Productivity and Nutrient Content of Wheat (Triticum aestivum L.) as Influenced by Sowing Temperatures and Bio-regulators

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A B S T R A C T

A field experiment was carried out during rabi seasons of 2016-17 and 2017-18 at Agronomy Farm, S.K.N. Agriculture University, Jobner, Jaipur, Rajasthan, to obtain a suitable combination of sowing at different thermal regimes and foliar sprays of bio-regulators. The experiment was conducted in a split-plot design with four replications. The main plot treatments comprised three sowings, viz. 22 °C, 20 °C and 18 °C and subplots consisted of eight treatments of bio-regulators, viz. control, water spray, SA @ 100 ppm, SA @ 200 ppm, TSA @ 100 ppm, TSA @ 200 ppm, TGA @ 100 ppm and TGA @ 200 ppm. Crop sown at 20 °C resulted in significantly highest yield and nutrient content over 22 °C and 18 °C. Among bio-regulators, an application of salicylic acid @ 200 ppm registered significantly highest yield and nutrient content in grain and straw of wheat, thus, hold a great promise in wheat production under heat stress.

Keywords
Bio-regulators, Nutrient content, Sowing temperature, Wheat, Yield

Introduction

Wheat (Triticum aestivum L.) is one of the chief sources of diet by providing half of the dietary protein and more than half of the calories to the rising population of India. As a consequence, scientists are always focusing to produce higher yields to feed the nation (Khan et al., 2015). Wheat is grown in India on 33.61 Mha and produces of 106.21mt with national average yield of 3160 kg/ha during 2019-20 (Anonymous, 2020a). In Rajasthan, the production reached the level 12.19 m t with productivity of 3676 kg/ha and acreage 3.31 m ha (Anonymous, 2020b). In developing countries, climatic variability can change Climate (abiotic stresses) causing strong physiological, biochemical, morphological, and molecular changes that negatively influence plant growth, quality and productivity (Meena et al., 2016). Among them, heat stress is a global anxiety that drastically reduces the yield and quality of wheat (Lal, 2013). In this situation, several factors have a significant role in improving wheat yield, such as early and on-time sowing, judicious use of inputs and stress alleviating chemicals (Meena et al., 2017).
Under the late sowing of wheat, applied inputs are not efficiently utilized which resulted into the yield declined by one percent every day (Khan et al., 2010). Consequently, all the growth stages, such as seed emergence, tillering, flowering, and grain filling, are negatively affected by the shortened crop growth period. A rise in temperature leads to leaf senescence by reducing the optimum growth period resulting in a low photosynthetic rate (Sattar et al., 2010).

Bio-regulators (salicylic acid, thio salicylic acid and thio glycolic acid) regulate physical and physiological activities of the plants under adverse conditions (Agarwal et al., 2017). Salicylic acid is an important signaling molecule naturally occurs in plants as hormone and aids to tolerance against environmental stresses such as salinity, chilling, drought, heat heavy metal toxicity stress (Singh et al., 2020). The plant photosynthetic effectiveness and canopy photosynthesis are increased by the spray of thio salicylic acid and TGA due to presence of S-H group as an integral constituent of these thiols (Shivran et al., 2019). They improve photosynthetically leaf surface area during vegetative phase in cereals by delaying senescence. Application of bio-regulators also increases the uptake and content of nutrients (N, P and K) as compared to control under heat stress (Vazirmehar and Rigi, 2014). Therefore, the present research aims to assess the effect of sowing at different thermal environments and foliar spray of bio-regulators on productivity and nutritional composition of wheat under the era of climate change.

**Materials and Methods**

An experiment was carried out during *rabi* seasons of 2016-17 and 2017-18 at the Agronomy Farm of S.K.N. College of Agriculture, Jobner situated at latitude of 26° 05’ North, longitude of 75° 28’ East and at an altitude of 427 metres above mean sea level. The site of the experiment is cold winter, hot and dry summer which is semi-arid type climate with 400 mm mean annual normal rainfall, of which 80% is received during July-September through south-west monsoon. The soil texture of the field was loamy sand with 8.25 pH, 1.24 dS/m EC, 0.22 % O.C. 130.3 kg/ha available N (Subbiah and Asija, 1956), 15.2 kg/ha available P (Olsen et al., 1954) and 149 kg/ha available K (Jackson, 1973). Field experiment was conducted in four times replicated split plot design with 24 treatments, which consisting of three sowing at different thermal environments, viz. D1 (22 °C), D2 (20 °C), D3 (18 °C) and eight foliar spray of bio-regulators, viz. B1, control; B2, water spray; B3, salicylic acid @ 100 ppm; B4, salicylic acid @ 200 ppm; B5, thiosalicylic acid @ 100 ppm; B6, thiosalicylic acid @ 200 ppm; B7, thioglycolic acid @ 100 ppm; and B8, thioglycolic acid @ 200 ppm. Bio-regulators were sprayed by using foot sprayer at tillering and ear emergence stages of crop growth.

The wheat cultivar ‘Raj 3765’ was sown during the experimentation, by pora method using 100 kg/ha seed rate with the 22.5 cm row spacing. The recommended dose of N (120 kg/ha) was applied in two splits, half dose before sowing and remaining half dose with first irrigation. The entire dose of phosphorus (40 kg P2O5/ha) was incorporated into the soil as basal just before sowing of the crop. Urea and DAP were broadcasted for nitrogen and phosphorus application. Six irrigations were given during entire life cycle of crop. Harvesting was done manually and after threshing, cleaning and drying, the grain and straw yields of wheat was calculated and expressed in kg/ha. According to recommendations, all other cultural practices were carried out. At the time of threshing,
grain and straw samples were carried from each plot after proper drying and then grounding for estimation of nutrient content by standard methods.

**Results and Discussion**

**Effect of sowing at different thermal environments**

Yield and nutrient content in grain and straw varied significantly due to sowing at different thermal environments during both the years and in pooled mean. The significantly highest grain and straw yields of wheat were recorded under D_2 with the respective values of 3771 and 4880 kg/ha. The minimum grain and straw yields were noted with D_3 (3437 and 4533 kg/ha). The quantum increase in yield due to D_2 (sowing at 20 °C) was 5.28 and 9.72 per cent in grain yield and 4.79 and 7.65 per cent in straw yield over D_1 (sowing at 22 °C) and D_3 treatments. Changing the sowing time towards favourable environment created a significant effect on the crop yield, probably driven by the different thermal regimes prevailing throughout the grain filling period resulted into higher yield. The findings of Tripathi et al., (2013), Kumar et al., (2013) and Suleiman et al., (2014) are closely related to above results.

Sowing of wheat at 20 °C (D_2) significantly increased the nutrient (N, P and K) content in grain and straw and being at par with sowing at 22 °C (D_1) in respect to P content in straw proved superior over D_1 and D_3 treatments. The N, P and K content in grain and straw have positive association with temperature prevailed during the crop growth period and on-time sowing. These findings were similar to those of Mukherjee (2012) and Mukherjee et al., (2017) (Table 1).

**Table.1 Effect of sowing at different thermal environments and foliar spray of bio-regulators on grain and straw yields**

| Treatments                             | Grain | Yield (kg/ha) | Straw |          |          |
|----------------------------------------|-------|---------------|-------|----------|----------|
|                                        |       | 2016-17       | 2017-18 | Pooled   | 2016-17  | 2017-18  | Pooled   |
| Sowing at different thermal environments |       |               |       |          |          |
| D_1                                    | 3667  | 3498          | 3582  | 4742     | 4572     | 4657     |
| D_2                                    | 3860  | 3681          | 3771  | 4940     | 4820     | 4880     |
| D_3                                    | 3503  | 3372          | 3437  | 4623     | 4443     | 4533     |
| SEM±                                   | 55    | 55            | 39    | 62       | 47       | 39       |
| CD (P=0.05)                            | 189   | 191           | 120   | 213      | 163      | 119      |
| Foliar spray of bio-regulators          |       |               |       |          |          |
| B_1                                    | 3258  | 3203          | 3230  | 4314     | 4195     | 4254     |
| B_2                                    | 3398  | 3318          | 3358  | 4470     | 4326     | 4398     |
| B_3                                    | 3538  | 3327          | 3432  | 4623     | 4312     | 4467     |
| B_4                                    | 3991  | 3758          | 3874  | 5045     | 4952     | 4998     |
| B_5                                    | 3701  | 3461          | 3581  | 4842     | 4564     | 4703     |
| B_6                                    | 3879  | 3701          | 3790  | 4944     | 4916     | 4930     |
| B_7                                    | 3724  | 3575          | 3649  | 4910     | 4697     | 4804     |
| B_8                                    | 3925  | 3792          | 3858  | 5000     | 4932     | 4966     |
| SEM±                                   | 87    | 67            | 55    | 94       | 87       | 64       |
| CD (P=0.05)                            | 245   | 189           | 153   | 265      | 247      | 180      |
| Interaction (D x B)                     |       |               |       |          |          |
| SEM±                                   | 150   | 116           | 95    | 163      | 151      | 111      |
| CD (P=0.05)                            | NS    | NS            | 265   | NS       | NS       | NS       |
Table 2: Effect of sowing at different thermal environments and foliar spray of bio-regulators on nitrogen content in grain and straw

| Treatments | Nitrogen content (%) |  |  |  |  |  |  |  |  |  |  |
|------------|----------------------|---|---|---|---|---|---|---|---|---|---|
|            | Grain                |  | Straw          |  |  | Pooled |  |  | Pooled |  |  |
|            | 2016-17 | 2017-18 | Pooled | 2016-17 | 2017-18 | Pooled |
| Sowing at different thermal environments |  |  |  |  |  |  |  |  |  |  |  |
| D₁        | 1.65 | 1.53 | 1.59 | 0.581 | 0.559 | 0.570 |
| D₂        | 1.77 | 1.65 | 1.71 | 0.630 | 0.605 | 0.617 |
| D₃        | 1.59 | 1.52 | 1.56 | 0.536 | 0.515 | 0.525 |
| SEm±      | 0.04 | 0.03 | 0.02 | 0.02 | 0.02 | 0.011 |
| CD (P=0.05) | 0.13 | 0.11 | 0.07 | 0.06 | 0.06 | 0.035 |
| Foliar spray of bio-regulators |  |  |  |  |  |  |  |  |  |  |  |
| B₁        | 1.57 | 1.51 | 1.54 | 0.506 | 0.483 | 0.494 |
| B₂        | 1.60 | 1.53 | 1.56 | 0.544 | 0.523 | 0.534 |
| B₃        | 1.67 | 1.50 | 1.59 | 0.604 | 0.581 | 0.593 |
| B₄        | 1.86 | 1.75 | 1.80 | 0.655 | 0.623 | 0.639 |
| B₅        | 1.65 | 1.48 | 1.57 | 0.551 | 0.532 | 0.542 |
| B₆        | 1.65 | 1.55 | 1.60 | 0.596 | 0.576 | 0.586 |
| B₇        | 1.64 | 1.53 | 1.58 | 0.575 | 0.556 | 0.566 |
| SEm±      | 0.05 | 0.05 | 0.03 | 0.03 | 0.03 | 0.019 |
| CD (P=0.05) | 0.13 | 0.14 | 0.09 | 0.07 | 0.07 | 0.052 |
| Interaction (D x B) |  |  |  |  |  |  |  |  |  |  |  |
| SEm±      | 0.08 | 0.09 | 0.06 | 0.05 | 0.05 | 0.03 |
| CD (P=0.05) | NS | NS | NS | NS | NS | NS |

Table 3: Effect of sowing at different thermal environments and foliar spray of bio-regulators on phosphorus content in grain and straw

| Treatments | Phosphorus content (%) |  |  |  |  |  |  |  |  |  |  |
|------------|------------------------|---|---|---|---|---|---|---|---|---|---|
|            | Grain                 |  | Straw          |  |  | Pooled |  |  | Pooled |  |  |
|            | 2016-17 | 2017-18 | Pooled | 2016-17 | 2017-18 | Pooled |
| Sowing at different thermal environments |  |  |  |  |  |  |  |  |  |  |  |
| D₁        | 0.479 | 0.455 | 0.467 | 0.165 | 0.161 | 0.163 |
| D₂        | 0.528 | 0.510 | 0.519 | 0.170 | 0.171 | 0.171 |
| D₃        | 0.437 | 0.413 | 0.425 | 0.154 | 0.153 | 0.153 |
| SEm±      | 0.015 | 0.016 | 0.011 | 0.004 | 0.005 | 0.003 |
| CD (P=0.05) | 0.052 | 0.054 | 0.034 | 0.012 | 0.014 | 0.012 |
| Foliar spray of bio-regulators |  |  |  |  |  |  |  |  |  |  |  |
| B₁        | 0.404 | 0.382 | 0.393 | 0.152 | 0.146 | 0.149 |
| B₂        | 0.442 | 0.417 | 0.430 | 0.154 | 0.155 | 0.155 |
| B₃        | 0.502 | 0.477 | 0.489 | 0.165 | 0.164 | 0.165 |
| B₄        | 0.553 | 0.534 | 0.543 | 0.174 | 0.171 | 0.173 |
| B₅        | 0.449 | 0.431 | 0.440 | 0.158 | 0.159 | 0.158 |
| B₆        | 0.503 | 0.475 | 0.489 | 0.169 | 0.168 | 0.168 |
| B₇        | 0.473 | 0.453 | 0.463 | 0.163 | 0.160 | 0.162 |
| SEm±      | 0.022 | 0.024 | 0.016 | 0.005 | 0.006 | 0.005 |
| CD (P=0.05) | 0.062 | 0.068 | 0.045 | 0.015 | 0.017 | 0.015 |
| Interaction (D x B) |  |  |  |  |  |  |  |  |  |  |  |
| SEm±      | 0.04 | 0.04 | 0.03 | 0.009 | 0.014 | 0.008 |
| CD (P=0.05) | NS | NS | NS | NS | NS | NS |
Table 4 Effect of sowing at different thermal environments and foliar spray of bio-regulators on potassium content in grain and straw

| Treatments                                | Potassium content (%) |                  |                  |                  |                  |
|-------------------------------------------|-----------------------|------------------|------------------|------------------|------------------|
|                                           |                       | Grain 2016-17    | 2017-18          | Pooled 2016-17   | 2017-18          | Pooled          |
| Sowing at different thermal environments  |                       |                  |                  |                  |                  |                  |
| D1                                        | 0.446                 | 0.427            | 0.437            | 1.621            | 1.502            | 1.562           |
| D2                                        | 0.495                 | 0.477            | 0.486            | 1.736            | 1.621            | 1.678           |
| D3                                        | 0.401                 | 0.381            | 0.391            | 1.565            | 1.492            | 1.529           |
| treatments                                |                       |                  |                  |                  |                  |                  |
| Foliar spray of bio-regulators            |                       |                  |                  |                  |                  |                  |
| B1                                        | 0.371                 | 0.349            | 0.360            | 1.538            | 1.485            | 1.511           |
| B2                                        | 0.409                 | 0.389            | 0.399            | 1.565            | 1.495            | 1.530           |
| B3                                        | 0.461                 | 0.449            | 0.455            | 1.644            | 1.473            | 1.558           |
| B4                                        | 0.520                 | 0.501            | 0.510            | 1.832            | 1.717            | 1.775           |
| B5                                        | 0.416                 | 0.399            | 0.408            | 1.622            | 1.450            | 1.536           |
| B6                                        | 0.469                 | 0.448            | 0.458            | 1.617            | 1.523            | 1.570           |
| B7                                        | 0.440                 | 0.422            | 0.431            | 1.608            | 1.497            | 1.553           |
| B8                                        | 0.491                 | 0.467            | 0.479            | 1.698            | 1.668            | 1.683           |
| SEm±                                      | 0.026                 | 0.027            | 0.019            | 0.046            | 0.050            | 0.034           |
| CD (P=0.05)                               | 0.074                 | 0.075            | 0.052            | 0.129            | 0.140            | 0.094           |
| Interaction (D x B)                        |                       |                  |                  |                  |                  |                  |
| SEm±                                      | 0.05                  | 0.05             | 0.03             | 0.079            | 0.086            | 0.058           |
| CD (P=0.05)                               | NS                    | NS               | NS               | NS               | NS               | NS              |

Effect of foliar spray of bio-regulators

Data further indicated that different foliar spray of bio-regulator treatments were significantly influence the yield and nutrient content in grain and straw during both the years and in pooled analysis. The significantly higher values of grain and straw yields (3874 and 4998 kg/ha) of wheat were observed under the application of salicylic acid @ 200 ppm over remaining treatments while it was at par with thiosalicylic acid and thioglycolic acid @ 200 ppm. The significantly minimum grain and straw yields were obtained under control with the corresponding values of 3230 and 4254 kg/ha. Foliar spray of salicylic acid @ 200 ppm (B4) represented an increase in yield to the tune of 19.94 and 15.37 per cent in grain yield and 17.49 and 13.64 per cent in straw yield, respectively over B1 (control) and B2 (water spray). The period of photo synthetically active sites in crop plants are extended in response to exogenous application of bio-regulators towards higher biomass accumulation increase in the crop yield, consequently delayed senescence of plant organs (particularly leaves and flowers). These findings are in agreement with Kumawat et al., (2013) Sharma et al., (2013) and Nathawat et al., (2016).

Among foliar spray of bio-regulator treatments, SA @ 200 ppm (B4) recorded the significantly higher nitrogen and phosphorus content in grain and straw which was at par with B3 in respect of grain and with B3 and B8 in respect of straw. While with regard to P content in straw, the above treatment also remained at par with B5, B6 and B7. Application of SA @ 200 ppm (B4) significantly increased K content in grain and straw over other treatments but remained at par with B6 and B8. Since, content of nutrients is the function of grain and straw yield hence, a clear involvement of bio-regulators in the control of nutrient assimilation might be
expected. These results are in line with those of Muhal et al., (2014) and Premaradhya et al., (2018) (Table 2–4).

**Interaction effect**

Data represented that collective effect between sowing at different thermal environments and foliar spray of bio-regulators was found to be non-significant with regard to straw yield and nutrient content of wheat. While, interaction effect of sowing at different thermal environments and foliar spray of bio-regulator treatments on grain yield of wheat was found to be significant.

Based on the study, it was concluded that highest productivity and nutrient content in grain and straw were obtained with the application of salicylic acid @ 200 ppm at tillering and ear emergence stages of wheat along with sowing at 20 °C mean temperature.

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