Beneficial Effect of Taba® (Gibberellic Acid 0.001% L) A Liquid Growth Promoter and Chemical Fertilizers on Morphological and Yield Contributing Characters in Soybean (Glycine max L. Merril) Under Rainfed Conditions

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ABSTRACT
Soybean (Glycine max L. Merril) is one of the most important oilseed crop in the world accounting for more than 50% of oilseeds produced and 30% of the total supply of all vegetable oils. Nutrient management is one of the most important factors in successful cultivation of crops. The productivity of soybean in India is very low (1228 kg/ha) as compare to the world’s average productivity (2509 kg/ha). Hence, an experiment was conducted to study the effect of TABA® (Gibberellic acid 0.001% L) on soybean yield in rainfed conditions. TABA® 0.5, 1.0, 200 ml/L along with 100% RDF and 75% RDF were evaluated at Dr. PDKV, Akola (Amravati). Results compiled indicated that two applications of TABA® @ 2.0 ml/L along with RDF significantly increase no. of branches/plant (62.93), yield/plant (76.47%), 100 seed weight (13.28%), straw yield (60.84%), and yield by 57.80% over control and 27.67% over RDF. Similarly, TABA® along with 75% RDF can help to increase yield upto 34.70% over control and 8.98% over RDF. Hence, we can save 25% fertilizer dose for soybean crop for getting yield upto RDF. Similarly, spraying of TABA® did not show any phytoxic effect on soybean crop.

Keywords- Soybean, Glycine max, TABA®, GA, Gibberellic acid, Phyto-toxicity, Soybean yield.

I. INTRODUCTION
Soybean (Glycine max (L) Merril) now has been established as one of the most important oilseed crop in the world accounting for more than 50% of oilseeds produced and 30% of the total supply of all vegetable oils. It is unique crop having both high quality protein (40.0%) and oil (20.0%) content. It also helps in improving soil fertility through nitrogen fixation. Soybean is used information of low cost nutritionally balanced protein foods and drinks most essential for protein deficient countries. The protein from soybean is equivalent to that of meat, milk products and eggs in quality. In the ancient times, soybean was used as a medicinal plant in China as a specific remedy for proper functioning of heart, liver, kidneys and stomach (Kale, 1936). In USA, soybean was used in earlier days as a forage crops in combination with corn. It is one of the most popular protein ingredients in the world in manufacturing of livestock feeds like soybean flakes, soybean bittles for feeding fish, soaps, varnishes, printing inks, paints, enamels, insecticides, wallboards etc. Soybean oil is used in the manufacture of food preparations like cooking oils, salad dressing, sandwiches, vegetable oils, pharmaceuticals, cosmetics etc. Bhatnagar (1996) has reviewed the potentials of soybean for industry and food uses and presented a comparison with other food sources for protein and nutritive value. Therefore, soybean plays a major role in bridging the vegetable deficit in the country.

Expansion of soybean cultivation in India is increased due to its importance as a source of edible oil, de-oiled cake which is mostly exported, low priced source of high-quality proteins and other by-products and establishment of oil extraction plants. Due to this area under soybean in India has been increased up to 10.96 million hectares with 13.46 million tons production having 1228 kg/ha productivity, Madhya Pradesh which is called ‘Soybean state’ followed by Maharashtra, Rajasthan and Karnataka. Though India is fifth country in the world as regards area but the average productivity is very low 1228 kg/ha as compared to the world average of 2509 kg/ha. Therefore, considering to bridge this gap to increase the productivity of soybean in India through utilization of maximum available inputs. For achieving the desired crop productivity, there is a need of integration of alternative sources of nutrients (Tiwari, 2002). The sustainability in Indian agricultural production could be achieved only by ‘high input high output’ approach along with better agronomic is recorded in 125 districts. The Fe, Mn and B have also become most serious constraints in some agricultural production...
systems. In comparison to Indian scenario, soybean cultivated soils show wide spread deficiency of N and P, deficiency of K and S in large pockets and deficiency of Zn and B in small and scattered pockets. Therefore, there is need to manage these nutrients efficiently to obtain sustainable soybean production.

Plant growth promoters/ regulators (auxins, gibberellin, abscisic acid) are mostly used in agricultural industry for stimulation and synchronization of flowering and fruit setting, reduction or promotion of vegetative growth, defoliation and reduction of lodging of field crops (Briant, 1974). The most widely available compound is Gibberelllic Acid (GA3), which includes stem and internode elongation, seed germination enzyme production during germination, fruit setting and growth (Davis, 1955, Ross et al. 1990). Application of GA3 enhance photosynthesis and growth (Kwan 1996, Hayat et al. 2001). Likewise, it can stimulate rapid root and stem growth which induces mitotic divisions in the leaves (Kato, 1955, Brain 1958). However, GA regulates growth, application of very low concentrations has profound effect while too much have opposite effect (Riley 2012) management practices.

Fertilizers, most important sources of nutrients are considered to contribute 40-50% in crop production, particularly in dry lands (Katyal et al. 1999). They are costly and environmentally sensitive; therefore, efficient management is warranted. Nutrient removal by crops is normally higher than their requirement resulting in depletion of reserves of nutrients from the soil. The exclusive dependence on either fertilizers or organic sources is neither economically viable nor environmentally acceptable. An integrated nutrient management and supply system which involves combined use of fertilizers, organic manures, crop residues and bio-fertilizers will be an imperative feature of soil fertility maintenance for sustainable development of agriculture. Soils of India are generally poor in fertility as these are low in organic matter and have consistently been depleted of their nutrient resource due to continuous cultivation for many decades. The low and declining soil fertility are the main causes of low productivity of most of the cultivated lands and crops including soybean. In India most of the soils are deficient in either major nutrients as well as macro or micro-nutrients. In India, Sulphur deficiency. Therefore, an experiment was conducted to study the effect of TABA® (Gibberellic acid 0.001% L) on growth, oil and protein content and yield contributing characters in rainfed conditions of soybean.

II. MATERIALS AND METHODS

The field experiment was conducted to study the effect of TABA® (Gibberellic acid 0.001% L) on soybean at Agronomy Division Regional Research Centre, Amaravati (Dr. PDKV, Akola) during Kharif 2015 season in rainfed conditions. The experiment was laid out in Randomised Block Design with three replications. The soil of the experiment was medium black and a basal fertilizer dose of 30:70:30 kg NPK/ha was applied as per the treatment at the time of sowing (Dibbling). A promising soybean variety JS-335 was used in all the three replications in a gross plot size of 2.7 x 5.0 m with a spacing of 45 x 5 cm between two rows and between two seeds/plants. Spraying of TABA® were given at 35-40 days after sowing (DAS) and 55-60 DAS. All the recommended package of practices and agronomic practices were followed to raise a good crop. The Treatment details are given below –

| Treatment No. | Treatment details          |
|---------------|---------------------------|
| T-1           | Recommended dose of fertilizer (RDF) |
| T-2           | TABA® @ 1.0 ml/L           |
| T-3           | TABA® @ 2.0 ml/L           |
| T-4           | RDF + TABA® @ 0.5 ml/L     |
| T-5           | RDF + TABA® @ 1.0 ml/L     |
| T-6           | RDF + TABA® @ 2.0 ml/L     |
| T-7           | 75% RDF + TABA® @ 0.5 ml/L |
| T-8           | 75% RDF + TABA® @ 1.0 ml/L |
| T-9           | 75% RDF + TABA® @ 2.0 ml/L |
| T-10          | Control                   |

TABA® (Gibberellic acid 0.001% L) is a plant growth promoter and expensively used in agriculture for vegetative and reproductive growth of the plants. Gibberellic acid (GA) can stimulate root and stem growth, induces mitotic divisions in the leaves and increases seed germination (Kato 1958 and Brain 1958). TABA® contains protein hydrolyzed (2.5%), yeast extract of sea weeds (3.0%), ferrous sulphate (2.3%), manganese sulphate (4.3%) and water as a solvent. It is compatible with all commonly used liquid fertilizers, insecticides, herbicides and fungicides. It also improves the physiological efficiency of the crop by stimulating the hormonal and enzymatic activities and increases quality and finally yield. TABA® is residue free, nontoxic and environmentally safe for spraying.

Observations were recorded for plant height (cm), number of branches/plant, days to maturity, yield/plant (g), 100 seed weight (s), straw yield (kg/ha); Protein content (%), oil content (%) and seed yield (kg/ha). Data obtained were statistically analysed (ANOVA) according to the method given by Panse and Sukhatme (1985).

III. RESULTS AND DISCUSSION

Data obtained on nine morphological, quality characters and yield contributing characters are presented in Table-1 and significant trends are shown in fig-1 and 2. Results obtained indicated that except for plant height, days to maturity, 100 seed weight, oil and protein content, all the parameters were significantly influenced by the application of chemical fertilizers, TABA® and their
combinations.

i) Plant height (cm.)

Plant height was not significantly influenced due to application of TABA® and chemical fertilizers and their combined application in rained conditions. However, Treatment No. T-6 (RDF + TABA® @ 2.0 ml/L) gave 10.09% more height than control treatment followed by T-5 (RDF + TABA® @ 1.0 ml/L) with 6.79% and T-3 (TABA® @ 2.0 ml/L) with 4.14% more height than control treatment. Similarly plant height ranged from 40.33 cm (control) to 44.40 cm (T-6 treatment). Among all the treatments, T-6 (RDF + TABA® @ 2.0 ml/L) recorded maximum plant height (44.40 cm) followed by T-5 (43.07 cm), T-3 (42.00 cm), T-4 (41.92 cm) and T-2 (41.73 cm). From the above results it is revealed that plant height in soybean crop was increased with the application of TABA® which is a growth promoter having Gibberellic acid as a component.

Increase in plant height might be due to enhancement of cells division resulted in stem elongation which resulted into maximum plant height of soybean crop. The present results are in confirmative with those reported by Gosh and Mohiuddin (2005) in cotton, Iqbal et. al. (2001), Khan et. al. (2001) and Raut et. al. (2015a) in chickpea. Similar results of TABA® (Gibberellic acid @ 2.0 ml/L) has been reported by Kanitkar et. al. (2013) in Bt-cotton, Raut et. al. (2014a, 2014b, 2015c, 2016a, 2016b, 2016c) in tomato, soybean, redgram, onion, tomato and okra. The present findings are in agreement with, the above reports.

ii) Number of branches/plants

In regard to number of branches/plant was significantly influenced due to application of TABA® in combination with RDF and 75% RDF. In the present study, T-6 (RDF + TABA® @ 2.0 ml/L) treatment gave significantly highest No. of branches/plant (2.33) followed by T-9 and T-1 (2.07), T-8 (2.03), T-5 (1.97), T-4 (1.93), T-3 (1.90) and T-2 (1.87) treatments over control. All the above treatments gave 62.93% (T-6), 44.76% (T-9), 41.95% (T-8), 41.93% (T-5), 37.76% (T-4), 34.96% (T-3), 32.87% (T-2) higher/more branches over control treatment. Similar trends were also reported earlier by Singh and Singh (2005), Raut et. al. (2014c, 2016a) in tomato, Raut et. al. (2014b) in soybean, Raut et. al. (2015a) in chickpea, Raut et. al. (2016a) in red gram and Raut et. al. (2016b) in okra.
iii) Days to Maturity

In regard to days required to maturity did not differ significantly due to application of chemical fertilizers along with TABA®. Recommended dose of days as compare to control (98.0 days). However, Raut et al. (2015a, 2015b, 2016b and 2016c) reported significantly more days to maturity than controls. The reason is that gibberellic acid application may delay in flowering and pod development resulted in more days to maturity (Courtier and Water, 1962).

iv) Seed yield/plant (g)

It is clear from the results (Table-1) that all the treatments gave significantly more seed yield/plant than control treatment. Average seed yield/plant was maximum in T-6 (RDF + TABA® @ 2.0 ml/L) with 3.60 g and minimum in T-10 (control) with 2.04 g. Likewise T-6 (RDF + TABA® @ 2.0 ml/L) recorded 76.47% higher yield than control treatment followed by T-1 (46.56%), T-9 (43.13%), T-5 (41.67%), T-4 (38.73%), T-8 (34.80%), T-3 (33.82%) and T-2 (32.84%) over control treatment. These results are in agreement with Mozakar et. al. (1994) and Nisar et. al. (2001) who also found that application of gibberellic acid increased the total yield of tomato. Higher yield than control treatments were also reported earlier by Saleh and Abdul (1980), Raut et. al. (2014a, 2016b) in tomato Maske et. al. (1998), Rehman et. al. (2004), Sarkar et. al. (2002) and Raut et. al. (2014b) in soybean.

v) 100 seed weight (g)

The differences for 100 seed weight were non-significant for different doses of TABA® and RDF and their combinations. However, T-6 (RDF + TABA® @ 2.0 ml/L) gave higher 100 seed weight (8.19 g) followed by T-9 (75% RDF + TABA® @ 2.0 ml/L) with 8.15 g; T-3 (TABA® @ 2.0 ml/L) with 7.94 g and control has fertilizer (RDF) (T-1) required maximum days to maturity (100 days), followed by T-3 (TABA® @ 2.0 ml/L) with 99.67 days, T-6 (RDF + TABA® @ 2.0 ml/L) and T-9 (75% RDF + TABA® @ 2.0 ml/L) with 99.33 minimum 100 g. wt. of 7.23 g. Likewise, T-6 treatment gave 13.28% higher 100 seed weight than control treatment followed by T-9 (12.72%), T-3 (9.82%), T-5 (5.81%) and T-8 (4.84%) treatment. However, Singh and Singh (2005), Raut et. al. (2014a, 2014b, 2016) reported more 100 seed weight than control treatment by using GA3 and TABA®.

vi) Straw yield (kg/ha)

Application of TABA® in combination with RDF significantly influenced straw yield. Treatment No.6 (RDF + TABA® @ 2.0 ml/L) recorded significantly highest straw yield of 1914 kg/ha followed by T-5 (RDF + TABA® @ 1.0 ml/L) with 1824 kg/ha, T-9 (75% RDF + TABA® @ 2.0 ml/L) with 1776 kg/ha, T-4 (RDF + TABA® @ 0.5 ml/L) with 1718 kg/ha and T-1 (RDF) with 1662 kg/ha and T-3 (TABA® @ 2.0 ml/L) with 1588 kg/ha over control treatment. Likewise, T-6 treatment gave 60.84% higher straw yield over control treatment (T-10) followed by T-5 (53.28%), T-9 (49.24%), T-4 (44.37%), T-1 (39.66%) and T-3 (33.45%) treatment. In the present study TABA®along with chemical fertilizers increases plant height, number of branches/plant, seed yield/plant and 100 seed yield ultimately resulted into more straw yield. This increase in morphological characters might be due to cell elongation of stems and improvement in growth due to Gibberellic acid content in the TABA® product. Similar results were also reported by Deotale et. al. (1988), Javaid and Mohmood (2010), Raut et. al. (2014b), Raut et. al. (2017), and Alghabadi et. al. (2009) in soybean.
### Table 1: Effect of TABA® on growth and yield contributing characters in soybean

| Tr. No. | Treatments                  | Plant height (cm) | No. of branches/ plant | Days to maturity | Seed yield/plant (g) | 100 seed weight (g) | Straw yield (kg/ha) | Protein content (%) | Oil content (%) | Seed yield kg/ha | % increase in yield over RDF |
|---------|-----------------------------|-------------------|------------------------|------------------|----------------------|---------------------|---------------------|---------------------|-----------------|-----------------|-----------------------------|
| T-1     | RDF                         | 41.53 (2.98)      | 2.07 (44.76)           | 100.00 (2.04)    | 2.99* (46.56)        | 7.48 (3.46)         | 1662* (39.66)       | 38.59 (3.54)        | 17.85 (0.68)    | 1236 * (23.60) |
| T-2     | TABA® @ 1.0 ml/L            | 41.73 (3.47)      | 1.87* (30.76)          | 98.67 (0.68)     | 2.71* (32.84)        | 7.38 (2.07)         | 1480* (24.37)       | 38.07 (2.15)        | 17.80 (0.39)    | 1111 (11.10)    |
| T-3     | TABA® @ 2.0 ml/L            | 42.00 (4.14)      | 1.90* (32.87)          | 99.67 (1.70)     | 2.73* (33.82)        | 7.94 (9.82)         | 1588* (33.45)       | 38.53 (3.38)        | 17.97 (1.35)    | 1146 (14.60)    |
| T-4     | RDF + TABA® @ 0.5 ml/L      | 41.92 (3.94)      | 1.93* (34.96)          | 98.67 (0.68)     | 2.83* (38.73)        | 7.48 (3.46)         | 1718* (44.37)       | 38.67 (3.76)        | 18.00 (1.52)    | 1315 * (31.50) |
| T-5     | RDF + TABA® @ 1.0 ml/L      | 43.07 (6.79)      | 1.97* (37.76)          | 98.67 (0.68)     | 2.89* (41.67)        | 7.65 (5.81)         | 1824* (53.28)       | 38.73 (3.92)        | 18.03 (1.69)    | 1532 ** (53.20) |
| T-6     | RDF + TABA® @ 2.0 ml/L      | 44.40 (10.09)     | 2.33* (62.93)          | 99.33 (1.36)     | 3.60* (76.47)        | 8.19 (13.28)        | 1914** (60.84)      | 38.90 (4.37)        | 18.13 (2.26)    | 1578 ** (27.67) |

Note: Asterisks indicate significant differences from RDF at p<0.05.
However, Rehman et al. (2008) reported that nitrogen is the most important element in protein synthesis and its increase in optimum conditions increased the amount of protein content. Similarly, Shehata and Khawas (2003) showed that application of biological fertilizer on sunflower increases seed protein. Likewise, Raut et al. (2019) reported that application of biofertilizers do not influenced significantly but increased 8.47% higher oil content than control treatment.

**viii) Seed yield (kg/ha)**

It can be seen from Table-1 that soybean crop responded very well and gave significantly higher yield than control treatment. Seed yield ranged from 1000 kg/ha (T-10 control) to 1578 kg/ha (T-6) which is 57.80% higher than control treatment. The significantly highest seed yield (1578 kg/ha) was reported by T-6 (RDF + TABA® @ 2.0 ml/L) treatment in rainfed conditions followed by T-5 (RDF + TABA® @ 1.0 ml/L) with 1532 kg/ha; T-9 (75% RDF + TABA® @ 2.0 ml/L) with 1347 kg/ha; T-4 (RDF + TABA® @ 0.5 ml/L) with 1267 kg/ha; and T-8 (75% RDF + TABA® @ 1.0 ml/L) with 1171 kg/ha as compared to control treatment (1000 kg/ha). Similarly, T-6 treatment gave 57.80% higher yield followed by T-5 (53.20%), T-9 (34.70%), T-4 (31.50%), and T-8 (26.70%) over control treatment. Similarly, T-6 and T-5 treatments gave 27.67% and 23.94% higher yield respectively over RDF also.

Application of chemical fertilizers or growth promoters (TABA®) increases cell growth and its elongation which leads to increase in plant height, no. of branches/plant, seed yield/plant, straw yield and 100 seed weight resulted into higher seed yield. Previous reports of gibberellic acid (GA) increases seed yield have been
reported by Saleh and Abdul (1980), Raut et. al. (2014a, 2016b) in tomato, Kumar et. al. (1996) and Raut et. al. (2016) in Okra, Maske et. al. (1998), Rehman et. al. (2004), Sarkar et. al. (2002) and Raut et. al. (2014b_c) 2019) in soybean. Similar Results of TABA® have been reported by Kanitkar et. al. (2013) in Bt. Cotton, and Raut et. al. (2014a, 2014b, 2015b, 2015c, 2016a, 2016b, 2016c) in tomato, soybean, red gram, onion, tomato, red grami and okra. The present findings are found to be confirmative with these above reports. Likewise, it is also noticed that the higher concentrations of TABA® along with RDF were more effective than the lower concentrations.

ix) Phyto-toxicity

The visual effect on soybean plants revealed that plants sprayed with TABA® did not showed any phytotoxicity on crop health recorded at 10 days after treatment for chlorosis, necrosis, wilting, scourching, hyponasty and epinasty, and showing ‘O’ visual rating.

IV. CONCLUSION

From the present study conducted under rainfed conditions it can be concluded that application of TABA® individually and along with RDF and 75% RDF significantly brought about an improvement in no. of branches/plant, yield/plant, straw yield/ha, and total seed yield in soybean. Hence two applications of TABA® @ 2.0 ml/L along with RDF significantly increase in number of branches/plant (62.93%), seed yield/plant (76.47%), straw yield (60.84%) and seed yield by 57.80% over control and 27.67% over RDF. Even, TABA® @ 2.0 ml/L in combination with 75% RDF can also help to increase yield upto 34.70% over control and 8.98% over RDF which indicated 25% saving in chemical fertilizer. Similarly, spraying of TABA® did not show any phytotoxic effect on soybean crop.

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