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FOLIAR APPLICATION OF GROWTH PROMOTING SUBSTANCES STRONGLY INFLUENCE THE PHENOLOGY, GROWTH AND YIELD OF HYBRID MAIZE

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ABSTRACT

Plant growth promoting substances (PGPS) are being widely used in crop production to increase productivity and to overcome harmful effects caused by environmental stresses. The experiment was planned to evaluate the influence of PGPS on the growth, phenology and yield of spring maize. The growth promoting substances like kinetin (30 ppm), humic acid (2%), *Moringa* leaves extract (2%), salicylic acid (2%), ascorbic acid (2%), and water spray were applied twice as foliar sprays at 6 leaves and 8 leaves stage. Results showed that foliar application of kinetin, humic acid, MLE, ascorbic acid and salicylic acid significantly improved the growth, phenology and yield attributes of maize as compared to control. Results showed that maximum improvement in days to tasseling, leaf area index, crop growth rate and number of leaves per plant, grains per cob, 1000-grain weight, biological yield, and grain yield were recorded with the application of 2% ascorbic acid, however, the use of PGPS had no significant effect on the days to silking. Further, a maximum plant height was recorded with the foliar feeding of 2% humic acid. Moreover the highest value of chlorophyll (a, b) and total phenolic contents were recorded with kinetin (30 ppm). So, all tested PGPS were variable in their effect, however, they improved the plant performance and may be applied to improve growth and yield of maize.

Keyword: Maize, Growth Promoting Substances, Growth, Yield.

INTRODUCTION

Maize is potential multiple proposes crop; it is being used as grain and fodder crop around the world. It is the third most important cereal crop after, rice and wheat and staple food of many nations (Frova *et al.,* 1999). The population is increasing at an alarming rate, thus there is dire need to improve the per unit yield of maize crop (Gao *et al.,* 2010). Despite of the introduction of high yielding cultivars, there is a wide gap between the actual and potential yield of maize crop. A-biotic stresses and unavailability of inputs are the major reasons for the lower productivity of maize crop (Lawlor, 2002).

There are various approaches being used to improve the productivity of maize crop, one of them is exogenous application of plant growth promoting substances (PGPS). Foliar application of PGPS significantly improved the growth, physiology, yield and yield attributes of various crops. Likewise, Farahat *et al*. (2007) found that foliar feeding of growth substances remarkably increased the photosynthetic pigments, sugar and protein contents. Additionally, application of PGPS also improved the source-sink relationships, thus maintains the optimum supply of assimilates from source to sink resulting in a profound increase in crop yield (Solaimalai *et al.,* 2001). Similarly, Anjum *at el.* (2013) also found that exogenously applied PGPS improved the growth and yield of many cereals and oil seed crops.

Moringa leaves are rich source of nutrients, proteins, vitamin C and growth hormone like cytokinins. Thus it can be a valuable input for agricultural crop production (Makkar and Becker, 1996). Humic substances are also being used in agricultural system. Likewise the application of humic substances considerably increased the photosynthetic pigments, (Chen and Aviad, 1990), in addition, they also improved the growth and productivity of various crops (Ulukan, 2008). Ascorbic acid and salicylic acid are also prime growth substances that are widely using in agriculture. Foliar feeding of ascorbic acid improved the growth and quality of lemon grass (Tarraf *et al.*, 1999); additionally it also improved the uptake of micronutrients like nitrogen, phosphorus and potassium (Talaat, 2003). Salicylic acid also regulates the nutrient uptake, stomatal closure and transpiration rate, while it also inhibits the ethylene synthesis (Khan *et al*., 2003). Moreover, the exogenous application of salicylic acid increased the synthesis of photosynthetic pigments (Moharekar *et al*., 2003) and yield of various wheat and maize crop at lower concentration (Khan *et al.*, 2003). Kinetin is also an important PGPS and it improved the growth and yield of wheat and maize crop at lower concentrations (Shehata *et al*., 2001). Therefore, this investigation was carried out to determine the influence of PGPS on the performance and productivity of hybrid maize.

MATERIALS AND METHODS

Site Description and Treatments

Field experiment was conducted at experimental farm of Institute of Agricultural Sciences, University of the Punjab, Lahore during spring season 2014. The experiment comprised of following treatments. T_1: Foliar spray of Kinetin (30 ppm), T_2: Foliar spray of Humic acid (2%), T_3: Foliar spray of Moringa leaves extract (2%), T_4: Foliar spray of Salicylic acid (2%), T_5: Foliar spray of Ascorbic acid (2%), T_6: Foliar spray of water (Control).

Soil Analysis

Composite soil samples were taken from the depth of 0-20 cm and various physical and chemical properties of soil were determined by using standard procedures Homer and Pratt (1961). The experimental soil was loamy containing sand, silt and clay (43.23%, 40.65% and 11.10%), pH (7.73), organic matter (0.75%), phosphorus (P) and potassium (K) 25 and 133 ppm and nitrogen (N) 0.034% respectively.

Crop Husbandry

Seedbed was prepared by ploughing soil three times followed by planking. Maize hybrid, FSH-810 was sown on 23rd February, 2014 by maintaining the plant to plant distance 15 cm and ridge to ridge distance 75 cm. Fertilizers were used at the rate of 250:100:100 kg ha^{-1} NPK. Full dose of P, K and 1/3 of N was used at the time of sowing, while the rest of N was applied with first irrigation. During whole crop season, five irrigations were applied. All other agronomic practices were kept normal and uniform.

Observation

Leaf area was measured by leaf area meter (CI-202, CID Bio-Science), whereas the leaf area index and crop growth rate was determined by the standard procedures of Watson (1952) and Hunt (1978). Twenty plants from each plot were chosen to determine the plant height, leaves per plant, cobs per plant, grains per cob and 1000 grain weight and later on averaged. The whole plots were harvested to determine the grain and biological yield. Similarly, chlorophyll a and b contents were measured by standard procedures of Arnon (1949), whereas the total phenolic contents were determined by standard procedure of Waterhouse (2002).

Experimental Design and Statistical Analyses

The study was made in randomized complete block design with three replications. The recorded data were analyzed by statistical software Statistix 8.1, while, the differences among the treatment means were compared by the least significant difference test at 5 % probability.

RESULTS

This study investigated the effect of different plant growth promoting substances applied as foliar sprays on the phenology, growth and yield spring maize. Maize phenology, growth and yield was significantly affected by foliar application of PGPS. Application of PGPS markedly improved the days to tasseling, however, PGPS failed to markedly improve the days to silking. Plants took more days for the tasseling and silking, where humic acid was applied, followed moringa leaf extract (MLE), however, a substantial reduction in days to taseeling and silking was recorded under control treatments (Table 1). The application of PGPS substances registered significantly higher values of all the growth attributes over control. Leaf area index (LAI), crop growth rate (CGR) and number of leaves were recorded highest by the foliar feeding of 2% ascorbic acid (Table 1). Further, a substantial reduction was recorded in LAI, CGR and number of leaves where MLE and water spray was applied. Moreover, the tallest plants were recorded with the foliar spray of 2% humic acid, while substantial reduction was recorded in plant height under control conditions (Table 1).

Table 1. Effects of treatments on days to tasseling, days to silking, leaf index, growth rate, number of leaves and the plant height.

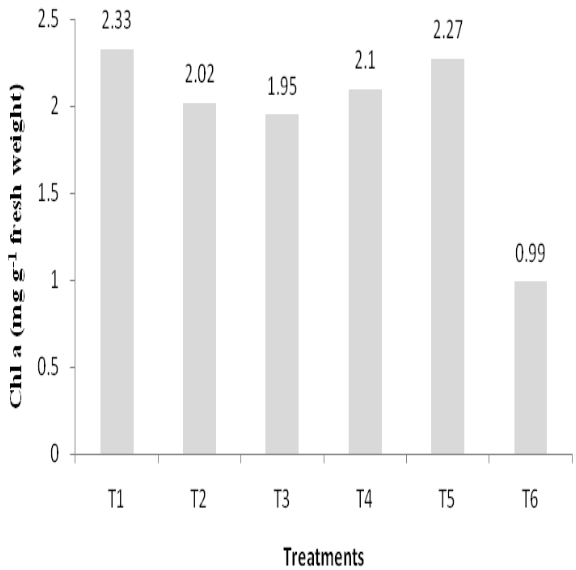
Treatments	Days to tasseling	Days to Silking	Max. Leaf area index	Max. Crop Growth Rate ($g\ m^{-2}\ d^{-1}$)	No. of leaves per plant	Plant height (cm)
Kinetin (30ppm)	45 bc	53	6.18 bc	16.07 c	15 a	203 b
Humic Acid (2%)	48 ab	55	6.36 b	16.90 b	12 c	214 a
MLE (2%)	47 abc	54	6.06 c	15.37 c	12 c	190 c
Salicylic Acid (2%)	46 bc	52	5.50 d	13.93 d	13 bc	200 b
Ascorbic Acid (2%)	50 a	51	6.76 a	18.77 a	16 ab	205 b
Control	44 c	50	5.07 e	12.30 e	11 c	182 d
LSD($p \leq 0.05$)	3.38	NS	0.29	0.77	2.15	5.25

Foliar applications of PGPS considerably improved the No. of grain rows per cob, No. of grain rows per cob, 1000-grain weight, biological yield and grain yield (Table 2), however foliar application of PGPS had no significant effect on the cobs per plant (Table 2). Maximum grain rows per cob (17.33) were recorded with foliar application of kinetin, which was statistically at par 2% ascorbic acid with 16 rows per cob. Results revealed that foliar application of 2% ascorbic acid remained more effective than the other PGPS resulted in more number of grains (18.75%), 1000 grain weight (19.18%), biological yield (20.91) and grain yield (30.70) as compare to the application of humic acid, kinetin, MLE, ascorbic acid and control (Table 2). Further, a substantial reduction was recorded in yield and yield related attributes under control treatment (Table 2).

Table 2. Effects of PGPS treatments on yield parameters of maize.

Treatments	Cobs per plant	No. of grain rows per cob	Grains per cob	1000-grain weight (g)	Biological yield (t/ha)	Grain yield (t/ha)
Kinetin (30ppm)	1.8	17.33 a	620 a	225.53 c	21.19 d	6.48 c
Humic Acid (2%)	1.5	15 bc	580 b	240.70 b	22.66 b	7.12 b
MLE (2%)	1.3	14.67 bc	570 b	219.00 d	21.87 c	6.65 c
Salicylic Acid (2%)	1.6	14.33 c	585 b	212.00 e	20.15 e	5.86 d
Ascorbic Acid (2%)	1.9	16 ab	640 a	248.83 a	23.62 a	7.65 a
Control	1.5	14.33 c	520 c	206.10 f	18.68 f	5.30 e
LSD($p \leq 0.05$)	NS	1.54	23.04	4.48	0.46	0.38

Foliar applications of plant growth promoting substances significantly enhanced the leaf chlorophyll and phenolic content of maize crop. Highest values for chlorophyll a contents (2.33 mg g^{-1}) were recorded with foliar application of 30 ppm kinetin, followed by 2% ascorbic acid (2.27 mg g^{-1}), 2% salicylic acid (2.1 mg g^{-1}), humic acid (2.02 mg g^{-1}) and 2% MLE (1.95 mg g^{-1}), respectively. However, minimum chlorophyll a content (0.99 mg g^{-1}) was found in plants treated with foliar application of water (Fig. 1a). As for the chlorophyll b contents maximum value were seen with foliar application of 30 ppm kinetin (2.17 mg g^{-1}) followed by 2% ascorbic acid (2.1 mg g^{-1}), while the minimum value of chlorophyll b (0.8 chlorophyll b) contents was recorded in control treatment (Fig. 1b). Exogenous application of PGPS also improved the phenolic contents. Maximum value of phenolic contents (0.06 mg GAE/L) were recorded in 2% ascorbic acid, which was statistically at par with 30 ppm kinetin (0.05 mg GAE/L), however, the minimum value of phenolic contents (0.03 mg GAE/L) were recorded in control. Overall, results revealed that foliar applied PGPS improved total phenolic contents in maize (Fig.2).



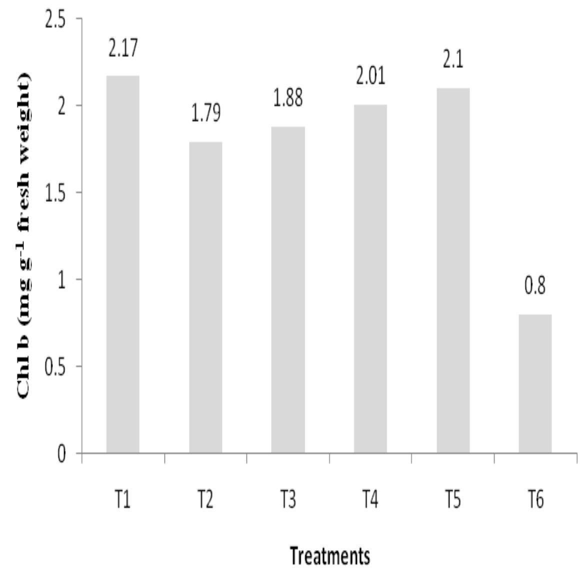


Fig.1(a). Effect of PGPS on chlorophyll a contents of maize.

Fig.1(b). Effect of PGPS on chlorophyll a contents of maize.

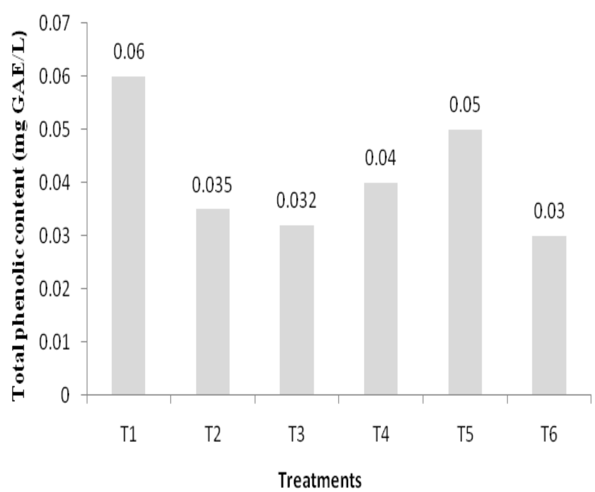


Fig. 2. Effects of PGPS on total phenolic contents of maize.

DISCUSSION

This study investigated the potential of different PGPS on the growth, phenology and yield of maize hybrid. The foliar feeding of PGPS substantially improved the phenology and growth related attributes. The increase in growth related attributes LAI, CGR, leaves per plant and plant could be explained by the fact that exogenous application of PGPS helps plant in turgor maintenance, and promotes antioxidative enzymatic activity and carbohydrate metabolism (Farooq *et al.*, 2008). These results are corroborated with the previous literature (Fuglie, 2000; Hamada and Al-Hakimi, 2001), they stated that application of MLE, ascorbic acid and other PGPS improved the growth attributes of various plant species. Further, Bakhsh *et al.* (2011) also reported the significant effects of PGPS on the growth, yield and yield components of rice.

The application of PGPS substantially improved the yield and yield related attributes. However, the application of 2% ascorbic was seen as excellent strategy to improve the yield and yield related attributes as compare to the other treatments. The increase in yield and yield related attributes could be due to many reasons. As the application of PGPS like, fulvic acid, brassinolides and humic acid not only improved the growth and yield and also favors other physiological and biochemical attributes in maize and soybean (Anjum *et al.,* 2011). Moreover the application of PGPS regulates the photosynthesis, gas exchange attributes and enzymatic activities to alleviate oxidative damage (Anjum *et al.,* 2011). In addition, the use of PGPS improved the seedling growth and seed vigor (Basra *et al.*, 2011). Moreover, (Solaimalai *et al.,* 2001) reported that the exogenously applied PGPS improves crops performance by establishing a strong source sink relationship (Solaimalai *et al.,* 2001).

In this study the foliar feeding of PGPS greatly influenced the chlorophyll a and b. This confirms the progressive effect of PGPS on the photosynthetic pigments of maize. Similar results were reported by (Fathy *et al.*, 2003) they found a marked improvement in photo synthetic pigments with the application of ascorbic acid and other antioxidants. The increase in chlorophyll contents by PGPS could also attributed to their scavenging effect which provides the protection to chlorophyll and chloroplast against degradation caused by reactive oxygen species.

These findings are in accordance with previous findings of various researchers. Likewise, Rhoads and McIntosh, (1991) found that foliar feeding of salicylic acid remarkable enhanced the chlorophyll and anthocyanin contents in Spirodela plants, similarly, Ferrara *et al.* (2007) found that the use of humic acid enhanced the chlorophyll contents, whereas Das *et al.* (2002) also reported that foliage feeding of kinetin also increased the chlorophyll contents in mulberry plants. Similarly, the foliar application of PGPS also increased the total phenlic contents. These results are in line with previous results of Amin *et al.* (2008) who also found that the foliar application of PGPS increased the photosynthetic pigments and total phenolic contents.

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