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SUMMARY – At some specific stages of wheat (*Triticum aestivum* L.) growth, commercially available organic growth stimulants (biostimulants) were tested from 1999 to 2003 in Saudi Arabia. Small amounts (up to a few l/ha) of biostimulants (Vigro, Biomin, Humiplus and Humacare) were used and evaluated on wheat crops. These products consisted of micronutrients, humic acid, extracts of seaweeds, plants and amino acids. Field tests of these substances at various nutrient levels, locations, forms and timings resulted in enhanced crop yields and produce quality. Improvement of plant growth and increases in yield were observed for all biostimulants, but Vigro showed significant yield increases. The plants treated with Vigro exhibited an increase in the total tiller number of 21%, a greater number of fertile florets per spike. Nevertheless the economic yield (grain yield) had improved by 8.2%.

Key words: Wheat, rain fed, biostimulants, tillering.

RÉSUMÉ – *"Effet des biostimulants sur la production de blé (*Triticum aestivum *L.)". A certains stades spécifiques de croissance du blé (*Triticum aestivum *L.), des stimulants organiques de croissance (biostimulants) disponibles dans le commerce ont été testés de 1999 à 2003 en Arabie Saoudite. De petites quantités (jusqu'à quelques l/ha) de Biostimulants (Vigro, Biomin, Humiplus et Humacare) ont été utilisées et évaluées sur des cultures de blé. Ces produits étaient composés de micronutriments, acide humique, extraits d'algues, plantes et acides aminés. Les essais au champ de ces substances sous plusieurs niveaux de nutriments, emplacements, formes et calendriers ont donné une amélioration des rendements des cultures et de la qualité des produits. Une amélioration de la croissance végétale et une augmentation du rendement ont été observées avec tous les biostimulants, mais Vigro a montré des augmentations de rendement significatives. Les plantes traitées avec Vigro ont montré une augmentation de 21% du nombre total de talles, et un plus grand nombre de fleurons fertiles par épi. Néanmoins le rendement économique (rendement en grain) s'était amélioré de 8,2%.*

Mots-clés : *Blé, non irrigué, biostimulants, tallage.*

Introduction

In the Arab world, rainfed agriculture constitutes about 82% of the total area under cultivation and about 28% is left fallow every year (ACSAD, 2003). This agriculture is generally characterised by low productivity, uncertainty and limited profits. Water availability has also an important influence on crop productivity and is determined by the quantity and distribution of rainfall and the soil capacity to store water. Wheat is one of the most important crops and widely grown in the region (FAO, 2003).

Various agricultural techniques can be used within an integrated farming system to decrease the cost of production and increase the yield per unit area. Within the past few years, several materials that may regulate growth and production have been placed on the market. Growers have used these materials and have reported various degrees of success. Wheat growers are searching for ways to increase yield in an economic manner. The object of this study is to confirm that biostimulants considerably aid in alleviating environmental stress conditions, are effective in increasing wheat yield and study their involvement in production parameters.

On the sandy alkaline soils, growers obtained a growth and yield response of wheat to an application of humates, which enhances uptake of nutrients (Hanson, 1988). These soils are very low in organic matter. Siddique *et al*. (1990) reported that modern wheat cultivars have progressively lower root:shoot ratios at anthesis which make them sensitive to drought and more dependent on irrigation. Corn and potato yields have been reported to be affected by seaweed preparations (Chapman and Chapman*,* 1980).

Since biostimulants are used commercially to increase wheat yield, it was necessary to study the influence of exogenous biostimulants on the growth process in wheat. Yield is the integration of metabolic reactions in plants and all factors that influence this metabolic activity during plant growth can affect the yield (Ibrahim, 1999). The yield potential of wheat is dependent on early events and determined by number of spikelets, number of fertile florets, grains per spikelet and grain size. Production of wheat is largely dependent on genotype, seeding rate, photoperiod, temperature, water and nutrient status during the tillering period (Rajala and Peltonen-Sainio, 2000). Tillering is an important adaptive characteristic of wheat that enables plants to utilise fully available space and resources (Langer, 1972; Peltonen-Sainio and Peltonen, 1995).

Despite some efforts being directed towards examining the influence of fertilisers on wheat production, there is no documented literature about the effects of biostimulants used at the different growth stages of wheat production. Therefore, this study was initiated to determine possible effects of some available biostimulants on the tillering and productivity of wheat plants under semi arid environment conditions.

Materials and methods

Two experiments were carried out to evaluate the productivity of wheat crops treated with commercial biostimulants (Vigro, Biomin, Humiplus and Humacare) (Table 1). Experiment I was to determine the effect of biostimulant type (Vigro, Biomin, Humiplus and Humacare) on wheat productivity while in experiment II the effect of Vigro was assessed for three successive seasons on a large scale; i.e. a half circle of the central pivot was used and the other half was used as control (water). Fields were selected at ASTRA and NADEC farms. The soil at the experimental site was classified as sandy and poor in organic carbon and nitrogen (Rabie *et al*., 1991). The mean annual precipitation varied between 50 mm to 100 mm. During each season, the N fertiliser urea (46% N) at the rate of 75 kg N/ha was applied four times during the growing season. Phosphorus fertiliser was applied in the form of triple super phosphate (46% P_2O_5) at the rate of 180 kg/ha applied during land preparation. The commercial wheat cultivar 'Yecora rojo' was sown between mid and late November each year. Weeds were mechanically controlled (disking) during the fallow period. The seeding rate was 180 kg/ha. Pesticides were applied as needed and central pivot irrigation was also provided as needed.

Table 1. Biostimulant application to wheat over 3 seasons (1999-2002)

Biostimulant	Composition	Rate (l/ha)	Application times
Vigro	Biologically derived plant growth promoters, amino acids and enzymes	1	2
Biomin	Micronutrients and amino acid glycine	2	2
Humiplus	Humic acids; include carboxyls, phenolic hydroxyls, ketons, and quinones	2	2
Humacare	Humic acids; include carboxyls, phenolic hydroxyls, ketons, and quinones	2	2

Experimental design, data collection and statistical analysis

The experiment was set up in a randomised complete block design with 4 replications. The plots with foliar biostimulant or water (control) were sprayed at a rate of 290 l/ha. The biostimulant treatments consisted of Vigro, Biomin, Humiplus and Humacare at 1-2 l/ha that are applied at two times: 12 and 26 days after planting. Treatments are shown in Table 1.

After 4 weeks of treatment, fifteen plants were examined from the border rows for number of tillers. At harvesting, four samples of main spikes were collected to evaluate the number of grains per spike. Each treatment consisted of the treated half circle and the non-treated control, which were harvested, separated and thrashed to measure the grain yield and the weight of 1000 seeds.

Data were analysed using SPSS packages. The results were subjected to an analysis of variance (ANOVA); a test for significant differences between means at $P < 0.05$ and $P < 0.01$ was performed using the Duncan method. Means are presented with their standard error (SE).

Results and discussion

The growth of wheat changed significantly ($P < 0.01$) depending on the type of biostimulant treatment (Table 2). Several parameters were improved over the control as a direct result of the biostimulant treatments, i.e., number of tillers, grain number per spike, grain size and yield (Table 2). Although all biostimulants improved the growth of wheat plants, this promoter effect was not significant ($P < 0.01$) except for Vigro treatments as shown in Table 2.

Table 2. The effect of foliar biostimulant treatment on wheat productivity during 2002-2003

Treatments	Number of tillers	Quantity of seeds in main ear	Weight of 1000 seeds (g)	Yield (kg/ha)
Control	2.73 ± 0.08b	34.25 ± 0.54b	40.85 ± 0.31b	6097.00 ± 32.40b
Vigro	3.33 ± 0.11a	38.58 ± 0.65a	44.37 ± 0.47a	6597.25 ± 40.92a
Biomin	2.90 ± 0.14b	34.85 ± 0.30b	41.50 ± 0.50b	6162.50 ± 62.50b
Humiplus	2.55 ± 0.13b	34.60 ± 0.70b	41.23 ± 0.74b	6120.00 ± 47.08b
Humacare	2.73 ± 0.16b	33.72 ± 0.28b	41.00 ± 0.58b	6160.00 ± 62.72b

^{a,b}Means with the same letters are not significantly different at $P < 0.05$.

The number of tillers significantly ($P < 0.01$) increased to (3.33 ± 0.11) after treatment with Vigro that resulted in greater total dry matter. The application of Vigro has increased root mass, thus the larger root system supports the uptake of water and nutrients. The effect of Vigro might be due to plant growth promoters or precursors that maintain the activity of endogenous phytohormones and improve plant growth during tillering. As reported by Jackson (1997), unfavourable environment leads to sharp changes in the balance of phytohormones; ABA accumulation, decline in IAA and cytokinins. Maintaining a high level of ABA in plants under stress promotes protective reactions, which decrease injurious effects on growth and accelerate growth resumption (Shakirova *et al.,* 2003).

The tested biostimulants showed significant ($P < 0.01$) effects on grain set as the quantity of seeds in the main ear was increased by Vigro treatments to (38.58 ± 0.65) over non-treated control (34.25 ± 0.54). This treatment might influence the partitioning of assimilates in such a way towards spikes. Previous studies showed that exogenous cytokinins enhance the transport of sucrose into young ears and increase grain set in wheat (Brokove and Prochazka, 1992).

Wheat plants treated with Vigro produced larger grain size (higher mass of 1000 seeds). The increase in wheat productivity was probably due to the increased rate of translocation of photosynthates from leaves to grains caused by Vigro treatment (Ray and Chouduri, 1981).

The productivity of wheat is significantly ($P < 0.01$) improved by Vigro and not affected by the growing season. The effect of the growing season was non-significant ($P < 0.01$) and no differences were detected between the Vigro effects for the three growing seasons (Fig. 1). This may be attributed to similar climatic conditions over this period.

Conclusions

The general conclusion from all tested biostimulants is that certain biostimulants can counteract the deleterious effects of environmental stress conditions. The treatments of wheat with biostimulants contribute to an increase in the tolerance of these plants to environmental stress conditions. Data showed that the biostimulant type affects plant growth and yield of wheat. Biostimulant treatments are safe to handle, easy to apply, and inexpensive. The most important advantage of Vigro versus other biostimulants is economically viable. Further biochemical and cytological studies are required to improve our understanding of the effects of biostimulants on wheat tillering.

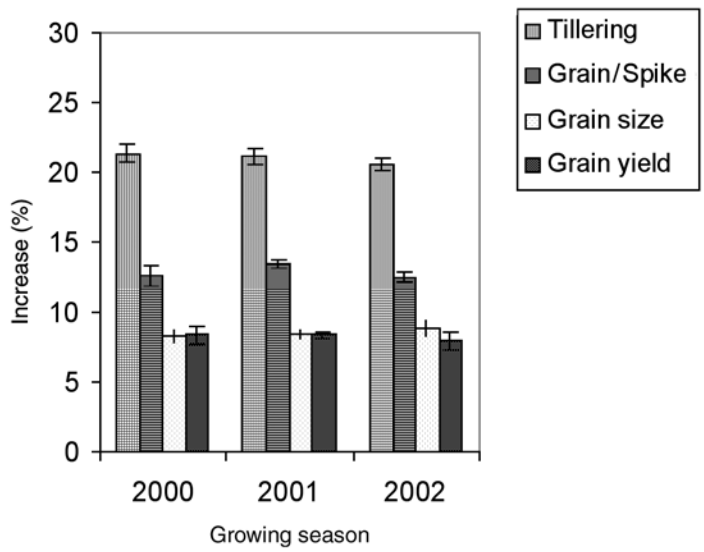

Fig. 1. Effects of Vigro treatment on wheat tillering, grain number per spike of main stem, grain size and grain yield. No significant differences at $P < 0.05$ between the growing seasons. Vertical bars represent SE. Results are the mean of three samples.

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