Response of Papaya (*Carica papaya L.*) cv. Taiwan to Foliar Potassium Nutrition through KGR Tab on Growth, Yield and Physiological Indices

Satish Kumar Yadav[1], Saurabh Tripathi[2], Sarjiwan Singh Manhas[3], Ram Dhanraj Pagar[4], Divakar Kumar[5], Parth Brat Yadav[6], Saurabh Kumar[7], Kousik Das[8]

[1,2,3,4,5,6,7,8] Crystal Crop Protection Ltd., Wazirpur, Delhi - 110052, India

***Abstract*—Papaya (*Carica papaya L.)* is an important fast-growing fruit crop known for its high-value, continuous harvest and nutritional value in tropical and subtropical producing regions. Introduction Potassium plays an essential role in various physiological processes that impact both growth and yield of plants due to its significant influence on water movement, enzyme activation, synthesis of starches and proteins. Among the nutrients obtained from soil, potassium mainly participates in photosynthesis, enzyme activation, osmotic regulation and translocation of assimilates, which are key physiological processes that directly determine plant growth and fruit development. To evaluate the effect of potassium plus micronutrients foliar formulation KGR Tab on growth parameters, yield attributes and productivity of papaya cv. during 2025–26 cropping season in Gujarat was conducted as a present study. Taiwan. The experiment was designed using a Randomized Block Design (RBD), with five treatments and three replications. Two important growth stages in terms of nutrient absorption during reproductive development, flowering and fruit set were selected for the application of foliar sprays. Results showed that potassium improved plant vigor, flowering, fruit retention and yield significantly higher than the control. KGR Tab alone gave 23.33 number of fruit/plants, which is higher as compared to the control, fruit length (22.33 cm.), fruit diameter (45.33 cm.) and yield t/ha (94.81). The improvements can be attributed to increased photosynthetic activity, better assimilate translocation and improved plant water balance. The conclusion of this study is that foliage potassium fertilizer use, through KGR Tab Applications results in significant improvement of physiological efficiency that leads to increased productivity in papaya.**

***Index Terms*—KGR, Potassium, Growth parameters, Yield**

I. INTRODUCTION

Papaya (*Carica papaya L.),* family Salicaceae, is one of economical the most important fruit crop producing in tropical and subtropical regions in the world. It is also appreciated because of its fast growth, early fruiting and high yield characteristics (6–12 months of planting) [3]. This crop provides high returns during the whole year due to continued fruiting and that is why farmers prefer it for fast economic rewards. Furthermore, papaya fruits are enriched in vitamins A, C and E, minerals, antioxidants as well as the proteolytic enzyme papain which has important applications in pharmaceutical, food and cosmetic industries. Papaya represents native to the tropics of South and Central America; India accounts for more than 40% of worldwide production, making it the leading producer. Still, the productivity average lags well behind where its potential lies. Deficiency of potassium became one of the major constraints for papaya production due to improper and imbalanced fertilization. As soils are depleted instead of replenished, potassium deficiency is a widespread problem on global scale due to shifting constantly in cultivation and intensive cropping systems.

Role of Potassium in Papaya:

Potassium (K) is a major macronutrient involved in regulating various physiological as well as biochemical plants processes. It is catalytic rather than a structural component of many processes in plants. Potassium activates more than 60 enzymes involved in food metabolism, protein synthesis and photosynthesis. You control opening and closing of stomata better. You save water, consume it more efficiently. Also, potassium is involved in the translocation of photo assimilates (sugars) from leaves to developing fruits through the vascular system and has a direct influence on fruit size, weight and quality. Adequate potassium availability improves fruit firmness, total soluble solids (TSS), sugar levels and shelf life. Hence, it enhances the stress tolerance of plants to a large-scale abiotic environment stress, such as drought, salinity, and extreme temperature [10]. In papaya, the symptoms include marginal chlorosis (yellowing) of leaves and stunted growth, smaller fruit size, decreased sweetness of the fruit, as well as increased flower and fruit drop cz of de lower health status meaning that the yield will be lower or for example reducing de market value.

Need for Foliar Nutrition:
Although potassium is well established as a soil fertiliser, it seldom exists in full availability for plant uptake due to soil fixation, leaching losses other less suitable soils. In addition, foliar fertilization is more effective and efficient as these nutrients are directly absorbed through the leaf surface and travel long distances to be used by the plant almost instantly. This is especially effective at certain critical developmental stages, namely when nutrient demand is at a maximum (flowering and fruit development).

About KGR Tab:
KGR Tab (1 tab/15 L) A proprietary formulation, KGR Tab is Advance Potassium based foliar prepared with slow releasing Fertilising Technologies for readily available potassium in Controlled release. Well, it ensures efficient absorption and is characterised by better nutrient utilisation efficiency and enhanced physiological activity in plants. It exposes K more directly to the foliage in papaya since (KGR Tab, 1 tab/15 L) supplies K onto foliage, further aiding growth and yield attributes as well as improving fruit quality.

Mythology and Cultural Significance:
Papaya is originally from Central America but has become naturalised worldwide and its cultural use in agricultural and traditional systems entrenched through centuries of time. It is commercially one of the most important fruit crops in our country and was brought into India by Portuguese traders 400 years ago during the second half of the 16th Century. In traditional Indian Medicine, papaya is highly valued for its gastrointestinal and therapeutic properties. Papain an enzyme obtained from papaya latex used to treat digestive disorders, promote digestion and healing of wounds. The fruit is said to also be used for liver health promotion and boosting immunity. Papaya is one of the most fruiting and fast-growing plants, which is why in tropical civilizations it has always symbolized fertility, masculinity and prosperity. Symbolizes continuous productivity and abundance with its habit of producing continuously.

II. MATERIALS AND METHODS

Soil of the experimental field was indicated to be clay loam in texture identified as highly suitable for papaya cultivation with its properties balancing water retention and aeration [9]. Clay loam soils retain the necessary moisture and nutrients to nourish plant life while providing adequate drainage due to its combination of sand, silt, and clay. Results showed that throughout the study, soil pH is with neutral to slightly alkaline reaction (pH = 7.2). The pH range also have a relatively positive impact on nutrient availability and uptake in papaya, as under such range of conditions most essential nutrients remain available for the plants. Soil organic carbon does also fall under the medium class at 0.58%. Organic carbon is crucial as it binds soil particles, increases microbial activity and enhances the ability of soil to retain nutrients. Its nitrogen (N) and phosphorus (P) from the medium are sufficient for vegetative growth and root development. The analyses showed that the binding K content was high and that the available K content was below 1. This scarcity might result in harm to the advancement of plants, improvement and yield of fruits which precipitates the clinical basis for this examination in potash increment at discrete remedy of KGR Tab (1 tab/15 L). Among the different experimental designs, Randomized Block Design (RBD) is one of the most widely used design in agriculture research to reduce variability due to field and hence to enable a meaningful comparison between treatments. A well-known design that is generally used in experimental studies is Randomised Block Design (RBD), which involves randomisation of treatments and investigations over large set of small blocks (also called as experimental field). This helps to minimize variation in soil conditions (for example moisture and texture), as along with environmental effects (e.g., wind waves). There were three replications of the experiment, that is, each treatment was repeated (in different blocks) three times. Replication allows statistical analysis, and reduces the influence of random variation, thus increasing results accuracy and reliability. Sufficient available area for growth and spacing for papaya plants (3 × 3 m interplanted). The goals are that proper space will maintain optimum interception of the sun through the plant crown, provide adequate circulation air as well as adequate root expansion space, so that these conditions enable healthy plants with high yield. Drip irrigation system through which gauged amount of water supplied to the plants. This method delivers targeted water directly to the root zone, reducing evaporation and ensuring persistent moisture availability. That also allows you to maintain soil moisture at ideal level thus favoring nutrient uptake and the general quality of plants.

Treatments Details

S. No.	Treatment
T1	Control
T2	KGR + Pluton
T3	KGR Tab (1 tab/15 L)
T4	Legend (FMC)
T5	Pluton

Observations Recorded:

Materials and Methods Data Collection the parameters: growth, reproductive and yield were measured to assess papaya performance with treatments applied. Plant height (cm) In order to assess the growth index of plants, plant height was recorded as taller plants have a greater nutrient uptake potential and favourable agro-environment conditions [30]. Stem girth was determined as a trait reflecting strength and mercility that has bearing on successful fruit set in is derived fodder crops to avoid lodging. Leaves were counted per plant as a surrogate for photosynthetic potential, since leaves are the primary nodes of food production. The more leaves, the better your plants grow. Flowering is a key stage controlling fruit set and we have measured the number of flowers per plant to investigate reproductive potential. To directly measure productivity, fruits per plant were counted. Fruit size and market quality were evaluated by measuring the fruit length and diameter, as larger fruits are generally favoured by consumers. Lastly, yield was assessed on a plant and hectare basis to quantify the economic performance of each treatment. Merged, these observations allowed for a comprehensive view of plant growth, development and productivity.

t-test:

T-Test: One of the most used statistical tests for hypothesis testing of difference between means. It is most used to test whether there is a statistically significant difference between the means of two groups or the mean of a single group against some known or hypothesized value. It is extremely useful in situations with small sample sizes (m, n < 30) but adaptable for larger datasets when required conditions are satisfied. The t-test functions by comparing the difference between group means scaled to the variability present within each of the two groups, represented in terms of standard error. In order to check whether these t values are significant or not, they can be compared against the critical values at an α-level of significance (most often 5%) in a t-distribution table. It is where more calculated value will be with the critical value that difference between the two groups is considered statistically significant. In conclusion, the t-test is a straightforward yet powerful method for estimating treatment effects and drawing meaningful conclusions about the data collected from your experiment.

Analysis of variance (ANOVA):

Analysis of variance (ANOVA) was conducted for pest population, crop health parameters and yield data among various treatments. This method enables you to know if the differences between treatments that have been seen takes place because of the true treatment, or experimental noise. Contrast that's ANOVA if you will take a look at behemoth component of the total variance among experimental groups. After the determination of all specific differences by ANOVA, means for incides ions concentrations in treatments were separated using LSD test at 5% significance level. So, then we can do the post-hoc test with that to tell which pairs of treatments are different from each other significantly. The statistical procedures were carried out according to the procedure of Gomez and Gomez (1984), applied in agricultural research. The discussions of science-based robustness and certainty associated with quantifying active substances on pest occurrence, crop health and yield performance ensure scientific credibility.

Duncan’s Multiple Range Test (DMRT):

Duncan's multiple range test (DMRT) is a common post-hoc statistical procedure implemented after Analysis of Variance (ANOVA) for the use of determining specific differences among treatment means. The ANOVA determines if we have significant differences among the treatments and DMRT tells us exactly which one differs from the other. This method ranks the means of treatments either in ascending or descending order and compares treatment using a range value calculated from the experiment data. Means are therefore grouped together with letters to indicate statistically similar groups. Treatments labelled with the same letter are not significantly different from one another ($p < 0.05$), whilst treatments that received different letters differ significantly in their performance. It is mainly used in agricultural experiments contrasting more than one treatment at a time for yield, growth or pest reduction (e.g. This creates a simple and straightforward comparison of treatments, which can be useful for drawing valid inferences and recommending the most effective treatment in clinical studies.

Colby’s Method for Synergism/Antagonism:

A two-way interaction effect of treatment combinations was examined by comparing the observed mortality rates of KGR on papaya pests with the expected mortality value determined according to Colby’s formula (Colby, 1967). This method is often used to determine whether the combined effect of two active components is synergistic, additive, or antagonistic in this regard. Expected mortality is calculated mathematically based on each component working alone (individual efficacy), allowing a prediction for combined activity. The nature of interaction between treatments can be precisely determined by comparing the expected value with actual observed mortality under field conditions. If the observed mortality risk is (much) higher than expected, it indicates synergism, whereas if the value is lower, this suggests antagonism. If both values are close enough, it is considered an additive effect. This way, the analytical foundations for comprehending how species interact in relation to treating actions (i.e., effects on crops and pests) with combined treatments are established, and potentially excellent combinations that maximize pest management while increasing crop protection efficacy can be identified.

$$E = (A + B) - \frac{(AB)}{100}$$

where E is the expected mortality, and A and B are the observed mortalities of individual components.

Synergistic effects were indicated if the observed mortality was greater than the expected mortality, while antagonistic effects were noted if the observed mortality was lower.

Validation and Interpretation:

The analysis of variance (ANOVA) results provided a significant foundation for comparison of the various treatments as well as discovering substantial differences among treatment groups. This allowed resolving how much each treatment affected the measured parameters of interest. Secondly, Colby method of investigating interactions between insecticidal component of formulations was performed to assess whether combined effects were additive, synergistic or antagonistic. In this example we added the ANOVA results to analyze the dialog batch throughput for an even broader and more interpretable insights, in combination with Colby’s interaction analysis (multiple range tests). The combination of these analyses enabled an evaluation of the effectiveness and efficiency of a newly developed formulation on pestial suppression and yield increase. Such a cumulative evaluation not only reinforced the findings, but it also helped in designing the optimal treatment parameters to produce better field growth.

III. RESULTS AND DISCUSSION

Results and discussion: The outcomes shown that potassium-based treatment was significantly influenced the growth parameters, yield attributes and yield of papaya over control. The maximum values of plant height, stem girth and number of leaves were observed in treatment T3 which shows improvement in vegetative growth and vigour of plant. By contrast, T3 further induced optimum productivity that included maximum yield components (fruits per plant, length and diameter of fruit). The increase in yield essentially is a result of the better photosynthate use with improved Photosynthetic efficiency, along with enhanced nutrient (NPK) uptake and efficient assimilation translocation in favour of developing fruits. These results of the present work confirm for papaya plant that potassium contributes to growth and yield performance.

Correlation Analysis:

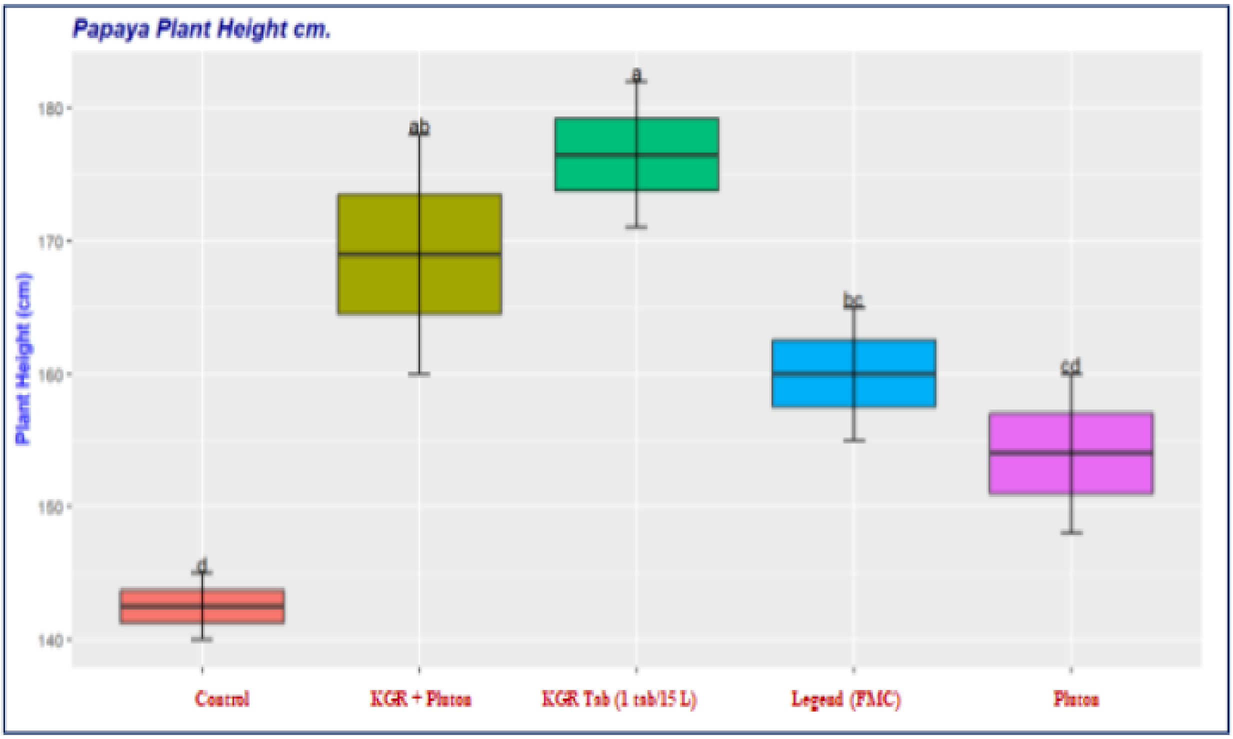
This is useful when the vegetative and reproductive growth stages are both strongly positively associated with yield (t/ha) in papaya, as indicated by a high correlation coefficient (r) of 0.68 and 0.69 between T30 and T40, respectively for both growth phases at P value $\leq$ 0.01 level (Table I). Higher yields were associated with increased early growth as both plant height stem girth and number of leaves were correlated on yield at vegetative stage. Likewise, in the reproductive stage, flower number and fruit set as well as fruit size exhibited a strong correlation with yield. This proves that both elms are critical for final yield. In conclusion, the highly positive correlation at both stages indicates that better vegetative growth leads to greater reproductive performance, translating into increased papaya yield.

Stage	Parameter	Correlation (*r*)
Vegetative	Plant Height (cm)	0.99
	Stem Girth (cm)	0.99
	Leaves/Plant	0.98
Reproductive	Fruits/Plant	0.99
	Fruit Length (cm)	0.99
	Fruit Diameter (cm)	0.99

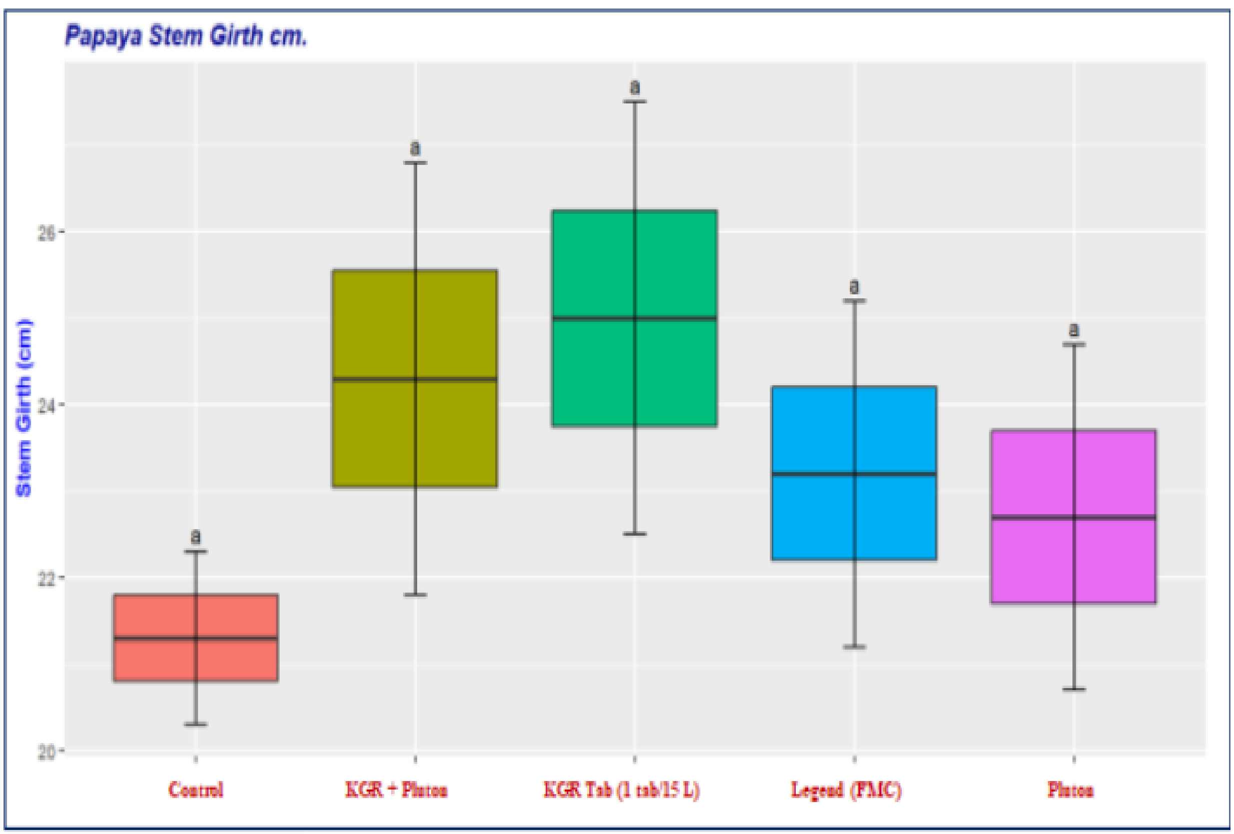
Growth Parameters:

It was statistically at par with T2 (Table 1) and data pertaining to growth parameters clearly revealed the most superior vegetative performance of treatment T3 over all other treatments. The data on plant height cm:182, stem girth (cm): 27.5 And Leaves per plant(No) :38 Figure fourth showed that T3 was the best treatment it produced significantly highest value and this is back to T3 grouped by letter “a” This indicates that T3 belongs to the class with the best overall performance and was statistically superior to treatments T4 and T5, which were all classified in group b, with one exception being the control T1 placed under the categorization group c. The identical grouping of T2 and T3 under ‘a’ land are statistically similar, shows that the two treatments (T2 &T3) have comparable growth promoting effect. Despite this, T3 numerically outperformed T2 in all parameters measured, indicating that vegetative vigor was improved with T3 compared to control, increasing nutrient uptake and physiological activity. Treatments T4 and T5, on the other hand, achieved intermediate growth performance and treatment T1 had consistently the lowest values, indicating weak vegetative development owing to lack of successful nutrient supplementation. All in all, T3 exhibited the most beneficial growth response indicating a reinforced plant structure and increased plant vigor, which is crucial for reproductive development and optimum yield potential under field conditions.

Treatment	Plant Height (cm)	Stem Girth (cm)	Leaves/Plant
T1	145	22.3	28
T2	178	26.8	36
T3	182	27.5	38
T4	165	25.2	33
T5	160	24.7	32



*Mean followed by the superscript (a, b & c) of same at p<0.05 based on Duncan's Multiple Range test (DMRT)



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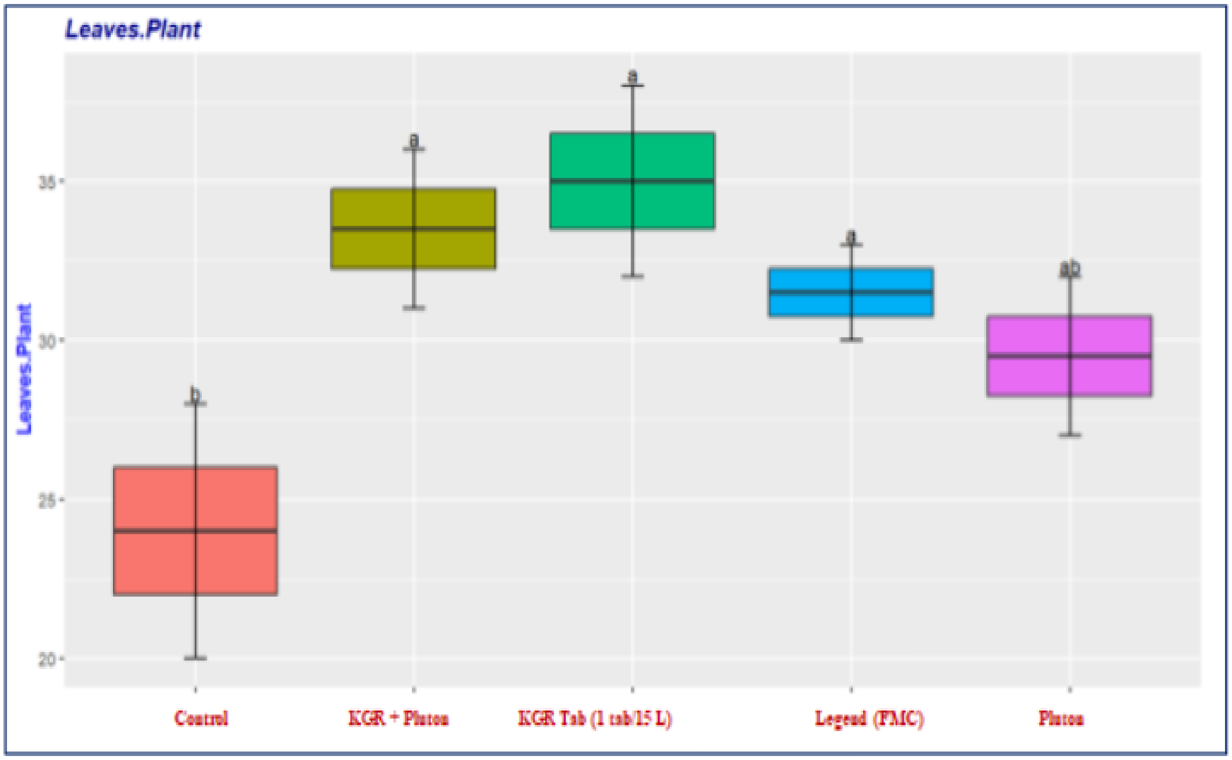
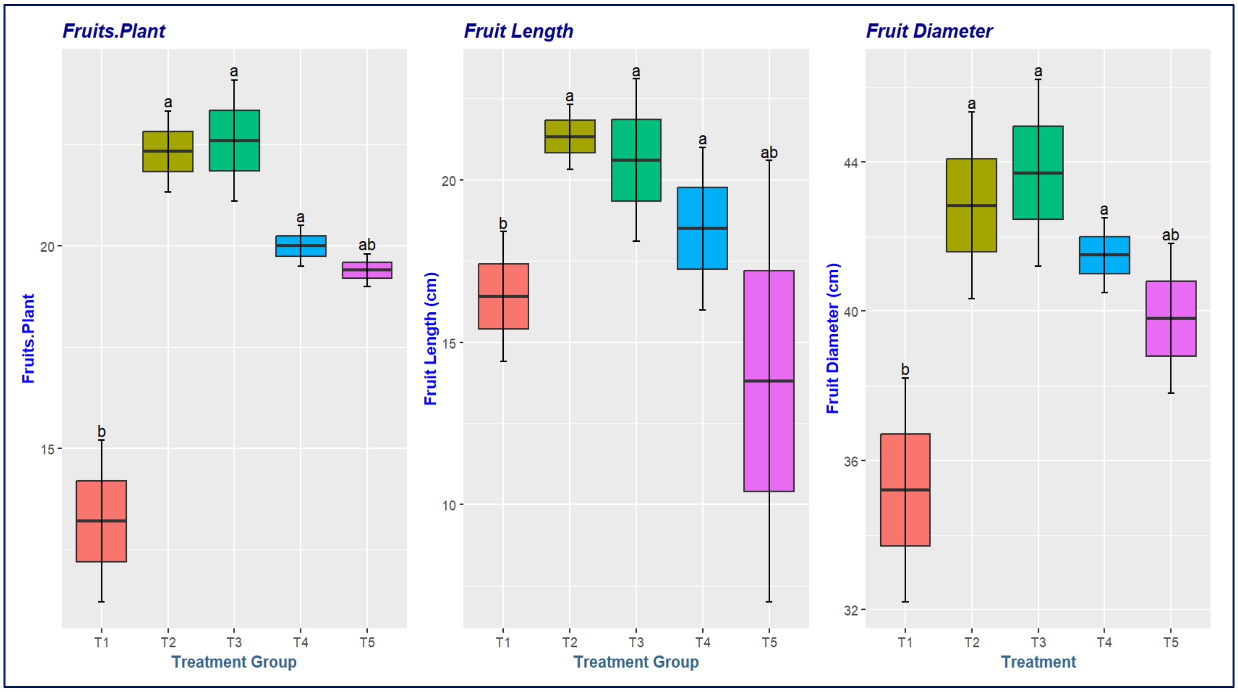


*Mean followed by the superscript (a, b & c) of same at p<0.05 based on Duncan's Multiple Range test (DMRT)

Yield Attributes:

The data of the yield attribute indicated that treatment T3 (KGR Tab (1 tab/ 15 L)) was found to be superior having the best performance in all parameters as compared to other treatments, but it was statistically on par with T2 for all observed characteristics. In the comparison of means: The maximum values for fruits per plant (24.1), fruit length (23.1 cm) as well as fruit diameter (46.2 cm) were recorded in T3-KGR Tab (1 tab/15 L), and all these values were placed in grouping with significance letter “a”. This means that T3 is part of the best performance group and statistically different from treatments T4 and T5, classed in "b", as well as clearly superior to the control T1, classified in "c". Even though T2 also comes under the same significance group “a”, T3 numerically improved all the yield attributes showing better fruit development and reproductive efficaciously over others. This improvement is translated into better physiological activity in the plant, increased nutrient uptake, and more assimilate translocation resulting in greater fruit size and numbers. Comparatively, all the performance parameters showed moderate values for T4 and T5, while continually recording the poor values of all measured parameters from treatments with T1. Thus, it can be inferred that T3 KGR Tab (1 tab/15 L) showed better yield attributes along with good field performance and it is one of the most effective treatments for enhancing papaya productivity under prevailing experimental conditions. ANOVA showed significant differences among treatments and DMRT indicated that T3 was superior to market standards (T4 and T5) control, but at par or slightly better with the rest of the treatments. The enhancement in performance of T3 can be ascribed to improved photosynthesis, more efficient assimilate translocation and quicker fruit development.

Treatment	Fruits/Plant	Fruit Length (cm)	Fruit Diameter (cm)
T1	15.20	18.40	38.20
T2	23.33	22.33	45.33
T3	24.10	23.10	46.20
T4	20.50	21.00	42.50
T5	19.80	20.60	41.80



*Mean followed by the superscript (a, b & c) of same at p<0.05 based on Duncan's Multiple Range test (DMRT)

Control (T1) KGR + Pluton (T2) KGR Tab (1 tab/15 L) (T3) Legend (FMC) (T4) Pluton (T5)

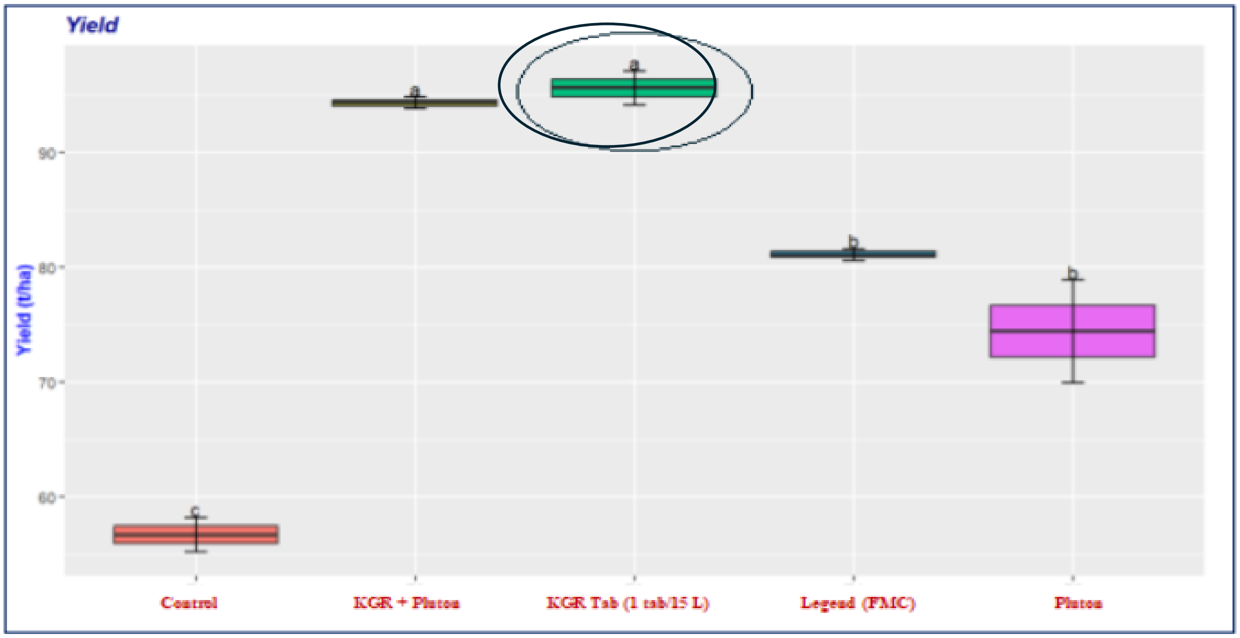
Yield: Results obtained from yield data (Table 2) indicate that treatment T3 KGR Tab (1 tab /15 L) is the best performing treatment among all treatments and was significantly superior in both terms of yield per plant as well as yield per hectare. The other treatment resulted (T3) showed the best performance over other treatments in term of yield per plant (88.2 kg/plant and stats ap to T2.) and t/ha with 97.1 t/ha. The presence of the same significance letter "a" for T2 and T3 suggests that both treatments are statistically equal at the 5%, although again T3 showed a marginal numerical advantage in this trial producing better field performance. In contrast, the control treatment T1 showed the lowest yield (52.4 kg/plant; 58.2 t/ha.) and was denoted by c, meaning that it was significantly lower than all other treatments. Treatments T4 (72.5 kg/plant, 80.6 t/ha) and T5 (70.8 kg/plant, 78.9 t/ha) were also intermediate but considerably lower than both treatments T2 and T3 in grouping letter "b". Consequently, T3 presented higher consistency of the response with productivity and was obtained the highest fruit doi (where doi represents number of injuries) among all other treatments, this fact can also be ascribed to better availability of nutrients and a high physiological efficiency.

Treatment	Yield (kg/plant)	Yield (t/ha)
T1	52.4	58.2
T2	85.33	94.81
T3	88.2	97.1
T4	72.5	80.6
T5	70.8	78.9

Analysis of Variance: Response variable Papaya Yield

When KGR Tab (1 tab/15 L) was evaluated under a randomized block design (RBD), it produced significant effects for statistically significant LSD and high coefficient of determination (R^2=0.98), establishing an excellent model fit; the normality assumption was not violated, moreover, experimental precision is declared via low values of Sem (1.87) and Sed (2.64); Coefficient of variation CV=3.28%; Finally indicated by t-value calculated to LSD 7.34 in comparing with t-values, i.e., 10% level (-2.77) of significance between treatments, could be considered extremely significant among them).

Variable	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Replication	1	22.4	22.50	3.21	0.14
Treatment	4	2045.4	511.35	73.05	0.0005 ***
Residuals	4	28.0	7.00		
*Significance codes: *** 0.001; ** 0.01; * 0.05*					



*Mean followed by the superscript (a, b & c) of same at p<0.05 based on Duncan's Multiple Range test (DMRT)

It is a component of physiological functions, which helps to improve the performance of crops. Enhancing Photosynthesis: One of its main functions is enhancing the photosynthesis process, regulating chlorophyll synthesis and stomatal activity to increase carbon dioxide uptake in plants and as a result energy production. It also improves assimilate translocation by enhancing transport of sugars formed in leaves to developing fruits which enhances fruit growth and increases fruit size. Potassium is also involved in stomatal opening and closing, which makes it more efficient for water use and saves transpiration. Whether it is flower drop reduction through hormonal balance which makes fruit density higher and yield potential better. In addition, potassium has been documented to improve tolerance of plants to some common non-biological stresses including drought and salinity which allow for stable performance under adverse environmental conditions. These results provide support of previous work reported by Cakmak (2005) who emphasized the importance of potassium in stress tolerance, Koch *et al.* Zhang *et al.* (2019), who highlighted its importance in partitioning assimilation and Zhang et al. Potassium Nutrition on Quality Improvements in Fruit Despite the leisure of content by Musab Dweib *et al.*

IV. CONCLUSION

The current study confirms that foliar application of KGR Tab (1 tab/15 L) positively promotes growth, yield attributing parameters along with overall productivity of papaya (Carica papaya L.) cv. Taiwan under field conditions. The vegetative growth of treated plants was significantly higher including plant height (178 cm), stem girth (26.8 cm), number of leaves (36) leading to healthy plant vigour and better physiological efficiency. Further, he observed that flower and fruit drops were significantly lower in seedlings supplemented with K, resulting in significantly higher number of flowers and fruits per plant than control (23.33 vs. 15.2/ plant). While KGR Tab application resulted in fruit size increments having 22.33 cm length and 45.33 cm diameter which resulted in an increase of marketable yield. The yield was 85.33 kg per plant (94.81 t/ha), which was significantly improved compared to the control (52.4 kg per plant and 58.2 t/ha). These improvements are primarily associated with the function of potassium in photosynthesis, activation of enzymes, assimilate transport and maintaining water balance within plant tissues. The foliar application assured fast nutrient availability during critical stages like flowering and fruit setting. Statistical analysis with Randomized Block Design (RBD)propped the accuracy of results (R^2=0.98, CV=3.28%). Consequently, KGR Tab can be recommended to improve the production and quality of papaya fruits.

KEY CONCLUSIONS AND RECOMMENDATIONS

- KGR Tab (1 tab/15 L) demonstrates statistically significant superiority over individual components ($p < 0.05$).
- Strong dose-response relationship with yield plateau above KGR Tab (1 tab/15 L).
- Maximum yield achieved at KGR Tab (1 tab/15 L).
- Excellent safety profile with zero phytotoxicity across all doses

ACKNOWLEDGEMENT

Field Biology Division, Research and Development, A unit of, Crystal Crop Protection Ltd., B-95, Wazirpur Industrial Area Road, Block B, Phase 2, Ashok Vihar, Delhi, 110052, India

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