

TITLE

IMPACT OF DIFFERENT SEED PRIMING METHODS WITH BIO FRETILIZERS AND BOTANICALS ON GROWTH, YIELD AND YIELD ATTRIBUTING TRAITS OF SWEET CORN (*Zea mays* L.)

Variety (SUGAR-75)

ARTICLE TITLE: *Original Research Article*

Impact of different seed priming methods with biofertilizers and botanicals on growth, yield and yield attributing traits of Sweet corn (*Zea mays* L.)

ABSTRACT

A field experiment was conducted during Rabi season of 2021-2022 at Field Experimentation Center of Department of Genetics and Plant Breeding, SHUATS, Prayagraj, U.P. The experiment was laid out in Randomized Block Design, with a view to find out the suitable Seed priming methods with bio fertilizers and botanicals on growth, yield and yield attributing traits of Sweet corn (*Zea mays* L.). For this purpose, 13 priming methods including control were used to study under field conditions. The results indicated that Field emergence percentage at 4,7, and 10 DAS, Plant height at 30, 45, 60 and at harvest DAS, Days to 50% Tasselling, Days to 50% Silking, Days to Maturity, Cob length (cm), Cob girth (cm), Number of cobs per plant, Number of rows per cob, Number of grains per row, Seed index (g), Seed yield per plant (g), Seed yield per plot (t/ha), Stover yield (t/h), Biological yield (t/ha) and harvest index (%), were significantly recorded highest in Azospirillum at 30g (12 hours) followed by Azospirillum at 20g (12 hours) when compared to other treatments. It is suggested that seed priming with Azospirillum @ 30g (12 hours) is used for improving growth, yield and yield attributing traits of sweet corn could be recommended.

Keywords: Sweet corn, Seed priming, Azospirillum, Moringa leaf extract, yield attributes.

1. INTRODUCTION

Maize (*Zea mays* L.) is a C4 plant belonging to family Poaceae, Chromosome No. (2n=20) and it is having high yielding potential. This crop is called as miracle crop and queen of cereals due to its high productivity (Ikramulla *et al.*, 2011). It is third most important cereal crop after rice and wheat and is being grown throughout the year but mainly as Kharif crop. In India maize is grown in 9.86 M ha area with a production and productivity of 31.51 million tones and 3,195 kg/h respectively contributing 2.53% share over world's production (Directorate of Economics and Statistics 2021).

Since, maize is an industrial important crop, the demand for maize seed is more. On realizing the importance of maize in seed industry, the private seed companies are now concentrating more on maize hybrid development and because of continuous research many hybrids were also developed. Among various specialty corns, Sweet corn (*Zea mays* L.) is a mutant type with one or more recessive alleles in homozygous condition, which enables the endosperm to accumulate twice the sugar content as that of corn and controls the conversion of sugar into starch inside the endosperm of kernel. Its consumption at immature stage as roasted and boiled ears is a popular practice as the kernels are sweet (content 12–20% sugar), creamy, tender and crispy. After harvesting green cobs, the plants of sweet corn are used as green fresh or dry fodder. This specialty corn with its high market value is gaining popularity and now a day's its cultivation is the first choice of the farmers (Suthar *et al.*, 2014). Sweet corn can be grown all-round the year under irrigated condition, enabling it to fit in intensive cropping systems.

For existence of any variety or hybrid, timely supply of quality seed is foremost requirement. Good quality seed is the key for successful agriculture to produce a vigorous seedling ensuring higher yield (Kishore Varma *et al.*, 2017). In this context, agricultural practices are shifting towards a more sustainable approach of using transgenic plants, plant growth-promoting bacteria, nano formulations, bio fertilizer, and bio control agents for enhancing crop productivity (Berg *et al.*, 2010; Adesemoye and Egamberdieva 2013; Mishra *et al.*, 2014).

Seed priming technique is used for improving the vigor, establishment, and efficiency of seedlings in the fields. The early stage of seed germination requires suitable conditions; however, various biotic and abiotic factors hinder the process of germination. Seed biopriming using beneficial and eco-friendly biological agents could lead to improved physiology of seeds resulting into enhanced vigor of the seedlings (Ghassemi-Golezani

2008). Nitragin (Azotobacter, Azospirillum, Pseudomonas) inoculation seeds have 44% higher Leaf area index and 61% higher leaf chlorophyll index and 24% increase in ear dry weight (Kouchebagh *et al.*, 2012). *Moringa oleifera* has attained enormous attention because it is considered to be rich in a variety of natural plant growth regulators such as Zeatin which belongs to class of cytokinins and thus can be used as a source of cytokinins. It is also enriched with various macro-nutrients such as phosphorous and potassium along with micro-nutrients (Yasmeen, 2011). (Eman, 2013) suggested that *Lantana camara* aqueous extract could be used as a potential allelopathic substance for some weed bio-control.

2. MATERIALS AND METHODS

The experimental study was carried during Rabi Season 2021-2022 at Field Experimentation Centre of Department of Genetics and Plant Breeding, Naini Agricultural Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, U.P. The site is located at latitude 25.35 N longitude 82.25 E at an altitude of 78m above mean sea level. The soil is sandy loam in texture with moderate water holding capacity having PH between 7.0 to 8.0. The experiment was laid out in Randomized Block Design with 13 treatments replicated thrice. With the view to find out suitable seed priming methods with bio fertilizers and botanicals on Sweet corn (SUGAR-75) The experiment comprising 13 possible treatments viz., T₀- control, T₁-Azotobacter @ 10g for 12 hours, T₂- Azotobacter @ 20g for 12 hours, T₃- Azotobacter @ 30g for 12 hours, T₄- Azospirillum @ 10g for 12 hours, T₅- Azospirillum @ 20g for 12 hours, T₆- Azospirillum @ 30g for 12 hours, T₇- Moringa leaf extract @ 5% for 12 hours, T₈- Moringa leaf extract @ 10% for 12 hours, T₉- Moringa leaf extract @ 15% for 12 hours, T₁₀- Lantana leaf extract @ 5% for 12 hours, T₁₁- Lantana leaf extract @ 10% for 12 hours, T₁₂- Lantana leaf extract @ 15% for 12 hours. The above said treatments are prepared by using following methods:

Seed Priming with the Azotobacter and Azospirillum was carried out by using 10% sugar solution carrier. The sugar solution was prepared by adding 100 g sugar in 1 litre of water and boiled. Then After cooling the solution, maize seeds were put in the solution pot and taken out and the inoculants 10grams, 20grams, 30grams were thoroughly mixed with the maize seeds. These seeds were kept in shade before planting.

For the Preparation of Moringa leaf extract and lantana leaf extract the tender leaves of the

respective plants were collected separately and dried beneath the shade the dried leaves were ground with electric mixer grinder or mortar and pestle. The extract was subjected to sieving repeatedly through muslin cloth and then exactly 50 grams and 100 grams and 150 grams leaf powder was taken using weighing balance and diluted with 100ml of pure water to prepare the required 5%,10%,15% leaf extract solutions for seed priming (Gurjar *et al.*,2012)

The non primed seeds were formed the control.

3. RESULTS AND DISCUSSIONS

The results in Table 1, 2, 3 depicts that the mean performance of Different seed priming methods with biofertilizers and botanicals on growth, yield and yield attributing traits of Sweet corn (*Zea mays L.*) .

3.1 Field emergence percentage (4, 7, 10 DAS):

The maximum field emergence at 4 DAS was recorded in T6 – Azospirillum (30g) (42.22) followed by T5 – Azospirillum (20g) (41.11) whereas minimum field emergence at 4 DAS was recorded in Lantana leaf extract @ 15% (30)

The maximum field emergence percentage at 7 DAS was recorded in T6 – Azospirillum (30g) (68.88) followed by T5 – Azospirillum (20g) (67.77) whereas minimum field emergence at 7 DAS was recorded in Lantana leaf extract @ 15% (55.33).

The maximum field emergence percentage at 10 DAS was recorded in T6 – Azospirillum (30g) (92.22) followed by T5 – Azospirillum (20g) (91.11) whereas minimum field emergence at 10 DAS was recorded in Lantana leaf extract @ 15% (75.55)

Similar findings reported that 22.44% increase of maize sprouting was observed after a co-inoculation with *Pseudomonas fluorescens* and *P. putida* and a 20.39% increase after *Azospirillum* spp. Inoculation. (Novumo *et al.*, 2013).

3.2 Plant height at 30, 45, 60& at harvest DAS:

The maximum plant height at 30 DAS was recorded in T6 – Azospirillum (30g) (38.93) followed by T5 – Azospirillum (20g) (37.77) whereas minimum plant height at 30 DAS was recorded in Lantana leaf extract @ 15% (31).

The maximum plant height at 45 DAS was recorded in T6 – Azospirillum (30g) (108.67) followed by T5 – Azospirillum (20g) (106.93) whereas minimum plant height at 45 DAS was recorded in Lantana leaf extract @ 15% (74.63).

The maximum plant height at 60 DAS was recorded in T6 – Azospirillum (30g) (180.3) followed by T5 – Azospirillum (20g) (177.5) whereas minimum plant height at 60 DAS was recorded in Lantana leaf extract @ 15% (131.73).

The maximum plant height at harvest was recorded in T6 – Azospirillum (30g) (227.3) followed by T5 – Azospirillum (20g) (215.56) whereas minimum plant height at harvest was recorded in Lantana leaf extract @ 15% (165.83).

Similar findings by **Suthinraj *et al.* (2017)** evidently proved that the seed inoculation of Azospirillum and application of recommended dose of fertilizers along with foliar spray of panchagavya @ 3% at 30, 45 and 60 DAS (T11) will be an appropriate integrated nutrient management on the growth and yield of hybrid maize with due care on soil fertility

3.3 Days to 50% Tasselling:

The early days to 50% tasselling was recorded in T6 – Azospirillum (30g) (53.33) followed by T5 – Azospirillum (20g) (54) whereas late days to 50% tasselling was recorded in Lantana leaf extract @ 15% (53.33).

3.4 Days to 50% silking:

The early days to 50% silking was recorded in T6 – Azospirillum (30g) (60.67) followed by T5 – Azospirillum (20g) (62) whereas late days to 50% silking was recorded in Lantana leaf extract @ 15% (67.33).

3.5 Days to Maturity:

The early days to maturity was recorded in T6 – Azospirillum (30g) (81) Followed by T5 – Azospirillum (20g) (82.67) whereas late days to maturity was recorded in Lantana leaf extract @ 15% (87)

3.6 Cob length:

The maximum Cob length was recorded in T6 – Azospirillum (30g) (21.73) followed by T5 – Azospirillum (20g) (21.16) whereas minimum Cob length was recorded in Lantana leaf extract @ 15% (12.33)

3.7 Cob girth:

The maximum Cob girth was recorded in T6 – Azospirillum (30g) (17.46) followed by T5 – Azospirillum (20g) (16.33) whereas minimum Cob girth was recorded in Lantana leaf extract @ 15% (10.3).

3.8 Number of cobs per plant:

The maximum Number of Cobs per plant was recorded in T6 – Azospirillum (30g) (2.13) followed by T5 – Azospirillum (20g) (2.06) whereas minimum Number of cobs per plant was recorded in Lantana leaf extract @ 15% (1.06).

Similar findings by **Kharutso *et al.* (2016)** reported that the plant height, number of green leaves plant⁻¹, stem thickness (cm), and leaf area index were recorded highest with application of FYM @10t ha⁻¹ followed by FYM @ 10 t ha⁻¹ + Azospirillum @ 20 g kg⁻¹ seed. FYM @ 10 t ha⁻¹ has also produced highest yield attributing characters like cobs weight (120.51g), number of grain rows (34.84), length of cob (15.29 cm), grain weight (81.66 g), grain yield(1.82 t ha⁻¹) straw yield(3.01) of maize.

3.9 Number of rows per cob:

The maximum Number of rows per cob was recorded in T6 – Azospirillum (30g) (18) followed by T5 – Azospirillum (20g) (17.66) whereas minimum Number of rows per cob was recorded in Lantana leaf extract @ 15% (13.33).

3.10 Number of grains per row:

The maximum Number of grains per row was recorded in T6 – Azospirillum (30g) (37.33) followed by T5 – Azospirillum (20g) (35.8) whereas minimum Number of grains per row was recorded in Lantana leaf extract @ 15% (31.86).

Similar findings reported that, the inoculation with Azospirillum increased the yield, number of grains in a cob row, ear length and number of grains per ear. They concluded that inoculation of maize seeds by Azospirillum could reduce the application of nitrogen fertilizer, increase the grain yield up to 30 percent and prevent pollution of environment by extended sustainable agriculture. (**Davaran *et al.*, 2010**).

3.11 Seed index:

The maximum Seed Index was recorded in T6 – Azospirillum (30g) (25.8) followed by T5 – Azospirillum (20g) (25.7) whereas minimum seed index was recorded in Lantana leaf extract @ 15% (18.73).

3.12 Seed yield per plant:

The maximum Seed yield per plant was recorded in T6 – Azospirillum (30g) (220.03) followed by T5 – Azospirillum (20g) (214.63) whereas minimum Seed yield per plant was recorded in Lantana leaf extract @ 15% (97.03)

3.13 Seed yield per plot:

The maximum Seed yield per plot was recorded in T6 – Azospirillum (30g) (6.6) followed by T5 – Azospirillum (20g) (5.63) whereas minimum Seed yield per plot was recorded in Lantana leaf extract @ 15% (1.73).

Similar findings by **Fernando *et al.* (2019)** observed that inoculation with *A. brasilense* increased LCI, stem diameter, ear length, and nitrogen use efficiency (NUE), with a positive effect on grain yield. The increase in N rate up to 200 kg ha⁻¹ with *A. brasilense* inoculation increased grain yield, independently of the N source. The application of 100 kg ha⁻¹ of N as urea, with inoculation of *A. brasilense* produced the highest profit in maize production.

3.14 Stover yield:

The maximum Stover yield per plot was recorded in T6 – Azospirillum (30g) (9.7) followed by T5 – Azospirillum (20g) (8.86) whereas minimum Stover yield was recorded in Lantana leaf extract @ 15% (4.36)

3.15 Biological yield:

The maximum Biological yield per plot was recorded in T6 – Azospirillum (30g) (16.3) followed by T5 – Azospirillum (20g) (14.5) whereas minimum Biological yield was recorded in Lantana leaf extract @ 15% (6.1)

Similar findings by **Veresoglou *et al.* (2010)** concluded that meta-analysis of 91 field and 175 pot studies conducted between 1981 and 2008 on the inoculation of cereal seeds with Azospirillum isolates has for example concluded to an average 10-15% increase in grain and forage yields respectively.

3.16 Harvest index:

The maximum Harvest index was recorded in T6 – Azospirillum (30g) (40.49) followed by T5 – Azospirillum (20g) (38.84) whereas minimum Harvest index was recorded in Lantana leaf extract @ 15% (28.38)

Table 2: Mean performance of different seed priming methods for pre harvest characters in Sweet corn (*Zea mays* .L)

| Symbols | Treatments | Cob Length (cm) | Cob girth (cm) | Number of Cobs / plant | Number of Rows / cob | Number of Grains / row | Seed index (g) |
|-----------------|----------------------|------------------------|-----------------------|-------------------------------|-----------------------------|-------------------------------|-----------------------|
| T ₀ | Control | 13.3 | 11.53 | 1.26 | 14 | 32.6 | 20.56 |
| T ₁ | Azotobacter | 16.8 | 14.56 | 1.73 | 16.33 | 34.13 | 23.13 |
| T ₂ | Azotobacter | 17.46 | 14.8 | 1.8 | 16.66 | 34.53 | 24.03 |
| T ₃ | Azotobacter | 18.73 | 15.16 | 1.93 | 17 | 35.13 | 24.33 |
| T ₄ | Azospirillum | 19.66 | 15.3 | 2.06 | 17.33 | 35.46 | 24.86 |
| T ₅ | Azospirillum | 21.16 | 16.33 | 2.06 | 17.66 | 36.13 | 25.7 |
| T ₆ | Azospirillum | 21.73 | 17.46 | 2.13 | 18 | 37.33 | 25.8 |
| T ₇ | Moringa leaf extract | 15.26 | 14.53 | 1.46 | 15.67 | 33.26 | 23.03 |
| T ₈ | Moringa leaf extract | 16.8 | 14.66 | 1.53 | 16 | 33.8 | 23.63 |
| T ₉ | Moringa leaf extract | 16.76 | 14.63 | 1.66 | 16.67 | 33.86 | 23.86 |
| T ₁₀ | Lantana leaf extract | 13.03 | 11.63 | 1.2 | 14.33 | 32.73 | 19.73 |
| T ₁₁ | Lantana leaf extract | 12.9 | 11.13 | 1.13 | 13.66 | 32.46 | 19.06 |
| T ₁₂ | Lantana leaf extract | 12.33 | 10.3 | 1.06 | 13.33 | 31.86 | 18.73 |
| | Minimum | 12.33 | 10.3 | 1.06 | 13.33 | 31.86 | 18.73 |
| | Maximum | 21.73 | 17.46 | 2.13 | 18 | 37.33 | 25.8 |
| | Mean | 16.61 | 14 | 1.62 | 15.89 | 34.1 | 22.8 |
| | C.V. | 6.22 | 4.93 | 11.62 | 3.92 | 2.5 | 3.87 |
| | S.E.m | 0.59 | 0.39 | 0.108 | 0.36 | 0.49 | 0.51 |
| | C.D. 5% | 1.74 | 1.16 | 0.31 | 1.05 | 1.44 | 1.49 |
| | F- Test | S | S | S | S | S | S |

Table 3: Mean performance of different seed priming methods for post harvest characters in Sweet corn (*Zea mays* .L)

| Symbols | Treatments | Seed yield / plant (g) | Seed yield / plot (t/ha) | Stover yield (t/ha) | Biological yield (t/ha) | Harvest index (%) |
|-----------------|----------------------|-------------------------------|---------------------------------|----------------------------|--------------------------------|--------------------------|
| T ₀ | Control | 152.7 | 2.56 | 5.7 | 8.26 | 30.96 |
| T ₁ | Azotobacter | 189.46 | 4.83 | 8.33 | 13.13 | 36.77 |
| T ₂ | Azotobacter | 197.86 | 5.16 | 8.56 | 13.73 | 37.6 |
| T ₃ | Azotobacter | 205.2 | 5.3 | 8.7 | 14 | 37.69 |
| T ₄ | Azospirillum | 209.63 | 5.3 | 8.7 | 14 | 37.86 |
| T ₅ | Azospirillum | 214.63 | 5.63 | 8.86 | 14.5 | 38.84 |
| T ₆ | Azospirillum | 220.03 | 6.6 | 9.7 | 16.3 | 40.49 |
| T ₇ | Moringa leaf extract | 165.8 | 3.73 | 7.73 | 11.46 | 32.59 |
| T ₈ | Moringa leaf extract | 169.2 | 3.96 | 7.9 | 11.86 | 33.45 |
| T ₉ | Moringa leaf extract | 181.53 | 4.63 | 8.16 | 12.8 | 36.2 |
| T ₁₀ | Lantana leaf extract | 133.96 | 2.26 | 5.5 | 7.76 | 29.19 |
| T ₁₁ | Lantana leaf extract | 116.63 | 1.76 | 4.36 | 6.13 | 28.76 |
| T ₁₂ | Lantana leaf extract | 97.03 | 1.73 | 4.36 | 6.1 | 28.38 |
| | Minimum | 97.03 | 1.73 | 4.36 | 6.1 | 28.38 |
| | Maximum | 220.03 | 6.6 | 9.7 | 16.3 | 40.49 |
| | Mean | 173.36 | 4.11 | 7.43 | 11.54 | 34.52 |
| | C.V. | 3.9 | 9.85 | 8.56 | 8.54 | 4.08 |
| | S.E.m | 3.91 | 0.23 | 0.36 | 0.56 | 0.81 |
| | C.D. 5% | 11.41 | 0.68 | 1.07 | 1.66 | 2.37 |
| | F-Test | S | S | S | S | S |

4. CONCLUSION

On the basis of one season experimentation it is concluded that among all the seed priming methods, seed priming with T₆-Azospirillum @ 30g for 12 hours **has shown significantly better performance** followed by T₅-Azospirillum @ 20g for 12 hours in all the growth, yield and yield attributing traits. Therefore further investigation is needed to arrive at valid recommendations.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

- 1. Adesemoye A.O., Egamberdieva, D. (2013).** Beneficial effects of plant growth promoting rhizobacteria on improved crop production: the prospects for developing economies. In: Maheshwari DK (ed) *Bacteria in agrobiolgy: crop productivity. Springer, Berlin/Heidelberg*
- 2. Berg, G., Egamberdieva, D., Lugtenberg, B., Hagemann, M. (2010).** Symbiotic plant-microbe interactions: stress protection, plant growth promotion and biocontrol by *Stenotrophomonas*. In: Seckbach JMG, Grube M (eds) *Symbiosis and stress. Springer, Dordrecht/Heidelberg/ London/New York*, pp 445–460.
- 3. Davaran Hagh, E., Rahimzadeh Khoii, F., Valizadeh, M., Khorshidi, M., (2010).** The role of *Azospirillum lipoferum* bacteria in sustainable production of maize. *Journal of Food, Agriculture & Environment*, Vol.8 (3&4), July-October 2010.
- 4. Eman, T., El-Kenany., Salama, M. El-Darier.(2013).** Suppression effects of *Lantana camara* L. aqueous extracts on germination efficiency of *Phalaris minor* Retz. and *Sorghum bicolor* L. (Moench), *Journal of Taibah University for Science*, 7:2, 64-71
- 5. Fernando, S. Galindo., Marcelo, C. M., Teixeira Filho., Salatiér Buzetti., Paulo, H. Pagliari., José, M.K. Santini., Cleiton, J. Alves., Marcio, M. Megda., Thiago, A. R. Nogueira., Marcelo, Andreotti, and Orivaldo Arf. (2019).** Maize Yield Response to Nitrogen Rates and Sources Associated with *Azospirillum brasilense*. *Agronomy Journal*, Volume 111, Issue 4
- 6. Ghassemi-Golezani, K., Sheikhzadeh-Mosaddeg, P., Valizadeh, M. (2008).** Effect of hydropriming duration and limited irrigation on field performance of chickpea. *Res J Seed Sci* 1(1):34–40.
- 7. Gurjar, M.S., Ali.,S., Akhtar, M. and Singh, K.S. (2012)** Efficacy of plant extracts in plant disease management. *J. Agric. Sci.*, 3: 425-433
- 8. Ikramullah., Iftikhar. H. K., Muhammad. N and Mohammad, K. N. S. (2011).** Heterotic effects on yield and protein content in white quality protein maize. *Sarhad Journal Agriculture* 27 (3): 52-56.
- 9. Kouchebagh, S. B., Mirshekari, B., & Farahvash, F. (2012).** Improvement of corn yield by seed biofertilization and urea application. *World Applied Sciences Journal*. 16(9),

10. **Kharusto, A., Singh, A. P., Longkumer, L. T., Singh, P. L. and Singh, P. K. (2016).**Effect of organic manures and azospirillum on productivity and economics of maize (*Zea mays* L.)*Asian J. Soil Sci.* **11**(1):213-216.
11. **Kishore Varma, P., Yamuna C., Suresh V., Ravi Teja, M. and Vijay Krishna Kumar, K.(2017).** Potentiality of native *Bacillus* species in enhancing sesame seed germination and their antagonism against *Macrophomina phaseolina* under in vitro conditions. *Journal of Oilseeds Research*, **34**(2): 98-102.
12. **Noumavo, P.A., Kochoni, E., Didagbé, Y.O., Adjanohoun, A., Allagbé, M., Sikirou, R., Gachomo, E.W., Kotchoni, S.O., Baba-Moussa, L., (2013).**Effect of different plant growth promoting rhizobacteria on maize seed germination and seedling development. *Am. J. Plant Sci.* **4**, 1013–1021.
13. **Suthar, M., Singh, D., Nepalia, V. and Singh, A. K. (2014).** Performance of sweet corn (*Zea mays*) varieties under varying fertility levels. *Indian Journal of Agronomy*, **59**(1): 168-170.
14. **Suthin Raj T., Sudhagar Rao G.B., Rex Immanuel R., and K. R. Pushpanathan.(2017).** Effect of Panchagavya and combination of Biofertilizer and RDF on Hybrid maize (*Zea mays* L.) *Journal of Emerging Technologies and Innovative Research. (JETIR)* October 2017, **Volume 4**, Issue 10.
15. **Veresoglou, S.D., Menexes, G., (2010).** Impact of inoculation with *Azospirillum* spp. on growth properties and seed yield of wheat: a meta-analysis of studies in the ISI Web of 20 Science from 1981 to 2008. *Plant Soil* **337**, 469–480.
16. **Yasmeen A (2011).** Exploring the potential of *Moringa (Moringa oleifera)* leaf extract as natural plant growth enhancer. M Sc (Hons.) Agriculture, Department of Agronomy Faculty of Agriculture, University of Agriculture, Faisalabad, Pakistan.