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**Nadendla Harshavardhan**
M.Sc. Genetics and Plant Breeding, Lovely Professional University, Phagwara, Punjab, India

**Addagarla Bhanu Prakash**
M.Sc. Genetics and Plant Breeding, Lovely Professional University, Phagwara, Punjab, India

**Gowreddy Sai Ram Reddy**
M.Sc. Genetics and Plant Breeding, Lovely Professional University, Phagwara, Punjab, India

**ENV Sai Lakshmi**
M.Sc. Horticulture-Fruit Science, Lovely Professional University, Phagwara, Punjab, India

**Kanak Bhati**
Assistant Professor, Department of Genetics and Plant Breeding, Lovely Professional University, Phagwara, Punjab, India

**Corresponding Author**
**Nadendla Harshavardhan**
M.Sc. Genetics and Plant Breeding, Lovely Professional University, Phagwara, Punjab, India

# Effects of secondary metabolites in wheat: A review

**Nadendla Harshavardhan, Addagarla Bhanu Prakash, Gowreddy Sai Ram Reddy, ENV Sai Lakshmi and Kanak Bhati**

**Abstract**
Wheat is an important crop in the world, lack Secondary metabolites and their effects with antioxidants, Heat stress and with Essential oils of *Fusarium* spp, the role of involvement of Antioxidants, Temperature and Environment factors with different concentrations of secondary metabolites were been discussed in this review paper from the leaf glycine, Total Phenolic Content, number of tillers, number of spikelet's, the weight of 100 grains, its harvesting Index and Grain Yield were been discussed using different genotypes and secondary metabolites were studied.

**Keywords:** Wheat, secondary metabolites, phenolic, glycine, heat stress, antioxidants, essential oils

## Introduction
Wheat (*Triticum aestivum* L. 2n=42) is a self-pollinated Poaceae family member and one of the world's most popular cereals in many nations, including India. Because of its vast acreage, excellent production and significant position in the international food grain trade, it has been dubbed the "King of Cereals." It is India's most significant food crop, providing both protein and energy. Wheat is India's second-largest food crop, after rice, in terms of both acreage and production. Wheat is used to make bread, chapatti, porridge, flour and suji, among other things. Wheat (*Triticum* spp.) is one of the world's most significant small-grain cereals, with roughly 730 million tons produced each year (FAO, 2017) [26].

Several fungal diseases around the world may have a substantial impact on this production. Among these, fusarium head blight (FHB) is one of the most common and destructive diseases, capable of severely reducing crop yield as well as quality. These causal agents are able to biosynthesize mycotoxins, substances with toxic activity in humans and animals (da Rocha *et al.*, 2014). Secondary metabolites appear to be related with lower production of reactive oxygen species heat stress (and hence less cell damage) and modest changes in the metabolome, whereas pre-activation of heat shock transcription factors appears to be relevant.

The inverse relationship of proline with physiological traits and grain yield was observed except for stomatal resistance where it remained positive. proline accumulation improved the yield of wheat crop under water and temperature stress by regulating leaf water potential**.**

## Effect of Heat Stress
Shahid *et al.* (2017) [15] conducted research at the University of Agriculture Faisalabad's Agronomic Research Area. Galaxy-2013, Punjab-2011, AARI-2011, Millat-2011 and Mairaj-2008 genotypes were discovered. To determine the entire emergence of the spike, five plants in each plot were tagged. Heat stress was induced from the appearance of the spike until the commencement of grain filling by covering the main plots with a transparent polythene sheet, while the control plot was left in the ambient environment Javed *et al*., (2014) [10]. To keep the story going, holes were punched in various places on the polythene sheet. With the aid of a digital temperature and humidity meter, the temperature was recorded in the morning, noon and evening throughout the imposition of heat stress.

Leaf Proline (umol g¹) Aas - 2011, Chakwal - 50 and Mairaj - 2008′ manifested an increment of 21% in leaf proline content under a high-temperature environment compared with the control. The incline in proline content characterized the heat tolerance of these cultivars. The highest decrement (51%) in stressed conditions as against those of the control was observed in genotypes 'NIBGE - NIAB – I 'and' Kohistan - 97'. The decline in proline content under stressed conditions showed the heat susceptibility of these genotypes.

Under heat stress, leaf Glycine Betaine (mol g1) Aas - 2011', Chakwal - 50' and Mairaj - 2008′ showed a 17 percent and 13 percent increase in glycine betaine content, respectively, compared to the control. In 'Punjab – 2011 'and' Galaxy - 2013′, the highest decrement was produced by a high-temperature environment (36 percent in both). In ambient conditions, 'Aas 2011', 'Fareed - 2006', 'Chakwal - 50', 'Punjab- 2011', 'AARI- 2011', 'Galaxy - 2013', 'Millat - 2011' and 'Mairaj - 2008' were statistically comparable, however under high temperature conditions, 'Aas - 2011', 'Chakwal - 50 The greater total phenolic content of these genotypes when compared to the control may be described as an increase in proline and glycine betaine in 'Aas - 20111,' Chakwal - 50,' and Mairaj - 2008. Total phenolic accumulation content. The total phenolic content and thermotolerance were shown to have a favourable relationship (Mahmood *et al*. 2014) [13]. Increases in glycine betaine and proline are also consistent with the findings of Raza *et al*. (2015) [20], who found that proline and glycine betaine accumulation increased stress tolerance. Under stressful conditions, tolerant genotypes showed an increase in proline and glycine betaine, but susceptible genotypes showed a reduction. Furthermore, proline and glycine betaine decreased MDA and, as a result, yield under stress. Total Phenolic Content (mg GAE $g^1$)

The total phenolic content of 'Aas – 2011', 'Chakwal - 50 'and Miraiaj - 2008′ increased by 22 percent, 20 percent and 24 percent, respectively. The total phenolic content of 's - 2011' and Chatwal - 50' were substantially greater in the ambient environment and statistically similar. 'Aas - 2011′ and "Chakwal - 50′ were statistically comparable under strained situations, but 'Mairaj - 2008′ was statistically equivalent to Chatwal - 50′. In 2013, there was the greatest drop in total phenolic content in the stressed environment compared to the control Kohistan - 97 (67 percent) and Pakistan (65%). More proline, glycine betaine and less MDA buildup under heat can be attributed to higher total phenolic content in "Chakwal - 50", "Mairaj 2008, "and" Aas - 2011" compared to the control plots. Increased proline and glycine betaine levels may have aided in assimilate partitioning. As a result, yield drop was reduced for these types when exposed to heat. Furthermore, the involvement of total phenolic content in sustaining proline and glycine betaine quantities resulted in a high positive connection between total phenolic content and proline and glycine betaine contents. Stress tolerance was improved by increasing phenolic content. Increased proline and glycine betaine accumulation resulted in improved stress tolerance (Saleem *et al*. 2016) [21]. Malondialdehyde (mmol g1) production differed dramatically between wheat genotypes. MDA levels were dramatically increased in a high-temperature setting, indicating increased lipid peroxidation under stress. A non-significant interaction emerged from genotypes' indistinguishable responses in stressful and non-stressed situations. MDA levels were significantly lower in genotypes AAS - 2011 (0.91 mol g') and Chatwal - 50 (0.96 mol g'). The highest MDA biosynthesis was observed in Pakistan in 2013 (124 mol $g^1$). "Pakistan - 2013 was statistically comparable to Punjab - 2011. AARI - 2011 Galaxy – 2013', 'Millat - 2011, Fareed - 2006, NIBGE NIAB and' Kohistan-97.

Low MDA in Aas - 2011, Chakwal - 50 and Mairaj 2008 can be linked to these genotypes' increased capacity to accumulate proline, total phenolic content and glycine betaine in a high-temperature environment, according to (Khaliq *et al*. 2015) [11]. Pakistan - 2013 and Kohistan - 97' may have been less able to collect proline, total phenolic content and glycine betaine due to their high lipid peroxidation levels. The deleterious effects of MDA on proline and glycine betaine accumulation were supported by a substantial negative relationship of glycine betaine, proline and phenolic levels with MDA during heat stress. Wheat genotypes with lower MDA had a greater chance of surviving under stress.

The number of fertile tillers did not change substantially between the control and heat-stress main plots, according to (Gulnaz *et al*. 2011) [8] Number of Fertile Tillers (m22). The cultivars, on the other hand, differed greatly from one another. In both major plots, all cultivars displayed an unmistakable tendency of non-significant interaction. Punjab 2011 had the maximum number of fertile tillers (377.13 m2), which was statistically equivalent to genotypes 'AARI - 2011, Galaxy - 2013', 'AAS - 2011' and Pakistan - 2013. The genotype 'Kohistan - 97' yielded the fewest fruitful tillers (278.88 m2). Differences in the genetic makeup of genotypes can be attributed to the diversity of response in terms of the number of fertile tillers, as shown in previous studies. Various genotypes have been discovered to have diverse genetic patterns of nodal roots.

Count of Grains in a Spike Thenumbert of grains each spike differed significantly depending on heat stress and genotype. The heat vs. variety interaction was noteworthy since different responses were found under ambient and heat-induced circumstances. High temperatures had negative consequences for many grains each spike. In terms of the number of grains per spike, cultivars performed differently. 'Kohistan - 97' showed the greatest reduction in the number of grains per spike when exposed to high temperatures compared to the control (21%).

**Table 1:** Correlation of matrix of plant readings due to Effect of Heat Stress in Secondary metabolites

| Parameter | Leaf Proline | Glycine Betaine | Total Phenolic Content | Malondialdehyde | No. of Fertile Tillers | No. of Grains per Spike | 1000 Grain Weight | Harvest Index | Grain Yield |
|---|---|---|---|---|---|---|---|---|---|
| Leaf Proline | 1 | | | | | | | | |
| Glycine Betaine | 0.98 | 1 | | | | | | | |
| Total Phenolic Content | 0.98 | 0.96 | 1 | | | | | | |
| Malondialdehyde | 0.95 | 0.96 | 0.95 | 1 | | | | | |
| No. of Fertile Tillers | 0.14 | 0.14 | 0013 | 0.77 | 1 | | | | |
| No. of grains per spike | 0.74 | 0.76 | 0.74 | 0009 | 0.34 | 1 | | | |
| 1000 Grain Weight | 0.03 | 0.10 | 0000 | 0.46 | 0.83 | 0.42 | 1 | | |
| Harvest Index | 0.86 | 0.75 | 0.81 | 0.73 | 0.33 | 0.83 | 0.29 | 1 | |
| Grain Yield | 0.86 | 0.93 | 0.84 | 0.95 | 0.50 | 0.80 | 0.27 | 0.85 | 1 |

Genotypes 'Aas - 2011' and 'Chakwal - 50' showed the smallest decrease in the number of grains per spike in stressful circumstances (10 percent for both) a weight of 1000 grains (g) Due to the negative effects of high temperatures, the weight of 1000 grains was greatly reduced and different cultivar responses were also seen. Despite this, all genotypes showed indications of incompatibility between control and heat stress, resulting in a substantial heat-variety interaction. The genotypes AARI - 2011′ (35%) and Pakistan- 2013 (35%). Showed the greatest reduction in 1000-grain weight under heat stress compared to ambient circumstances (33%). 'Chakwal - 50′ set the record for the lowest temperature under heat stress (14%). In a non-stressed environment, the genotypes "Millat - 2011", "Fareed - 2006" and "Pakistan 2013" were statistically comparable to "Chakwal - 50". 'Millat– 2011 'and' Pakistan 2013', on the other hand, generated considerably lower 1000-grain weights than Fareed - 2006'Chakwal - 50 according to (Raza *et al*. 2015) [20]. Harvest Indicator (%). Heat stress resulted in a considerably reduced harvest index as compared to the control; however, there was no significant heat genotype influence in this respect. Genotypes 'NIBGE - NIAB (24 percent) and Kohistan - 97'(25 percent) showed a greater heat-induced decline in harvest index, whereas genotypes as – 2011 ′(10 percent),' Mairaj - 2008′ (10%). 'Fareed 2006 (12 percent) and Chatwal - 50'showed a lower decline in harvest index when compared to the control (12 percent). In comparison to the control, the harvest index Kohistan - 97 and NIBGE - NIAB - 1' decreased much more during heat stress than the other cultivars, indicating that these genotypes accumulate more MDA. Higher MDA levels may have lowered proline glycine levels. Contents of betaine and phenolic acids. As a result, carbohydrate partitioning in the spike may have deteriorated, resulting in a decrease in the harvest index. Furthermore, the substantial negative relationship between harvest index and MDA resulted in metabolite reduction mediated by MDA. Under stress, increased MDA reduced metabolite accumulation and reduced grain yield.

**Effect of Secondary metabolites in grain**
Grain yield (t ha - 1) Due to the negative effects of heat stress, grain production was severely reduced. The genotypes' different genetic composition shows a considerable variation in their capacity to generate yield under ambient and high-temperature conditions. Under high- temperature circumstances, Aas - 2011' had the greatest grain yield (3.71 t ha11) among the cultivars and "Aas - 2011' was statistically equivalent to 'Mairaj – 2008 'and' Chakwal - 50'under heat stress conditions. Under heat stress, the grain yield of Cultivars Pakistan 2013', 'NIBGE - NIAB 1' and Kohistan - 97' was 2.21, 2.03 and 2.24, respectively, showing that these cultivars are susceptible to heat. Grain yield exhibited moderate heat tolerance in all other varieties.

All 4 inoculated species (*F. graminearum*, *F. avenaceum*, *F. acuminatum* and *F. pole*) biosynthesized a selected variety of secondary metabolites detected through LC-MS/MS in grain harvested at physiological maturity. The profile of secondary metabolites differed relying on the *Fusarium* species. The *F. graminearum* secondary metabolites that had accrued after spike inoculation withinside the greenhouse at zero, three, 6, or nine records are said in element in Supplementary Table S2. In general, secondary metabolite accumulation tended to be better from inoculations at three and six days than at zero and nine days. Among the secondary metabolites, DON, 15AcDON and 5-hydroxyculmorin had been gift withinside the maximum concentrations. The accumulation of DON became better after inoculation at three days than from the opposite inoculation timings ($P\leq$zero.02) besides after inoculation at 6 daa (P = zero.25) The DON:15AcDON ratio ranged from 4.1 (nine-day infections) to approximately 6 (three days and six days) to 13.7 (zero days). The accumulation of 15AcDON observed a comparable trend, with a better degree detected from inoculation at three daa than from zero daa ($P\leq$zero.04), at the same time as 6 daa and nine daa stages had been intermediate (Fig. 3B). In summary, a better price of DON and 15AcDON accumulation withinside the grain became reached on the intermediate *F. graminearum* inoculation timings, specifically at three days, instead of on the early or overdue inoculation timings. As for the opposite *F. graminearum* secondary metabolites, a statistically considerable height of an accumulation from three-day inoculation, in assessment to the earliest or cutting-edge inoculation timings, became reached through 15-hydroxyculmoron, 5-hydroxyculmorin and chrysin metabolites. Total ENs (calculated through the sum of all six analogs analyzed) and MON had been the secondary metabolites gift withinside the maximum attention in any respect 4 inoculation timings with *F. avenaceum*. EN analogue concentrations displayed the subsequent gradient: ENB1 > ENB2 > ENA1 > ENB > ENA > ENB3. Total ENs and MON, despite their numerically better stages after three daa and six daa, did now no longer vary considerably through inoculation timing ($P\geq$zero.38). In those experimental conditions, the buildup of those secondary metabolites became now no longer in particular tormented by contamination timing at some point of anthesis.

**The Effect of Essential Oils at the ergosterol** attention in wheat samples Analysis of ergosterol (ERG) attention allowed us to estimate the diploma of boom inhibition of the 2 species, *F. graminearum* and *F. culmorum*, in wheat grain after the addition of the EO solutions. The percent discount becomes additionally calculated in assessment with the manipulated trials. The effects confirmed that the attention of ergosterol become considerably reduced in samples with the addition of examined EOs. An exception become discovered in orange EO trials, in which the discount in ERG attention amounted to 90.99% and 68.13% in *F. graminearum* and *F. culmorum* samples, respectively.

**The Effect of Essential Oils at the zearalenone**
The attention in wheat samples the quantity of zearalenone (ZEA) in wheat samples inoculated with *Fusarium* isolates becomes considerably decreased with the aid of using EO activity/addition. Very low concentrations of ZEA (0.00–5.33 μg/g) had been discovered in *F. graminearum* samples handled with EOs. ZEA discount becomes at 99.57–100%, with the bottom performance in samples with orange oil. The addition of EOs to the samples inoculated with *F. culmorum* additionally led to a vast discount withinside the ZEA quantity. The diploma of toxin discount reached 99.08–99.99% besides for the pattern with orange oil, in which the discount quantity become 68.33%.

**Conclusion**
Secondary metabolites appear to be related with lower production of reactive oxygen species (and hence less cell damage) and modest changes in the metabolome, whereas pre-activation of particular heat shock transcription factors appears to be relevant. By modulating leaf water potential, proline accumulation boosted wheat crop output under water and temperature stress. Change in the proline, glycine betaine, phenolic contents during the heat stress are best indicator of change in the number of grains per spike it would be

determine grain yield.

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