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# EFFICACY OF GROWTH PROMOTING HORMONES ON GROWTH AND YIELD OF RICE (*Oryza sativa* L.)

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**ABSTRACT**

A field experiment during Kharif, 2019 was conducted at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj, Uttar Pradesh, to find out the effect of gibberellic acid ($GA_3$) and naphthalene acetic acid (NAA) on growth and yield of rice. The data revealed that among the treatment, RDF + 75 ppm NAA at 45 DAT recorded the highest plant height (93.63 cm) whereas, RDF + 50 ppm $GA_3$ at 45 DAT recorded maximum total tillers (13.20), dry matter accumulation (2945.48 g/m$^2$), effective tiller/hill (9.27), number of grains/panicles (147.33), 1000 grain weight (23.08 g), grain yield (5.47 t/ha), straw yield (11.60 t/ha), rupee unit in gross return (160533.33 t /ha), net return (110383.54 t /ha) and B:C ratio (2.21). Thus we can conclude RDF + 50 ppm $GA_3$ at 45 DAT is more productive and economic, which enhanced yield by 22.66 % and 29 % of net return over control.

## INTRODUCTION

Rice (*Oryza sativa* L.) is a member of Poaceae family. It is the staple food for about one half of the world's population and supplies 20% of the calories consumed worldwide. Rice provides 27 % dietary energy supply, 20 % dietary protein and 3 % dietary fat. It can contribute nutritionally significant amounts of thiamine, riboflavin, niacin and zinc to the diet, but smaller amounts of other micronutrients. The demand for rice has increased dramatically because of the steady increase in population. However further expansion of rice plant area is difficult, because most arable land used for rice production is already converted into urban infrastructure. The additional rice must therefore be largely produced by increased yield per unit area. Therefore, improving rice yield potential has been the main objectives in many countries for several decades (Li *et al*., 2009).

The introduction of chemical growth regulators has added a new dimension to the possibility for improving the growth and yield of rice crop. Foliar application of plant growth regulators, both natural and synthetic, has proven worthwhile for improving crop growth against a variety of abiotic stresses. Plant hormones play a vital role in coordination of many growth and behavioral processes in the plant life. They regulate the amount, type and direction of plant growth. Remarkable accomplishments of Plant Growth Regulators (PGR) such as manipulating plant developments, enhancing yield and quality have been actualized in recent years using new emerging and efficient plant growth regulators. It has long been ascertained that plant hormones including auxins, gibberellins, cytokinin and ethylene *etc*., are involved in controlling developmental events such as cell division, cell elongation and protein synthesis. Plants have the ability to store excessive amounts of exogenously supplied hormones in the form of reversible conjugates which release active hormone when and where plant needs them during the growth period. Auxins (*i.e*., NAA) and gibberellins (*i.e*., $GA_3$) being well known plant growth promoting hormones has shown to be involved in a variety of plant growth and development processes (Frankenberger and Arshad, 1995).

NAA a synthetic growth regulators has proved its potentiality that in appropriate concentration affects the growth and yield on cereals including rice .Auxins may regulate cell elongation, tissue swelling, cell division, formation of adventitious roots, callus initiation and growth, induction of embryogenesis and promote cell wall loosening at very low concentration (Abel and Theologis, 2010). NAA is a high-efficiency auxin-like plant growth regulator, when applied in low concentrations as foliar spray on plants, it is transported basipetally downward slowly to initiate adventitious roots and better root activities, thus enhancing nutrient uptake. It also improves cell elongation and cell division and thus growth is enhanced. In small concentrations, it delays senescence. Hence, crop growth is found to increase significantly Chaudhuri *et al*. (1980).

Gibberellins are plant hormones that participate in regulation of many growth and developmental processes in various plants (Shibairo *et al*., 2006; Emongor, 2007). And these are especially important in regulating stem elongation, Gibberellic acid is responsible for stimulating the production of mRNA molecules in the cells and mRNA produced in this form, codes for the hydrolytic enzymes, which in turn improves the chances of fast growth (Sun, 2004). Growth regulators are proved to improve effective partitioning and translocation of accumulates from source to sink in the field crops. $GA_3$ is proved to improve effective portioning and translocation of accumulates from source to sink in the field crops (Senthil *et al*., 2003). $GA_3$ application was very effective in increasing seed set rate and grain yield through elongation of plant height, promoting panicle and spikelet exsertion, enhancing stigma exsertion and longevity and receptivity in rice and also key to win higher grain yield in rice production (Gavino *et al*., 2008). Addition of Gibberellic Acid on rice provides the plant with homogenous germination, saving seed amount, plant growth with high performance, increased tillering, high quality and yield (Elankavi *et al*., 2009)

Considering the above facts, the present study aimed to investigate the effect of Gibberellic Acid and Naphthalene Acetic Acid application, with the hypothesis that whether they can enhance the yield and net return of rice crop. Therefore, the objectives are to find out the effect of Gibberellic Acid and Naphthalene Acetic Acid on the growth and yield of rice crop and to find out the economics of different treatment combination.

## MATERIALS AND METHODS

### Experimental site and soil information

The experiment was carried out during Kharif season of 2019 at Crop Research Farm, Department of Agronomy, Naini Agriculture Institute, SHUATS, Prayagraj, Uttar Pradesh. This area is situated on the right side of the river Yamuna by the side of Prayagraj Rewa Road. Prayagraj has a humid subtropical climate. Summer lasts from March to September with daily highs reaching up to 48 ºC in the dry summer (from March to May) and up to 40 ºC in the hot and extremely humid monsoon season (from June to September). Rain from the Bay of Bengal or the Arabian Sea branches of the southwest monsoon falls on Prayagraj from June to September, with annual rainfall of 1,027 mm. The soils of the experimental plot were sandy loam in texture with pH of 7.2 (Prasad *et al*., 2006), organic carbon of 0.49 % and available nitrogen of 109.01 kg/ha by Walkley and Black method (Walkley and Black, 1934), available phosphorus of 21.80 kg/ha by Olsen's calorimetric method (Olsen *et al*., 1954), available potassium of 270.02 kg/ha by flame photometer method (Toth and Prince, 1949)

The experiment was laid out in Randomized Block Design (RBD) and replicated thrice. There were 13 treatments with 2 levels of $GA_3$ (50 ppm;100 ppm) and NAA (75 ppm;150 ppm) and 3 number of applications (45 DAT; 65 DAT; 45 and 65 DAT). Allocation of the treatment were done by the randomization following Fisher and Yates random number table. Pusa basmati-1 rice variety was used in the experiment. The data were recorded on 5 randomly selected plants from each plot for growth, yield and yield attributes. The growth attributes studied were plant height (cm), total tillers, dry matter accumulation (g/m$^2$). Yield attribute studied were number of effective tiller/hills, number of grains/panicles, 1000 grain weight (g), grain yield (t/ha), straw yield (t/ha) and harvest index (%). Along with growth, yield and yield attribute, economics of rice was also studied, which include rupee unit in gross return (t/ha), net return (t/ha), and benefit cost ratio to find out which treatment is more economical to farmers.

Plant height of rice was measured from the base of the plant at ground surface to the tip of the tallest leaf panicle using a standard meter scale. Total tillers/hill were counted from the five randomly selected hills. At 100 DAT of the crop total dry-matter accumulation was recorded from the five hills selected. These plants were air-dried and further dried in a hot air oven till constant weight was obtained. For effective tiller/hills, panicle-bearing tillers of the marked 5 hills were counted at harvesting. Number of grains/panicles was counted from the selected panicles. The 1,000-filled grains, taken from sampled panicles, were first counted and then weighed to compute the 1,000- grain weight. After harvesting, threshing, cleaning and drying, the grain yield of rice was estimated at 14% moisture content. Straw yield was recorded by subtracting grain yield from the total biomass yield. Yield was expressed in t/ha. Gross and net returns were calculated based on the grain and straw yield and the prevailing market prices of basmati rice. Benefit: cost ratio was calculated by dividing the net returns from total cost of cultivation. The benefit cost ratio was calculated by using following expression: unit rupee in net returns (t /ha) ÷ Cost of cultivation (t/ha). The data obtained from this study were analyzed statistically using the F–test, as per the procedure given by Gomez and Gomez (1984) and 5% level of significance was used to compared the differences among the treatment. The treatment differences that were non-significant at five per cent were denoted as NS.

## RESULTS AND DISCUSSION

### Effect of growth promoting hormones on growth attributes of rice

Among the growth attribute, there was significant difference in the analysis of variance of different treatment combinations, except for total tillers (Table 1).

The highest plant height was observed with the application of RDF + 75 ppm NAA at 45 DAT (93.63 cm) which was significantly superior over rest of the treatment, except for treatment with application of RDF + 50 ppm $GA_3$ at 45 DAT (88.87 cm), RDF + 100 ppm $GA_3$ at 45 and 65 DAT (86.43 cm), RDF + 50 ppm $GA_3$ at 65 DAT (86.07 cm) and RDF + 150 ppm NAA at 65 DAT (85.67 cm) being statistically at par with RDF + 75 ppm NAA at 45 DAT . The increased in plant height observed under NAA is due to, NAA is a high-efficiency auxin-like plant growth regulator. When applied in low concentrations as foliar spray on plants, it is transported basipetally downward slowly to initiate adventitious roots and better root activities, thus enhancing nutrient uptake. It also improves cell elongation and cell division and thus growth is enhanced. In small concentrations, it delays senescence. Hence, crop growth is found to increase significantly. Similar findings were earlier reported by Basuchaudhuri (2016).

Dry matter accumulation gradually increased with increased crop age and maximum dry matter accumulation was observed with the application of RDF + 50 ppm $GA_3$ at 45 DAT (2945.48

**Table 1: Effect of Gibberellic Acid ($GA_3$) and Naphthalene Acetic Acid (NAA) on growth attributes of Rice.**

| Treatment | Plant height (cm) at 100 DAT | Total tillers at 60 DAT | Dry matter accumulation (g/m$^2$) at 100 DAT |
|---|---|---|---|
| RDF + 50 ppm $GA_3$ at 45 DAT | 88.87 | 13.2 | 2945.48 |
| RDF + 50 ppm $GA_3$ at 65 DAT | 86.07 | 12.07 | 2706.06 |
| RDF + 50 ppm $GA_3$ at 45 and 65 DAT | 85.07 | 12.33 | 2704.17 |
| RDF + 100 ppm $GA_3$ at 45 DAT | 83.33 | 12.07 | 2647.96 |
| RDF + 100 ppm $GA_3$ at 65 DAT | 85.07 | 11.67 | 2722.17 |
| RDF + 100 ppm $GA_3$ at 45 and 65 DAT | 86.43 | 12.2 | 2701.73 |
| RDF + 75 ppm NAA at 45 DAT | 93.63 | 10.67 | 2845.27 |
| RDF + 75 ppm NAA at 65 DAT | 80.2 | 11.2 | 2717.95 |
| RDF + 75 ppm NAA at 45 and 65 DAT | 82.6 | 11.67 | 2727.95 |
| RDF + 150 ppm NAA at 45 DAT | 85.07 | 11.2 | 2698.29 |
| RDF + 150 ppm NAA at 65 DAT | 85.67 | 10.49 | 2638.07 |
| RDF + 150 ppm NAA at 45 and 65 DAT | 84.13 | 10.8 | 2714.84 |
| Control (RDF) + Water Spray | 81.6 | 11.53 | 2568.74 |
| SEm (±) | 2.78 | 0.98 | 79.29 |
| CD (5%) | 8.17 | NS | 232.57 |
| CV % | 5.66 | 14.72 | 5.05 |

**Table 2: Effect of Gibberellic Acid ($GA_3$) and Naphthalene Acetic Acid (NAA) on Yield and Yield Attributes of Rice.**

| Treatment | Effective tiller/ hill(no.) | Number of grains/ panicles | 1000 grain weight (gm) | Grain yield (t/ ha) | Straw yield (t/ ha) | Harvest index(%) |
|---|---|---|---|---|---|---|
| RDF + 50 ppm $GA_3$ at 45 DAT | 9.27 | 147.33 | 23.08 | 5.47 | 11.6 | 32.01 |
| RDF + 50 ppm $GA_3$ at 65 DAT | 8.41 | 145 | 22.1 | 5.38 | 11.27 | 32.32 |
| RDF + 50 ppm $GA_3$ at 45 and 65 DAT | 8.93 | 137.67 | 22.68 | 4.82 | 10.2 | 32.1 |
| RDF + 100 ppm $GA_3$ at 45 DAT | 8.47 | 138.93 | 22.11 | 4.89 | 10.1 | 32.64 |
| RDF + 100 ppm $GA_3$ at 65 DAT | 8.59 | 146.67 | 22.74 | 5.01 | 11.27 | 30.82 |
| RDF + 100 ppm $GA_3$ at 45 and 65 DAT | 8.6 | 137 | 21.84 | 5.43 | 10.67 | 33.71 |
| RDF + 75 ppm NAA at 45 DAT | 8 | 146.21 | 21.88 | 4.61 | 9.07 | 33.71 |
| RDF + 75 ppm NAA at 65 DAT | 8.67 | 139.65 | 22.42 | 4.86 | 9.67 | 33.42 |
| RDF + 75 ppm NAA at 45 and 65 DAT | 8.73 | 141 | 22.12 | 4.62 | 9.6 | 32.51 |
| RDF + 150 ppm NAA at 45 DAT | 8.07 | 135.96 | 19.78 | 4.57 | 8.73 | 34.29 |
| RDF + 150 ppm NAA at 65 DAT | 8.4 | 139.53 | 22.12 | 4.61 | 9.5 | 32.64 |
| RDF + 150 ppm NAA at 45 and 65 DAT | 8.73 | 136.67 | 21.96 | 4.86 | 9.73 | 33.72 |
| Control (RDF) + Water Spray | 7.1 | 134.33 | 19.45 | 4.23 | 8.33 | 33.68 |
| SEm (±) | 0.32 | 4.05 | 0.71 | 0.27 | 0.49 | 1.68 |
| CD (5%) | 0.96 | 11.89 | 2.1 | 0.8 | 1.46 | NS |
| CV % | 6.74 | 5 | 5.68 | 9.77 | 8.67 | 8.89 |

**Table 3: Effect of Gibberellic Acid ($GA_3$) and Naphthalene Acetic Acid (NAA) on Economic of Rice.**

| Treatment | Cost of Cultivation (t/ ha) | Gross Return (t/ ha) | Net Return (t/ ha) | Benefit cost ratio |
|---|---|---|---|---|
| RDF + 50 ppm $GA_3$ at 45 DAT | 50149.79 | 160533.3 | 110383.5 | 2.21 |
| RDF + 50 ppm $GA_3$ at 65 DAT | 50149.79 | 157540 | 107390.2 | 2.14 |
| RDF + 50 ppm $GA_3$ at 45 and 65 DAT | 57649.79 | 141383.3 | 83733.54 | 1.45 |
| RDF + 100 ppm $GA_3$ at 45 DAT | 57649.79 | 142770 | 85120.21 | 1.48 |
| RDF + 100 ppm $GA_3$ at 65 DAT | 57649.79 | 148953.3 | 91303.54 | 1.58 |
| RDF + 100 ppm $GA_3$ at 45 and 65 DAT | 72649.79 | 156966.7 | 84316.88 | 1.16 |
| RDF + 75 ppm NAA at 45 DAT | 43774.79 | 133230 | 89455.21 | 2.04 |
| RDF + 75 ppm NAA at 65 DAT | 43774.79 | 140703.3 | 96928.54 | 2.2 |
| RDF + 75 ppm NAA at 45 and 65 DAT | 44899.79 | 135136.7 | 90236.88 | 2.01 |
| RDF + 150 ppm NAA at 45 DAT | 44899.79 | 131310 | 86410.21 | 1.92 |
| RDF + 150 ppm NAA at 65 DAT | 44899.79 | 134453.3 | 89553.54 | 1.99 |
| RDF + 150 ppm NAA at 45 and 65 DAT | 47149.79 | 140980 | 93830.21 | 1.99 |
| Control (RDF) + Water Spray | 42649.79 | 122290 | 79640.21 | 1.87 |

g/m$^2$), which was significantly superior over rest of the treatment, except for treatment with application of RDF + 75 ppm NAA at 45 DAT (2845.27 g/m$^2$), RDF + 75 ppm NAA at 45 and 65 DAT (2727.95 g/m2), RDF + 100 ppm $GA^3$ at 65 DAT (2722.17 g/m2), RDF + 75 ppm NAA at 65 DAT (2717.95 g/m$^2$) and RDF + 150 ppm NAA at 45 and 65 DAT (2714.84 g/m$^2$), being statistically at par with RDF + 50 ppm $GA_3$ at 45 DAT . Results indicated that application of Gibberellic acid at optimum dose produced higher plant height, a greater number of tillers/hill and plant dry weight. The result of the present study is similar to the findings of Prasad *et al*. (2013) who observed that application of $GA_3$ had significantly registered the higher growth attributes of plant. $GA_3$ application might have increased the translocation of assimilates to the vegetative organ which resulted in the maximum of plant height, number of tillers/hill and plant dry weight.

**Effect of growth promoting hormones on yield and yield attributes of rice**

Application of $GA_3$ and NAA greatly influenced the yield and yield attribute of rice and the analysis of variance was significant for all the yield and yield attributes of rice except for harvest index (Table 2).

Number of effective tillers/hills was recorded maximum with the application of RDF + 50 ppm $GA_3$ at 45 DAT (9.27), which was significantly superior over the treatment with application of RDF + 150 ppm NAA at 45 DAT (8.07), RDF + 75 ppm NAA at 45 DAT (8.00), Control (RDF) + Water Spray (7.10) and rest of the treatments were statistically at par with RDF + 50 ppm $GA_3$ at 45 DAT. These results were in conformity with the results of Elankavi *et al*. (2009) who also observed that the exogenous application of $GA_3$ significantly increases various growth characters *viz*., plant height, number of tillers and yield attributes in rice.

Number of grains/panicles was recorded maximum with the application of RDF + 50 ppm $GA_3$ at 45 DAT (147.33), which was significantly superior over Control (RDF) + Water Spray (134.33) and rest of the treatments were statistically at par with RDF + 50 ppm $GA_3$ at 45 DAT. Jagadeeshwari *et al*. (2004) reported that application of $GA_3$ was significant in increasing the number of filled grains per panicle.

1000 grain weight was recorded maximum with the application of RDF + 50 ppm $GA_3$ at 45 DAT (23.08 g), which was significantly superior over the treatment with application of RDF + 150 ppm NAA at 45 DAT (19.78 g), Control (RDF) + Water Spray (19.45 g) and rest of the treatments were statistically at par with RDF + 50 ppm $GA_3$ at 45 DAT.

Grain yield was observed maximum with the application of RDF + 50 ppm $GA_3$ at 45 DAT (5.47 t/ha) which was significantly superior over the treatment RDF + 75 ppm NAA at 45 DAT (4.61 t/ha), RDF + 75 ppm NAA at 45 DAT (4.61 t/ha), RDF + 150 ppm NAA at 65 DAT (4.61 t/ha), RDF + 150 ppm NAA at 45 DAT (4.57 t/ha), Control (RDF) + Water Spray (4.23 t/ha) and rest of the treatments were statistically at par with RDF + 50 ppm $GA_3$ at 45 DAT. This might be due heavier buildup of sufficient food reserves diversified towards the developing higher number of panicles and filled grains/plant due to spraying of growth regulators which in turn registered higher grain yield Ramesh *et al*. (2019). Besides, higher grain yield might be due to better translocation of photosynthates from source to sink. Tiwari *et al*. (2011).

Straw yield was observed maximum with the application of RDF + 50 ppm $GA_3$ at 45 DAT (11.60 t/ha) which was significantly superior over rest the treatment, except for RDF + 50 ppm $GA_3$ at 65 DAT (11.27), RDF + 100 ppm $GA_3$ at 65 DAT (11.27), RDF + 100 ppm $GA_3$ at 45 and 65 DAT (10.67) and RDF + 50 ppm $GA_3$ at 45 and 65 DAT (10.20) being statistically at par with RDF + 50 ppm $GA_3$ at 45 DAT. Tiwari *et al*. (2011) reported that application of $GA_3$ increase the straw yield and increase in stem elongation leads to high biomass production

Foliar application of $GA_3$ registered higher yield attributes. The effect of gibberellic acid ($GA_3$) on growth and yield of rice (*Oryza sativa* L.) might be attributed to the increased supply of photosynthetic materials and its efficient mobilization in plants giving rise to increased stimulation of yield attributes (Tiwari *et al*., 2011). While, Zahir *et al*. (2007) observed that exogenously supplied PGRs may undergo several metabolic processes in the soil resulting in loss of their activity and reduced availability to plants and such type of behavior was only seen with IAA and Gibberellic acid. These results were in conformity with a number of workers such as Pandey *et al*. (1996), Jayaraj and Chandrasekharan (1997), Subbaih and Mittra (1997), Singh and Sahoo (1998), Kalavathi *et al*. (2000), and Elankavi *et al*. (2009).

**Effect of growth promoting hormones on economics of rice**

Table 3. indicate the highest gross return (160533.33 t/ha), rupee unit in net return (110383.54 t/ha) and benefit cost ratio (2.21) was obtained with the application of RDF + 50 ppm $GA_3$ at 45 DAT and therefore it is recommended to farmers for maximum benefit.

## CONCLUSION

Plant growth hormones significantly influence the crop productivity and profitability of rice crop. Based on one–season trial, we can conclude that RDF + 50 ppm $GA_3$ at 45 DAT is more productive and economic, which enhanced yield by 22.66 % and 29 % of net return over control.

## REFERENCES

**Abel, S. and Theologis A., 2010.** Odyssey of Auxin. In: Perspectives in Biology, Estelle, M., D. Weijers, K. Ljung and O. Leyser (Eds.). Cold Spring Harbor Lab. Press, USA.

**Basuchaudhuri P., 2016.** 1-Naphthaleneacetic acid in rice cultivation *Current Science*. **110(1):** 10 January.

**Chaudhuri, D., Basuchaudhuri, P. and Das Gupta, D. K., 1980.** Effect of growth substances on growth and yield of rice. *Indian Agric.*, **24:** 169–175.

**Emongor, V., 2007.** Gibberellic acid (GA3) influence on vegetative growth, nodulation and yield of cowpea (*Vigna unguiculata* (L.) walp. *J. Agron*. **6:** 509-517.

**Elankavi S., Kuppuswamy G., Vaiyapuri V. and Raman R. 2009.** Effect of phytohormones on growth and yield of rice. *Oryza*., **46:** 310-313.

**Frankenberger, Jr. W.T. and Arshad M., 1995.** Phytohormones in Soil: Microbial Production and Function. Marcel Dekker Inc., New York, USA.,P. 503.

**Gomez, K.A. and Gomez, A. A., 1984.** Statistical Procedures for Agricultural Research, edn 2, An International Rice Research Institute Book. Wiley-Inter-Science Publication, John Wiley & Sons, New York.

**Gavino, B.R., Pi, Y. and Abon, C.C. 2008.** Application of gibberellic acid ($GA_3$) in dosage for three hybrid rice seed production in the Philippines. *J. Agric Technol*. **4(1):** 183-192.

**Jayaraj, T. and Chandrasekharan B., 1997.** Foliar fertilization to changes seed yield and quality in rice. *Seed Res*. **25:** 50-52.

**Jagadeeswari, P., Kumar, S.S., Ganesh, M and Anuradha, G., 2004.**

Effect of foliar application of $GA_3$ on seed yield and quality in hybrid rice. *Oryza*. **35(1):** 26-30.

**Kalavathi, O., Ananthakalaiselvi A. and Vijaya J., 2000.** Economization of $GA_3$ use in hybrid rice seed production by supplementing with other nutrients. *Seed Res.* **28:** 10-12.

**Kokani, J. M., Shah, K. A., Tandel, B. M. and Bhimani, G. J. 2015.** Effect of FYM, phosphorus and sulphur on yield of summer blackgram and post-harvest nutrient status of soil. *The Bioscan*. **10(1):** 379-383.

**Li, J., Xin Y. and Yuan L. P. 2009.** Hybrid rice in China in Pushing the Yield Frontier. IFPRI Discussion Paper. Hybrid Rice Technology Development: Ensuring China's Food Security. International Food Policy Research Institute, Washington D.C. pp: 77-82.

**Nayek, S.S., Koushik Brahmachari, M.D. And Chowdhury, R. 2014.** Integrated approach in nutrient management of sesame with special reference to its yield, quality and nutrient uptake. *The Bioscan*. **9(1):**101-105.

**Olsen, R., Cole, C.V., Watanabe, F.S. and Dean, L.A., 1954.** Estimation of available phosphorus in soils by extraction with sodium bicarbonate. Circular-939, United States Department of Agriculture, Washington DC, USA

**Pandey, M.P., Mani S.C., Singh H. and Singh J.P., 1996.** Hybrid Rice Seed Production. A Technology Manual. Power Printers, New Delhi, India.

**Prasad, R., Shivay, Y.S., Kumar, D. and Sharma, S.N., 2006**. Learning by Doing Exercises in Soil Fertility–A Practical Manual for Soil Fertility, pp. 68, Division of Agronomy, Indian Agricultural Research Institute, New Delhi, India.

**Prasad R.N., Singh S., Yadava R.B. and. Chaurasia S.N.S 2013.** Effect of $GA_3$ and NAA on growth and yield of tomato. *Vegetable science.* **40(2):** 195-197.

**Ramesh S., Sudhakar P., Elankavi S., Suseendran K. and Jawahar S. 2019.** Effect of $GA_3$ on Growth and Yield of Rice (*Oryza sativa* L.) Plant Archives Vol. 19, Supplement 1, 2019 pp. 1369-1372

**Subbaih, G. and Mittra B.N., 1997.** Effect of foliar spray of micronutrient on growth and yield of rice. *Oryza*. **26:** 148-151.

**Singh, R. and Sahoo S. K. 1998.** Evaluating hybrid seed production technology along with new hormone mange Ferin. Ph.D. Thesis, Banaras Hindu University, Varanasi

**Sun, T. 2004.** Gibberellin Signal Transduction in Stem Elongation and Leaf Growth. In: Plant Hormones; Biosynthesis, Signal Transduction, Action, Davies, P.J. (Ed.). Kluwer Academic Publication, Dordrecht, The Netherlands, pp. 304-320.

**Senthil, A., Djanaguiraman M. and Chandrababu R. 2003.** Effect of root dipping of seedlings with plant growth regulators and chemicals on yield and yield components of rice (*Oryza sativa* L.) transplanted by broadcast method. *Madras Agric. J.* 90: 383-384.

**Shibairo, S.I., Demo P., Kabira J.N., Gildemacher P. and Gachango E., 2006.** Effects of gibberellic acid ($GA_3$) on sprouting and quality of potato seed tubers in diffused light and pit storage conditions. *J. Boil. Sci*. 6: 723-733.

**Toth, S. J.and Prince, A. L. 1949.** Estimation of cation-exchange capacity and exchangeable Ca, K, and Na contents of soils by flame photometer techniques. *Soil Science*. **67(6):** 439-446.

**Tiwari D., Pandey K.P., Giri S.P. and Dwivedi J. L. 2011.** Effect of $GA^3$ and other plant growth regulators on hybrid rice seed production. *Asian J. Plant Science*. **10(2):** 133-139.

**Walkey, A. and Black, I. A. 1934.** Determination of organic carbon in soils. *Soil Science.* **37:** 29-38.

**Zahir, A.Z., Iqbal M., Arshad M., Naveed M. and Khalid M., 2007.** Effectiveness of IAA, $GA_3$ and kinetin blended with recycled organic waste for improving growth and yield of wheat (T*riticum aestivum* L.). *Pak. J. Bot.*, **39:** 761-768.