S.K. and Singh W.J. (2020). Effect of salicylic acid and potassium nitrate on growth and Yield of Lentil (*Lens culinaris* L.) under Rainfed Condition. *Int. J. Curr. Microbiol. Appl. Sci.*, **9(11)**, 2779-2791.

Li, H.A.O., Liu S.S., Yi C.Y., Wang F., Zhou J.I.E., Xia XJ. and Yu J.Q. (2014). Hydrogen peroxide mediates abscisic acid induced HSP 70 accumulation and heat tolerance in grafted cucumber plants. *Plant Cell Environ.*, **37(12)**, 2768-2780.

Poudel, P.B. and Poudel M.R. (2020). Heat stress effects and tolerance in wheat: A review. *J. Biol. Today's World*, **9(3)**, 1-6.

Senaratna, T., Touchell D., Bunn E. and Dixon K. (2000). Acetyl salicylic acid (Aspirin) and salicylic acid induce multiple stress tolerance in bean and tomato plants. *Pl Growth Regulation*, **30**, 157–161.

Statistica (2022). https://www.statista.com/statistics/267268/production-of-wheat_worldwide-since-1990/

United States Department of Agriculture (USDA) (2022). https://ipad.fas.usda.gov/countrysummary/?id=IN&crop=Wheat

Wang, G.P., Zhang X.Y., Li F., Luo Y. and Wang W. (2010). Over Accumulation of Glycine Betaine Enhances Tolerance to Drought and Heat Stress in Wheat Leaves in the Protection of Photosynthesis. *Photosynthetica*, **48**, 117-126.