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Research Article

Impact of salicylic acid on wheat (*Triticum aestivum* L.) under cadmium stress in Pakistan

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Abstract

Cadmium (Cd) is highly toxic element for plants. It is found in Pakistani soils and comes from industrial waste. Cd has become one of the major metal stresses which pose a serious threat to plants. Salicylic acid (SA) detoxifies the toxic effects of Cd in crop plants and improves the growth of plants. Therefore, the study was conducted to investigate the impact of Salicylic Acid on Wheat under Cadmium stress. The experiment was conducted at University of Sargodha, Lyallpur Campus Faisalabad, Pakistan during winter 2017-18. The experiment was consisted of 2 factors viz. cadmium and salicylic acid. There were two levels of cadmium viz. control and application of cadmium at concentration of 500 µM and three levels of salicylic acid viz. application of salicylic acid at concentration 0.1 mM, application of salicylic acid at concentration 0.5 mM and application of salicylic acid at concentration 0.9 mM. Wheat cultivar AARI-2011 was selected for the trial. Cadmium Sulphate ($CdSO_4$) solution of concentration 500 µM, was applied for cadmium toxicity to the soil in the pots prior to sowing and sprayed at seedling stage (10 days after germination). Three concentrations of salicylic acid were used i.e. 0.1 mM, 0.5 mM and 0.9 mM as seed priming and as spray at seedling stage (10 days after seed germination). Replicated three times the experiment was laid out in Complete Randomized Design (CRD). Salicylic acid applied at concentration 0.5 mM under control was the most efficient in terms of seed germination. The morphological parameters were also significantly affected by the application of salicylic acid. Salicylic acid applied at concentration 0.5 mM under control and applied at concentration 0.9 mM under cadmium stress (with a difference of 4 %) were more efficient than other treatments in terms of seedling growth. Finally the yield parameters like number of spikelets, number of grains, 1000 grains weight and yield of wheat were also highly influenced by the application of salicylic acid under cadmium stress. Salicylic acid applied at concentration 0.5 mM under control and applied at concentration 0.9 mM under cadmium stress (with a difference of 0.9 %) were more efficient than other treatments in terms of yield parameters. The study portrays the significance of SA on wheat crop under Cd stress. The practical implication of this study is that under similar trial conditions, SA influences germination, growth and yield of crops in Cd toxic soils. Therefore, under Cd stress, SA should be applied for better yield and higher economic returns.

Keywords: Cadmium; Salicylic Acid; Stress; Wheat

Introduction

Wheat (*Triticum aestivum* L.) is fundamental food for larger part of individuals on earth and likewise the biggest source of food. It is one of real grain yields devoured by people and is developed the world over in differing situations [1]. The creating nations are the prominent merchants of wheat crop. By 2060, the total populace will ascend from current 6.8 billion to 11.8 billion **[2]**. In developing countries, yield of this prominent grain can be additionally expanded through high yielding assortments, planting at appropriate days and embracing new and trend setting innovations **[3, 4]**.

The world needs to confront various difficulties to defend its populace from sustenance lack. A dangerous atmospheric deviation is one of the prime difficulties which may contrarily influence the yield of wheat. Diverse development phases of wheat are influenced distinctively by various natural variables **[5]**. Regenerative phase of wheat is progressively delicate to temperature when contrasted with vegetative stage **[6]**.

With increment in industrialization, the overwhelming metal substances are likewise expanding antagonistically in soil. The mechanical waste has the blend of natural, inorganic, radioactive and substantial metals **[7]**. These substantial metals go about as fundamental micronutrients and assume a prominent job in plants, for example as cofactors of metabolic proteins. At the point when their sum increments past the cut-off points in the dirt, they become overwhelming metal worry in plants **[8-10]**.

Cadmium (Cd) being a portable overwhelming metal can be taken up by roots impactively and can be amassed in various plant parts **[7]**. It is increasingly lethal because of its high versatility into water **[11]**. The primary sources by which it might goes into the earth are mineral manures, metal-working businesses, and mining units **[12, 13]**. Cd hinders the plumule and radical development in rice **[14]** and root development is more influenced than shoot development in wheat **[15]**. Plant layer is the principal focus of overwhelming metal harmfulness, which may legitimately influence the core or respond with the hormones that are in ethereal plants parts **[16, 13]**.

Cd has become one of the major metal stresses which pose a serious threat to plants. In this context, exogenous application of SA could play an important role in mitigating the impact of Cd stress. Exogenous application of SA through rooting medium is one of the best mode to reduce the impact of Cd stress. SA enhances the resistance capacity of plants growing under Cd stress which, however, depends on the metal concentration and the duration of the treatment.

Salicylic Acid (SA) a straightforward phenolic atom has for quite some days been perceived as an intense phytohormone that controls plant improvement and barrier in higher plants **[17]**. The union of SA happens by two unmistakable and compartmentalized pathways. One pathway gets from phenylalanine and happens in the cytoplasm. Initially, phenylalanine smelling salts lyase (PAL) changes over phenylalanine into cinnamic corrosive; cinnamic corrosive is then decarboxylated to shape benzoic corrosive lastly experiences 2-hydroxylation to create SA **[18]**. Change of PAL qualities in Arabidopsis results in half abatement in pathogen-initiated SA gathering, recommending that the PAL pathway without a doubt adds to SA biosynthesis

[19]. Another biosynthetic pathway is through isochorismate synthase that catalyzes the change of chorismate into isochorismate **[20]**. In this pathway, SA is produced in chloroplasts from chorismate by the blend of two isochorismate synthases (ICSes); isochorismate synthase 1 (ICS1) and isochorismate synthase 2 (ICS2) **[21]**. Investigation of SA-insufficient freaks, sid2, uncovered that loss of ICS1 stifles the pathogen-initiated SA collection [20], though loss of both ICSes results in further decrease of SA focus **[21]**.

It has been settled that SA is a key sign controlling neighbour-hood and fundamental plant resistance reactions against pathogens **[20, 22]**. In this flagging pathway, SA-restricting proteins, for example salicylic acid binding protein 2 (SABP2), nonexpressor of Pathogenesis-related protein 3 (NPR3), nonexpressor of Pathogenesis-related protein 4 (NPR4) and nonexpressor of Pathogenesis-related protein 1 (NPR1) with high liking for SA, are viewed as SA receptors that incite the outflow of pathogenesis-related (PR) proteins and trigger foundational obtained obstruction **[23]**. Besides, SA has indicated prominent jobs in intervening plant reactions to abiotic stresses **[24]**, including dry spell **[25]**, chilling **[26]**, osmotic pressure **[27]**, thermogenesis **[28]** and overwhelming metal lethality **[29]**. As of late, the gainful jobs of SA in improving plant Cd resilience, which has been accounted for in a wide scope of plant species, have drawn much consideration. Be that as it may, the negative impact of SA was likewise noted in castor bean shoots in which pre-treatment with SA irritated Cd harm **[30]**. The impacts of SA on Cd-focused on plants rely upon numerous viewpoints, including the application mode, the convergences of Cd and SA and endogenous SA in the tried plants just as the various species and formative phases of the plants.

[31] Conducted a trial to study the role of SA in alleviating the Cd stress in Barley shoots and reported that SA unequivocally or totally stifled the Cd-prompted up-guideline of the cell reinforcement protein exercises. Cuts from leaves treated with SA for 24 h likewise demonstrated an expanded degree of resilience toward high Cd fixations as shown by chlorophyll a fluorescence parameter. The outcomes bolster the end that SA lightens Cd poisonous quality not at the degree of cell reinforcement guard but rather by influencing systems of Cd detoxification.

Materials and Methods

To determine the impact of SA on wheat under Cd stress, a pot experiment was conducted at University of Sargodha, Lyallpur Campus Faisalabad during winter 2017-18. Wheat cultivar AARI-2011 was selected for the trial. Pot experiment was conducted under the climate of Faisalabad. Cd Sulphate ($CdSO_4$) solution of concentration 500 µM, prepared by mixing 0.2315 g $CdSO_4$ in one L water, was applied for Cd stress to the soil in the pots prior to sowing and sprayed at shoot stage (10 days after germination). Three doses of SA were used i.e. 0.1 mM (prepared by mixing 0.0138 g SA in one L water), 0.5 mM (prepared by mixing 0.069 g SA in one L water) and 0.9 mM (prepared by mixing 0.1242 g SA in one L water) as seed priming and as spray at shoot stage (10 days after seed germination). Repeated 3 times the trial was laid out in Complete Randomized Design (CRD). Total 18 pots were randomly arranged.

Treatments

Factor A: Cadmium

T1: Control

T2: Cd (500 µM)

Factor B: Salicylic Acid

T1: SA_1 (0.1 mM)

T2: SA_2 (0.5 mM)

T3: SA_3 (0.9 mM)

Observations to be recorded

1. Days to start emergence (days)
2. Mean emergence days (days)
3. Emergence index
4. Shoot length (cm)
5. Root length (cm)
6. No. of spikelet per spike

7. Spike length (cm)
8. No. of grains per spike
9. 1000 grains weight (g)
10. Yield per plant (g)

Results and Discussion

The influence of salicylic acid on germination parameters of wheat under control and cadmium stress is given in (Fig. 1). It is clear from the figure that minimum time to start emergence was recorded in SA_3 under cadmium stress which was nearly equal to that of SA_1 under control. In the same way, mean germination time was minimum in case of SA_1 under control which was nearly equal to that of SA_3 under cadmium stress. The maximum emergence index was recorded in SA_2 under control and in SA_3 under cadmium stress respectively. Jun-Yu *et al.* **[14]** Also concluded that SA improved the germination parameters like mean germination time and emergence index significantly of crop plants under Cd stress.

The (Fig. 2) depicts the impact of salicylic acid on seedling growth of wheat under control and cadmium stress. It is clear from the figure that the wheat plants treated with SA_2 under control have maximum shoot length following with SA_3 under cadmium stress while wheat plants treated with SA_1 under cadmium stress have minimum shoot length. The maximum root length was recorded in SA_3 under cadmium stress which was nearly equal to that of SA_2 under control while minimum root length was recorded SA_1 under cadmium stress. The results are in line with that of **[17]** who reported that SA significantly improved the growth parameters in crop plants under Cd stress when plants were exposed to cd stress and exogenous SA was applied to crop plants.

The impact of salicylic acid on number of spikelets per spike and spike length of wheat under control and cadmium stress has been depicted in (Fig. 3). Maximum number of spikelets per spike were recorded in SA_3 under cadmium stress following SA_2 under control while minimum number of spikelets per spike were recorded in SA_1 under cadmium stress. The trend of spike length is slightly different. Maximum number of spike length was recorded in SA_2 under control which was nearly equal to that of SA_3 under cadmium stress while the minimum spike length was observed in SA_1 under cadmium stress. The results are also in line with that of **[17]** who reported that SA significantly improved the growth parameters in crop plants under Cd stress when plants were exposed to cd stress and exogenous SA was applied to crop plants.

The (Fig. 4) shows the effect of salicylic acid on yield parameters of wheat under control and cadmium stress. It is clear from the figure that the wheat plants treated with SA_3 under cadmium stress have maximum grains per spike following with SA_2 under control while wheat plants treated with SA_1 under cadmium stress have minimum grains per spike. The same trend was observed for thousand grains weight while for yield per plant, the trend was slightly different. The maximum yield per plant was observed in SA_2 under control which was almost equal to that of under SA_3 cadmium stress while minimum yield per plant was recorded in SA_1 under cadmium stress. Raskin **[17]** Conducted a trial to study the impact of SA on caster bean under Cd stress and concluded that SA significantly enhanced the yield of caster bean under Cd stress. The results obtained in this study are in line with that of **[17]**.

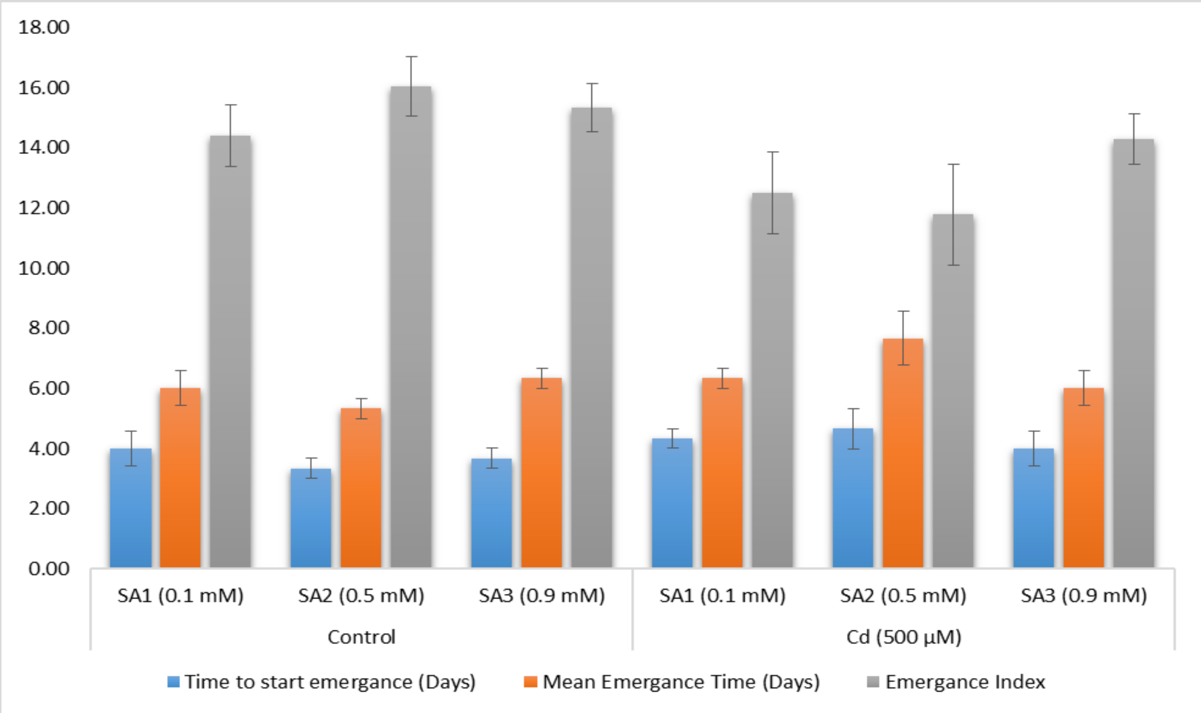

Figure 1. Influence of salicylic acid on germination parameters of wheat under control and cadmium stress

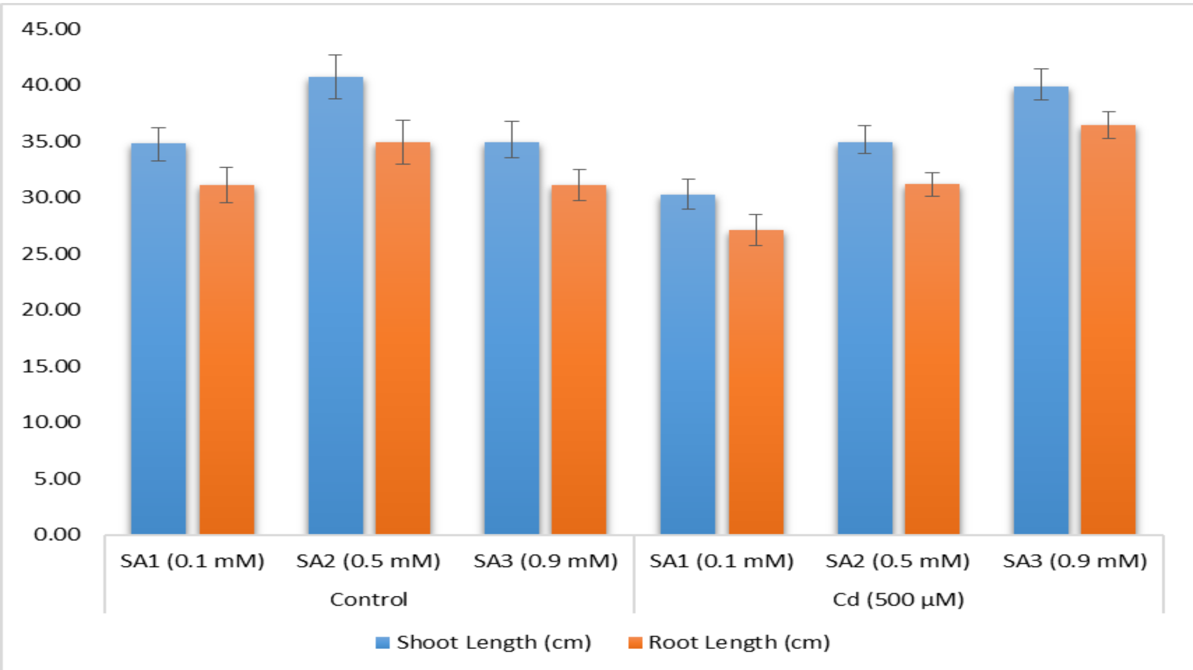

Figure 2. Impact of salicylic acid on seedling growth of wheat under control and cadmium stress

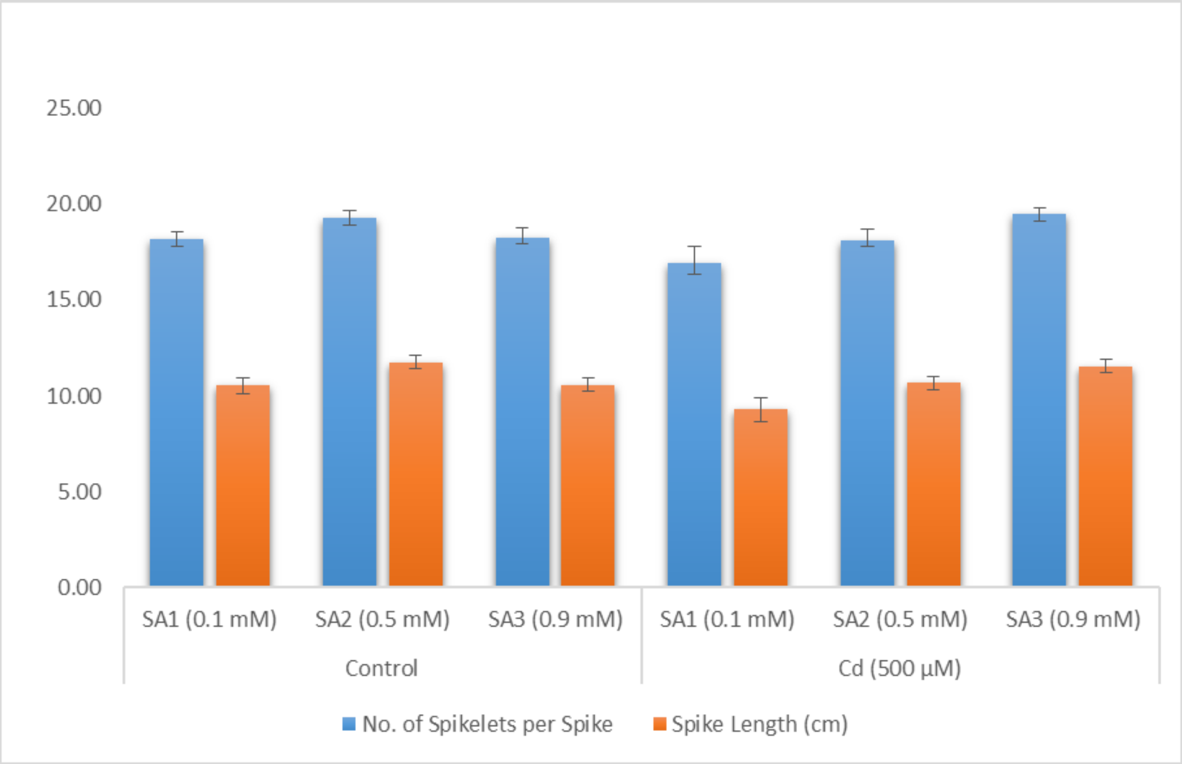

Figure 3. Effect of salicylic acid on number of spikelets per spike and spike length of wheat under control and cadmium stress

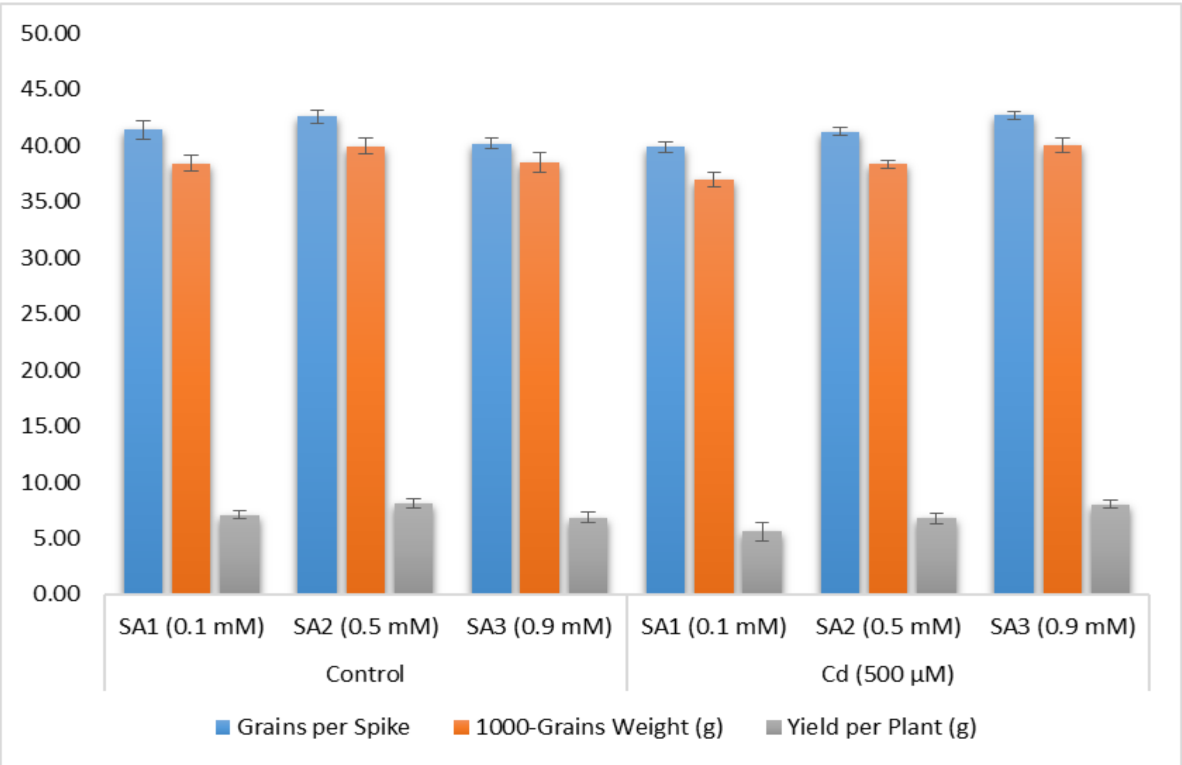

Figure 4. Influence of salicylic acid on yield of wheat under control and cadmium stress

Conclusion

The germination parameters of wheat were highly influenced by applying SA under Cd stress. SA applied at concentration 0.5 mM alone was the most efficient in terms of seed germination. SA applied at concentration 0.9 mM along with application of Cd also showed prominent results in terms of seed germination as compared to control. The growth parameters were also prominently affected by applying SA. SA applied at concentration 0.5 mM alone and at concentration 0.9 mM along with Cd stress (with a difference of only 4%) were more efficient than other treatments in terms of shoot growth under Cd stress. Finally, the yield parameters like No. of tillers, No. of spikelet, No. of grains, 1000 grains weight and yield of wheat and barley were also highly influenced by applying SA under Cd stress. SA applied at concentration 0.5 mM alone and applied at concentration 0.9 mM along with Cd stress (with a difference of 0.9%) were more efficient than other treatments in terms of yield parameters under Cd stress. It is also noted that increase of SA concentration from 0.5 mM to 0.9 mM alone have adverse impact on all parameters of wheat while the same pattern if applied under cadmium stress have positive impact on all parameters. Therefore, SA can be used at concentration 0.5 mM alone and at 0.9 mM under Cd stress for significant results.

The study portrays the significance of SA on wheat crop under Cd stress. The practical implication of this study is that under similar trial conditions, SA influences germination, growth and yield of crops in Cd toxic soils. Therefore, under Cd stress, SA should be applied for better yield and higher economic returns.

Authors' contributions

Conceived and designed the experiment: M Rizwan & S Baloch, Performed the experiments: S Ullah & H Shahzad, Analyzed the data: AA Khakwani, I Hussain & R Tahreem, Contributed reagents/ materials/ analysis tools: I Ahmad & N Latif, Wrote the paper: M Rizwan, S Ullah & R Tahreem.

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