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Foliar application of nutrients and plant growth regulators on growth and yield of finger millet

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Abstract
A field experiment was conducted to study the effect of foliar spray of nutrients and plant growth regulators on growth and yield of finger millet. The growth attributing characters like plant height, dry matter production and number of tillers m^{-2} increased significantly due to application of foliar spray of salicylic acid 40 ppm twice at pre and post flowering stage of crop growth over the other treatments. Yield contributing characters *viz.*, number of ear heads $hill^{-1}$, productive tillers m^{-2}, ear head weight, grain yield (3593 kg ha^{-1}) and straw yield (8735 kg ha^{-1}) was significantly increased due to application of foliar spray of salicylic acid 40 ppm twice at pre and post flowering stage of crop growth compare to other treatments.

Keywords: Foliar spray, growth attributes, salicylic acid, yield

Introduction
Finger millet is nutritionally comparable and even superior to other cereals especially with respect to protective nutrient. It has eight to ten times more calcium (344 mg /100 g) than wheat and rice and contain a good amount of iron, phosphorous, thiamine and other nutrient, besides high calorific value, the slowly digestible carbohydrates make it a food for long sustenance. Hence, finger millet could play an important role to alleviate malnutrition and to enhance nutritional security that has turned fragile due to excessive dependence on few major food crops (Rashmi and Seetharam, 2004) [15]. The lower productivity of finger millet could be attributed to several factors such as its cultivation in marginal and poor soils, inadequate irrigation and poor management practices. Among these factors, one of the important reasons for poor yield of finger millet is its fertilization aspect. Foliar spray of nutrients and plant growth regulators are fastest way to boost up crop growth because the nutrients are available to plants at the initial stages and critical stages. Foliar application of nutrients and growth regulators has been suggested for increasing the fertilizer use efficiency. It provides more rapid utilization of nutrients and permits the correction of observed deficiencies in less time than that would be required by soil treatments. Growth regulators can improve the physiological efficiency including photosynthetic ability and can enhance effective partitioning of accumulates from source and sink in the field crops (Solaimalai *et al*., 2001) [16]. Salicylic acid is one such plant growth regulator, which participates in the regulation of a number of physiological events taking place in the plant (Ashraf *et al.,* 2010) [3]. Hence, the present investigation was carried out with the foliar spray of nutrients and plant growth regulators on the growth and yield of finger millet.

Materials and Methods
Field experiment was conducted during *rabi* 2013-14 in Eastern block, Department of Farm Management, Tamil Nadu Agricultural University, Coimbatore to find out the effect of foliar spray of nutrients and plant growth regulators on growth and yield of irrigated finger millet (*Eleusine coracana* (L.) Gaertn). The soil of the experimental field was sandy clay loam in texture, low in available nitrogen (219.3 kg ha^{-1}), medium in available phosphorus (15.2 kg ha^{-1}) and high in available potassium (390.7 kg ha^{-1}) with pH 8.2 and 0.66% organic carbon. The experiment was conducted on Variety CO 13, comprising of eight treatments *viz.*, T_1 – Maize maxim 0.4% (2 kg ha^{-1}), T_2 – Maize maxim 0.5% (2.5 kg ha^{-1}), T_3 – Maize maxim 0.6% (3 kg ha^{-1}), T_4 – DAP 2% (10 kg ha^{-1}), T_5 – Boric acid 0.3% (1.5 kg ha^{-1}), T_6 – Salicylic acid 40 ppm (20 g ha^{-1}), T_7 – Gibberellic acid 50 ppm (25 g ha^{-1}) and T_8 – Control (no spray) was laid out in Randomized Block Design (RBD) replicated thrice. The recommended dose of 60: 30: 30 kg N, P_2O_5 and K_2O ha^{-1} was applied in the form of Urea (46% N), Single super phosphate (16% P_2O_5) and Muriate of potash (60 % K_2O). As per the

recommendation, basal application of 30: 30: 30 kg N, P_2O_5 and K_2O_5 ha^{-1} was applied uniformly to all plots at the time of transplanting and the remaining dose of 30 kg N ha^{-1} was applied at 45 days after transplanting. Foliar application of nutrients and plant growth regulators was applied twice at pre and post flowering stage of crop growth. Tamil Nadu Agricultural University has developed "Maize Maxim", a nutrient mixture (major, micro nutrients and growth regulators) to boost maize yield. Keeping this in view, the TNAU maize maxim was also included in the present investigation. The conversion efficiency was calculated with the help of the following formula and expressed as percentage.

$$CE\ (\%) = \frac{\text{Number of productive tillers m}^{-2}}{\text{Total number of tillers m}^{-2}} \times 100$$

Results and Discussion

Plant Height

Foliar fertilization had a significant effect on the growth attributes of finger millet. The data on plant height at 60 days after transplanting (DAT) and at harvest stages are presented in Table 1. The plant height was significantly higher with foliar application of nutrients and plant growth regulators. Foliar application of 40 ppm salicylic acid spray (T_6) registered plant height of 108.5 and 114.7 cm at 60 DAT and at harvest, respectively and was on par with gibberellic acid 50 ppm (T_7). This was followed by TNAU maize maxim spray 0.6% (T_3). The minimum plant height was recorded by control (T_8) with a plant height of 92.1 and 94.2 cm at 60 DAT and at harvest, respectively. Increased plant height by salicylic acid was also observed in corn and beans due to enhancement in photosynthetic rate (Bekheta and Talaat, 2009) [4]. The similar trend of response was observed earlier by Jeyakumar *et al*. (2008) [11] in blackgram and Maduraimuthu and Desikan (2013) [12] in sweet sorghum. This increase in plant height by salicylic acid might be attributed to its synergistic interaction with available endogenous auxin and it could be observed in terms of cell wall plasticity and cell elongation as reported in chenna millet (Datta and Nanda, 1985) [6] and in soybean (Zhao and Lin, 1993) [18].

Dry matter production

The data on plant dry matter production at 60 DAT and harvest stages are presented in Table 1. The dry matter production of finger millet was significantly influenced by the application of different nutrients and plant growth regulators as foliar spray at 60 DAT and at harvest. Among the foliar spray treatments, spraying of salicylic acid 40 ppm twice at pre and post flowering stage of crop growth (T_6) significantly resulted in higher dry matter production of 4998 and 7732 kg ha^{-1} at 60 DAT and at harvest, respectively. Whereas, control plot (T_8) produced lesser dry matter production of 4036 and 5593 kg ha^{-1} at 60 DAT and at harvest, respectively. This was in accordance with the earlier findings of Nagasubramaniam *et al*. (2007) [13] in baby corn and Jayalakshmi *et al.* (2010) [10] in groundnut. Salicylic acid plays a major role in improving dry matter production of green gram (Rama Rao, 2003). Salicylic acid plays a role in growth and development, photosynthesis, ion uptake and transport. Seed treatment or foliar spray of salicylic acid induces reduction in sodium absorption and toxicity which is further reflected in low membrane injury, high water content and high dry matter production (El-Tayeeb, 2005) [9].

Number of tillers

The higher number of tillers observed at 60 DAT and at harvest stage was presented in Table 1. Among the foliar spray treatments, spraying of salicylic acid 40 ppm twice at pre and post flowering stage of crop growth (T_6) markedly resulted in higher number of tillers m^{-2} (214 and 233 tillers m^{-2}) at 60 DAT and at harvest, respectively and it was on par with gibberellic acid 50 ppm spray (T_7). The minimum number of tillers m^{-2} *viz.*, 154 and 168 tillers m^{-2} was recorded with control (T_8) at 60 DAT and at harvest, respectively. Similar finding was also reported by Amin *et al.* (2008) [2] in wheat. The increase in number of branches on sesame could be due to the stimulatory effect on the production of branches by salicylic acid (Uma devi, 1998) [17]. The increase in number of branches and plant growth of beans as a result of gibberellic acid application could be due to cell elongation and cell division as reported by El-Fouly *et al*. (1988) [8]. This was in line with the finding on number of branches in pea by Bora and Sarma (2006) [5].

Number of productive tillers

Number of productive tillers m^{-2} of finger millet was appreciably influenced by foliar spray of nutrients and plant growth regulators (Table 2). The foliar spray of salicylic acid 40 ppm twice at pre and post flowering stage of crop growth (T_6) recorded the more number of productive tillers m^{-2} (185) than the other foliar spray treatments. The minimum number of productive tillers m^{-2} of 109 was recorded in the control (T_8). A similar effect of salicylic acid was observed by number of fertile tillers in wheat (Abouziena and Abd El Wahed, 2013) [1].

Conversion Efficiency

The calculated grain yield conversion efficiency was statistically significant due to the adoption of various treatments (Table 2). The conversion efficiency was higher (79.3%) under salicylic acid at 40 ppm. The lower conversion efficiency of 64.9% was recorded under control (T_8). It was in conformity with the finding of spike-producing tillers in wheat (Abouziena and Abd El Wahed, 2013) [1].

Ear head weight

Foliar spray of salicylic acid 40 ppm (T_6) twice at pre and post flowering stage of crop growth recorded higher ear head weight of 13.6 g (Table 2). Lower ear head weight of 10.5 g was noticed in control (T_8). The better partitioning of photosynthates from source to sink may be the reason for increased ear head weight. This result was in agreement with the results of spike weight in wheat by Amin *et al.* (2008) [2].

Grain yield

Spraying of foliar nutrients and growth regulators had significant influence on grain yield of finger millet (Table 2). The plant sprayed with salicylic acid at 40 ppm (T_6) produced significantly higher grain yield of 3593 kg ha^{-1}. This was followed by foliar application of gibberellic acid at 50 ppm (T_7) and this was on par with TNAU maize maxim at 0.6% (T_3) with grain yield of 3397 and 3319 kg ha^{-1}, respectively. Significantly lower yield of 2709 kg ha^{-1} was observed with control (T_8). This might be due to enhancement of growth attributing characters like plant height, dry matter production and number of tillers m^{-2} and yield attributing characters like number of productive tillers m^{-2}, ear head weight and also the nutrient uptake by finger millet. Dawood *et al.* (2012) [7] observed that increase in kernel yield and yield components

of sunflower by salicylic acid were due to the effect of physiological and biochemical processes that led to ameliorate in vegetative growth, active assimilation and translocation from source to sink.

Straw yield

Application of foliar spray exhibited significant influence on straw yield also (Table 2). Salicylic acid at 40 ppm (T_6) recorded the higher straw yield of 8735 kg ha^{-1}. The lowest straw yield (7436 kg ha^{-1}) was recorded with control (T_8). The straw yield enhancement due to the adoption of different treatments might be due to continuous supply of nutrients which in turn increased the plant height, dry matter production and number of tillers m^{-2} resulting in higher straw yield. This is also attributed due to the higher nutrient uptake throughout the crop growth period. The results of the present study were in confirmation with the finding of Amin *et al*. (2008) [2] in straw yield of wheat.

Table 1: Effect of foliar spray on the plant height (cm), dry matter production (kg ha^{-1}) and number of tillers m^{-2} of finger millet

Treatment	Plant height (cm)		Dry matter production (kg ha^{-1})		Number of tillers m^{-2}	
	60 DAT	Harvest	60 DAT	Harvest	60 DAT	Harvest
T_1 - TNAU maize maxim 0.4% (2 kg ha^{-1})	95.4	97.8	4191	6167	168	187
T_2 - TNAU maize maxim 0.5% (2.5 kg ha^{-1})	102.0	105.2	4442	6609	190	206
T_3 - TNAU maize maxim 0.6% (3 kg ha^{-1})	103.4	108.7	4680	7071	198	214
T_4 - DAP 2% (10 kg ha^{-1})	97.8	100.4	4312	6320	173	191
T_5 - Boric acid 0.3% (1.5 kg ha^{-1})	99.7	102.5	4422	6478	186	201
T_6 - Salicylic acid 40 ppm (20 g ha^{-1})	108.5	114.7	4998	7732	214	233
T_7 - Gibberellic acid 50 ppm (25 g ha^{-1})	106.0	111.6	4707	7156	205	224
T_8 - Control (no spray)	92.1	94.2	4036	5593	154	168
CD (p=0.05)	2.8	3.2	146	250	11	12

Table 2: Effect of foliar spray on the number of productive tillers m^{-2}, conversion efficiency, ear head weight (g) grain yield (kg ha^{-1}) and straw yield (kg ha^{-1}) of finger millet

Treatment	Number of productive tillers m^{-2}	Conversion efficiency (%)	Ear head weight (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T_1 - TNAU maize maxim 0.4% (2 kg ha^{-1})	128	68.5	11.5	2945	7760
T_2 - TNAU maize maxim 0.5% (2.5 kg ha^{-1})	152	73.7	11.9	3200	7996
T_3 - TNAU maize maxim 0.6% (3 kg ha^{-1})	164	76.6	12.6	3319	8270
T_4 - DAP 2% (10 kg ha^{-1})	132	69.1	11.7	2977	7826
T_5 - Boric acid 0.3% (1.5 kg ha^{-1})	147	73.1	11.9	3078	7874
T_6 - Salicylic acid 40 ppm (20 g ha^{-1})	185	79.3	13.6	3593	8735
T_7 - Gibberellic acid 50 ppm (25 g ha^{-1})	172	76.7	12.7	3397	8344
T_8 - Control (no spray)	109	64.9	10.5	2709	7436
CD (p=0.05)	5	1.0	0.8	187	300

Conclusion

Growth and yield attributing characters *viz.*, plant height, dry matter production and number of tillers, number of productive tillers, ear head weight grain yield and straw yield were significantly higher with foliar application of salicylic acid 40 ppm twice at pre and post flowering stage of crop growth when compared to other treatments.

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