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# "To Evaluate Potassium Salt of Phosphonic Acid, Against Late Blight (Phytophthora Infestance) in Potato"

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***Abstract:** Potassium salt of phosphonic acid is an elicitor of defence compounds that acts by systemic action for enhancing the plant's natural defense mechanisms. It is believed to stimulate the production of phytoalexins, which are antimicrobial compounds produced by plants in response to pathogens. Furthermore, phosphonates can interfere with the pathogen's ability to infect plant tissues and can inhibit spore germination and mycelial growth of Phytophthora infestans.*

***The study aimed to evaluate the efficacy of the potassium salt of phosphonic acid (trade names: Defend, Sanchar 40), alone and in combination with the ajujuvant in controlling late blight disease caused by Phytophthora infestans in potato cultivar Kufri Ashoka was taken during the Rabi season of 2021-22. The trial was conducted at the Zonal Agricultural Research Station, Chhindwara, M. P., The experiment was laid a Randomized Block Design with seven treatments for bio-efficacy and three for phyto-toxicity, studies, respectively. A total of three foliar applications as well as soil drenching were given at 10-days intervals, the disease incidence was assessed before and 10 days after treatment. Results indicated significant improvements in disease reduction, plant height and tuber weight with treatments involving Potassium salt of phosphonic acid. The best-performing treatment, PSPA at 2.5 g/lit combined with adjuvant and drenching of Potassium salt of phosphonic acid at 2.5 g/lit, resulted in a minimum percent disease incidence (PDI) of 8.95, a disease control rate of 81.33%, and gave maximum tuber yield of 189.10 q/ha, which was significantly higher than the untreated control. Furthermore, the treatment's cost-benefit ratio was notably favourable at 1:3.18. Other treatments with PSPA also demonstrated substantial disease control and yield potential, indicating the efficacy of potassium phosphonate formulations in managing late blight in potato crops.***

***The study highlights the potential of PSPA as an effective tool in management of late blight caused by Phytophthora infestans in potatoes. The significant reductions in disease incidence and the improvements in yield and plant growth observed with various treatments emphasize the value of PSPA in agricultural practices. Additionally, the better cost-benefit ratio further supports its practicality for use in commercial potato farming. These findings suggest that phosphonate-based treatments, especially when combined with appropriate adjuvants, can serve as a reliable, eco-friendly, and economically viable input for managing late blight and enhancing potato productivity.***

***Keywords:** Potassium salt of phosphonic acid (PSPA), Phytopathogens, Phytophthora infestans, Bio-efficacy, Phyto-toxicity, Disease incidence, Field efficacy, Tuber yield, Disease severity, Agricultural sustainability, Economic benefits, Adjuvant use, Phytoalexins, Plant defense mechanisms.***

## I. INTRODUCTION

Potato (*Solanum tuberosum L.*) is one of the most important staple crops globally, playing a vital role in food security and the agricultural economy. In India, the potato is a key crop grown in most of the area during the rabi season, contributing significantly to the livelihood of farmers and the availability of food. However, the crop is highly susceptible to various diseases, particularly late blight, caused by the oomycete pathogen *Phytophthora infestans.* Late blight is responsible for severe crop losses, leading to reductions in both yield and quality, and has historically been a major concern for potato producers (Gladieux *et al.,* 2011; Liew *et al.,* 2017). Effective management of late blight is critical for sustainable potato production, and the development of innovative management strategies is imperative. Systemic action products, such as PSPA, have emerged as potential tools for disease management due to their ability to enhance plant defence mechanisms and activate Phytoalexin production (Tosun *et al.,* 2017). These compounds can provide protection against pathogens while minimizing environmental impact, a crucial factor in promoting agricultural sustainability (Huang *et al.,* 2016).

The incorporation of adjuvants can further improve the effectiveness of these foliar spray treatments by enhancing their uptake and adherence to plant surfaces, thereby maximizing their potential for controlling late blight disease (Meyer *et al.,* 2010). This study evaluates the bio-efficacy of various concentrations of PSPA, both with and without adjuvants, in managing late blight in the potato cultivar Kufri Ashoka during the rabi season of 2021-22.

By assessing disease incidence, severity, tuber yield, and cost-benefit ratios, this research aims to contribute to the development of integrated disease management practices. Such practices can help ensure profitable potato production while addressing the challenges posed by foliar diseases, ultimately supporting agricultural sustainability.

## II. MATERIALS AND METHODS

### A. Experimental Design

The study was conducted during the Rabi season of 2021-22 to evaluate the efficacy of PSPA against Late blight disease (*Phytophthora infestans*) in potato variety: Kufri Ashoka. A randomized block design (RBD), consisting of seven treatments with three replications was used. The data were analysed as per standard statistical methods.

### B. Treatments

| S.N. | Treatments |
|---|---|
| $T_1$ | Potassium salt of Phosphonic acid 2g/lit spray with Adjuvant @ 0.5 ml/lit |
| $T_2$ | Potassium salt of Phosphonic acid @2.5 g/lit spray without Adjuvant |
| $T_3$ | Potassium salt of Phosphonic acid @2.5 g/lit spray with Adjuvant @ 0.5 ml/lit |
| $T_4$ | Potassium salt of Phosphonic acid 2 g/lit spray with Adjuvant @ 0.5 ml/lit and drenching of Defend @2g/lit |
| $T_5$ | Potassium salt of Phosphonic acid @2.5 g/lit spray with Adjuvant @ 0.5 ml/lit and drenching of defend 2.5g/lit |
| $T_6$ | Potassium salt of Phosphonic acid @2 g/lit plus Mancozeb @2.5g/lit spray with Adjuvant @ 0.5 ml/lit |
| $T_7$ | Untreated control |

### C. Application of Treatments

The fungicides were applied by a knapsack sprayer equipped with a hollow cone nozzle at the first appearance of the disease, using a spray volume of 500 liters per hectare. Three consecutive applications were performed, spaced at 10-day intervals. The treatments were applied as per treatments, and the following observations were recorded.

### D. Disease Assessment

The per cent disease incidence (PDI) was recorded before the initiation of treatment and at 5 and 10 days after each application. A disease severity assessment was conducted using a disease scoring scale (0-5) as described by Mohan and Thind (1999), as under.

| Score | Symptoms on foliage/leaf |
|---|---|
| 0 | No visible symptoms |
| 1 | 0-10 percent infection |
| 2 | 11-25 percent infection |
| 3 | 26-50 percent infection |
| 4 | 51-75 percent infection |
| 5 | >75 percent infection |

### *E. Calculation of the PDI*

Per cent Disease Incidence (PDI) for each treatment was calculated by following the standard formula: Six diseases categories were made on the basis of percent leaf area infected as shown in above table and percent disease intensity was calculated using formula:
PDI= of n*v/N*G*100
Where, submission, n= Number of leaves in each category. V =Numerical value of each category; N=Total number of leaves examined; G= Maximum numerical value.
Disease incidence (%)= No. of infected plants/ Total no. of plant assessed x 100
Per cent disease intensity: The intensity was assessed by using 0-5 rating scale (Shahzad and Bhat, 2005).
Disease Control (%) = Disease index in control treatment- Disease index in treatment X 100
Disease index in control (unsprayed) treatment

### *F. Yield Assessment*

The tuber yield was recorded for each plot, and yields were converted into Quintals per hectare (q/ha) basis. The marketable yield was also assessed. The cost-benefit ratio for each treatment was calculated to evaluate economic viability. The plant height, and average tuber weight were recorded at different stages of growth to evaluate the effect of treatments on the overall growth of potato plants.

## III. RESULTS AND DISCUSSION

### *A. Effect on Plant height and Tuber weight*

The application of PSPA showed statistically significant effects on plant height and tuber weight. The treatment with Potassium salt of Phosphonic Acid @2.5 g/lit, applied as foliar spray with an adjuvant and as soil drenching, resulted in the maximum plant height of 80.84 cm and tuber weight of 6.13 kg per plot significantly outperforming the control which exhibited a height of 64.46 cm and a tuber weight of 3.98 kg per plot. Treatment with PSPA @2 g/lit alone also yielded impressive results, with a height of 79.21 cm and tuber weight of 5.51 kg, (Table 1) indicating a positive response of PSPA as it also has property of stimulating plant growth. These findings suggest that PSPA enhances plant growth parameters, particularly in promoting taller plants which results in more tubers, these results are supported by essential factors contributing to overall yield reported by Khanna *et al.,* (2011) and Mukherjee *et al.,* (2015).

Table 1 Effect of PSPA on Plant height and Tuber weight of Potato

| Sr. No | Treatments | Height (cm) at 75 DAP | Average tuber Weight (kg/plot) |
|---|---|---|---|
| 1 | Potassium salt of Phosphonic acid @2g/lit spray with Adjuvant | 75.33 | 4.61 |
| 2 | Potassium salt of Phosphonic acid @2.5 g/lit spray without Adjuvant | 72.00 | 3.85 |
| 3 | Potassium salt of Phosphonic acid @2.5 g/lit spray with Adjuvant | 76.67 | 4.97 |
| 4 | Potassium salt of Phosphonic acid @2 g/lit spray with Adjuvant and drenching of Potassium salt of Phosphonic acid @2g/lit | 79.21 | 5.51 |
| 5 | Potassium salt of Phosphonic acid @2.5 g/lit spray with Adjuvant and drenching of Potassium salt of Phosphonic acid @2.5g/lit | 80.84 | 6.13 |
| 6 | Potassium salt of Phosphonic acid @2 g/lit plus Mancozeb @2.5g/lit with Adjuvent | 75.67 | 4.86 |
| 7 | Untreated control | 64.46 | 3.98 |
| | SEm $\pm$ | 1.74 | 0.58 |
| | CD @ 5% | 3.62 | 1.70 |

### *B. Effect on incidence of Late Blight Disease of Potato (Phytophthora infestans) and disease intensity*

The potassium salt of Phosphonic acid enhances plant defence through a dual mode of action: directly inhibiting oomycete pathogens and inducing systemic resistance by stimulating defence-related compounds like phytoalexins and PR (Phytogenesis Related) proteins. It also supplies potassium, improving plant vigour and stress tolerance. This makes it an effective and sustainable tool in integrated disease management. The assessment of late blight disease incidence revealed that all treatments were effective in reducing disease severity. Particularly, the application of Potassium salt of Phosphonic acid @2.5 g/lit with an adjuvant exhibited the lowest percent disease incidence (PDI) of 8.95, % disease intensity 3.61 and a disease control rate of 81.33%. These results are in accord with reports by Dorrance and Dyer (2009), who emphasize the efficacy of phosphonates in managing Phytophthora diseases in crops. As potassium phosphate has direct fungicidal properties, it inhibits growth and development of *phytophthora infestance*, the causal organism of late blight and reduce the severity of symptoms and minimise yield losses. The second best treatment, Potassium salt of Phosphonic acid @2 g/lit with similar application methods, also showed substantial control with a disease intensity of 4.70%. Such outcomes align with the current understanding that phosphonic acid derivatives can initiate systemic acquired resistance, enhancing plant vigour and disease resistance (Cohen, 2005). Due to systemic action PSPA when applied as foliar spray allow its direct uptake by the plant and this can be used in IPM and also can be combined with chemical fungicide for management of late blight. While the untreated control recorded a significantly higher PDI of 47.95, the comparative lower values in treated plots illustrate the effectiveness of these treatments in disease management strategies. Data presented in Table 2 show the response of PSPA on PDI after each application where all treatment showed significant reduction in PDI over control. This may be due to inhibitor of Phytophthora growth as reported for *Phytophthora nicotiane* by Ingle *et. al.* (2020) where 100% inhibition was observed.

Table 2: - Effect of PSPA on leaf blight incidence and intensity in Potato during Rabi, 2021-22

| Treatments | % Disease reduction over control | | | |
|---|---|---|---|---|
| | 10 days after first Application | 10 days after second spray | 10 days after third spray | % disease intensity at third spray (10 DAA) |
| Potassium salt of Phosphonic acid @2g/lit spray with Adjuvant | 49.62 | 59.66 | 65.76 | 5.72 |
| Potassium salt of Phosphonic acid @2.5 g/lit spray without Adjuvant | 45.34 | 55.61 | 61.84 | 7.75 |
| Potassium salt of Phosphonic acid @2.5 g/lit spray with Adjuvant | 51.85 | 61.92 | 68.07 | 5.66 |
| Potassium salt of Phosphonic acid @2 g/lit spray with Adjuvant and drenching of Potassium salt of Phosphonic acid @2g/lit | 59.05 | 72.94 | 80.98 | 4.70 |
| Potassium salt of Phosphonic acid @2.5 g/lit spray with Adjuvant and drenching of Potassium salt of Phosphonic acid @2.5g/lit | 60.21 | 73.66 | 81.33 | 3.61 |
| Potassium salt of Phosphonic acid @2 g/lit plus Mancozeb @2.5g/lit with Adjuvent | 53.70 | 64.81 | 70.91 | 5.17 |
| Untreated control | - | - | - | 17.94 |
| SEm $^{+}_{-}$ | | | | 1.19 |
| CD @ 5% | | | | 3.51 |

The potassium phosphonate exhibits direct antifungal activity as well as induction of plants defence response stimulating plant defence mechanism enhancing the potato plants natural resistance to infection. These properties help in control of late blight reducing the severity of symptoms and thus PSPA can be used in IPM due to its efficacy and safety from late blight and reduce the risk of yield loss. Similar results were obtained by Ingle *et. al.* (2020) in Nagpur mandarin, where PSPA (Sanchar 40) foliar sprays and soil drenching @ 3ml/lit recorded in reduction in number of lesion with oozing caused due to *Phytophthora necotinae* causing gummosis in citrus.

### C. *Effect on Tuber Yield*

In respect to yield the treatments involving PSPA application resulted in higher tuber yield and also marketable yield respectively. The maximum yields observed were 189.10 q/ha gross yield and 187.31 q/ha marketable yield for PSPA foliar spray @ 2.5 g/lit with adjuvant and drenching. This is a noteworthy increase in yield compared to untreated controls, which achieved just 139.24 q/ha gross yield (Table 3). Previous studies have indicated that Phosphorus is an essential nutrient for plant growth, for tuber development as playing a crucial role in various physiological and biochemical processes. Its importance in tuber development, particularly in crops like potatoes, is well-documented. (Bajpai *et al.* 2017)

Although application of Mancozeb with PSPA showed reduced disease (PDI) over control, the PSPA has significant potential for use in combination with conventional fungicides in integrated disease management programs. Its dual action—direct antimicrobial effects against oomycete pathogens and induction of systemic resistance in plants—makes it a strong candidate for enhancing the efficacy of chemical fungicides. When used together, PSPA can reduce the required dosage of chemical fungicides, lower the risk of resistance development in pathogens, and improve overall disease control. This synergistic use is particularly effective in managing soil- and foliar-borne diseases in crops. Its compatibility with various fungicide classes further supports its integration into sustainable and long-term crop protection strategies. The better response of treatments with foliar application and drenching may be due to Phytophthora as soil borne pathogen and it is managed in a better way by combining foliar sprays and soil drenching. Soil drenching often gives better performance because it may allow the systemic absorption of PSPA through the roots, ensuring efficient translocation throughout the plant. This method enables the compound to reach target tissues quickly, especially the vascular system, where it can both inhibit root pathogens directly and stimulate systemic resistance more effectively. In the trial on citrus conducted by Ingle *et. al.* (2020) also PSPA used as foliar sprays with soil drenching increased canopy volume and fruit yield in Nagpur Orange. Additionally, it may provide longer-lasting protection compared to foliar sprays, particularly against soil-borne diseases.

### D. *Cost Benefit Ratio*

The cost-benefit analysis demonstrated that the treatment involving PSPA @2 g/lit with adjuvant yielded the highest cost-benefit ratio of 1:3.18 (Table 3), indicating efficient use of inputs resulting in better returns. This reflects favourable economics in producing potatoes with applied input costs justifiable through increased productivity and profitability (Ali *et al.,* 2020). The effectiveness of PSPA in foliar applications can be improved by using the right adjuvants. Non-ionic surfactants, organosilicons and penetrants help to improve spray coverage, lower surface tension, and allow better penetration through plant surfaces. This enhances the systemic uptake and movement of potassium phosphite within the plant. Combining potassium phosphite with non-ionic surfactants or micronutrient-enriched blends, such as zinc and manganese, has shown better absorption and longer-lasting protection in various crops. Organosilicone adjuvants are especially good at promoting stomatal penetration due to their superior spreading and wetting abilities. (Coates & Lee 2011)

Table 3: - Effect of Potassium salt of Phosphonic acid on yield and C: B ratio in potato

| Sr. No | Treatment | Tuber gross yield (q/ha) | Marketable Yield q/ha | Cost benefit Ratio |
|---|---|---|---|---|
| 1 | Potassium salt of Phosphonic acid @2g/lit spray with Adjuvant | 169.10 | 168.64 | 1:1.98 |
| 2 | Potassium salt of Phosphonic acid @2.5 g/lit spray without Adjuvant | 166.26 | 165.75 | 1: 1.85 |

| | | | | |
|---|---|---|---|---|
| 3 | Potassium salt of Phosphonic acid @2.5 g/lit spray with Adjuvant | 173.05 | 172.42 | 1:2.47 |
| 4 | Potassium salt of Phosphonic acid @2 g/lit spray with Adjuvant and drenching of Potassium salt of Phosphonic acid @2g/lit | 188.82 | 186.94 | 1: 3.18 |
| 5 | Potassium salt of Phosphonic acid @2.5 g/lit spray with Adjuvant and drenching of Potassium salt of Phosphonic acid @2.5g/lit | 189.10 | 187.31 | 1: 3.07 |
| 6 | Potassium salt of Phosphonic acid @2 g/lit plus Mancozeb @2.5g/lit with Adjuvent | 176.30 | 176.01 | 1:2.04 |
| 7 | Untreated control | 139.24 | 137.95 | - |
| | SEm$^{+}_{-}$ | 1.24 | 1.34 | |
| | CD @ 5% | 3.72 | 4.02 | |

### *E. Phytotoxicity*

No any treatment concentrations showed any phytotoxic effect in potato crop at used concentrations of PSPA. Thus it is safe product which can be used by farmers in potato for management of Phytophthora late blight and for better tuber yield. The reports made by Ingle *et. al.* (2020) suggest that even after application of PSPA as foliar sprays and soil drenching in Nagpur Orange the PSPA reduces were much below MRL i.e. 0.666 mg/kg against limit of 70 mg/kg for orange fruits with peel containing safe use of PSPA in crops. As no any Phytotoxicity is observed the PSPA can be used for repeated applications safely and as required under cases of disease pressure, conditions favourable for disease and as per crop stage.

## IV. CONCLUSION

The study demonstrated that the potassium salt of Phosphonic acid is an effective tool for management of late blight (*Phytophthora infestans*) in potato, The results showed that treatments involving potassium salt of Phosphonic acid, especially when combined with adjuvants for spray and soil drenching, significantly reduced disease incidence and severity, with the best-performing treatment (Potassium salt of Phosphonic acid spray @ 2.5 g/lit with adjuvant and drenching of Potassium salt of Phosphonic acid @ 2.5 g/lit) achieving the maximum height plant disease control rate and a remarkable reduction in disease intensity. This was followed by PSPA concentration of 2g/lit

These treatments also contributed to improved plant growth, as evidenced by increased plant height and tuber weight, leading to higher overall yields compared to the untreated control. The maximum yield observed was 189.10 q/ha for the treatment with Potassium salt of Phosphonic acid @ 2.5 g/lit water with adjuvant and drenching, followed by 188.82 q/ha for Potassium salt of Phosphonic acid @ 2 g/lit spray with adjuvant and drenching 2gm / lit water.

The cost-benefit ratio was recorded as 1:3.18 for the treatment of 2g/lit which further underline the economic viability of using potassium salt of Phosphonic acid in managing late blight and making it an appealing option for disease management by potato farmers. No any treatment showed phytotoxic effects at the applied concentrations, highlighting the safety and suitability of the compound in potato farming.

In conclusion, Potassium Salt of Phosphonic Acid, particularly when combined with adjuvants for foliar sprays and soil drenching, offers a promising, eco-friendly, and economically viable solution for managing late blight disease in potatoes. This study supports its adoption as part of integrated disease management strategies, contributing to enhanced potato productivity and agricultural sustainability. The studies also highlight that for effective management of Phytophthora in potato results in better tuber yield, when foliar application with soil drenching is supported.

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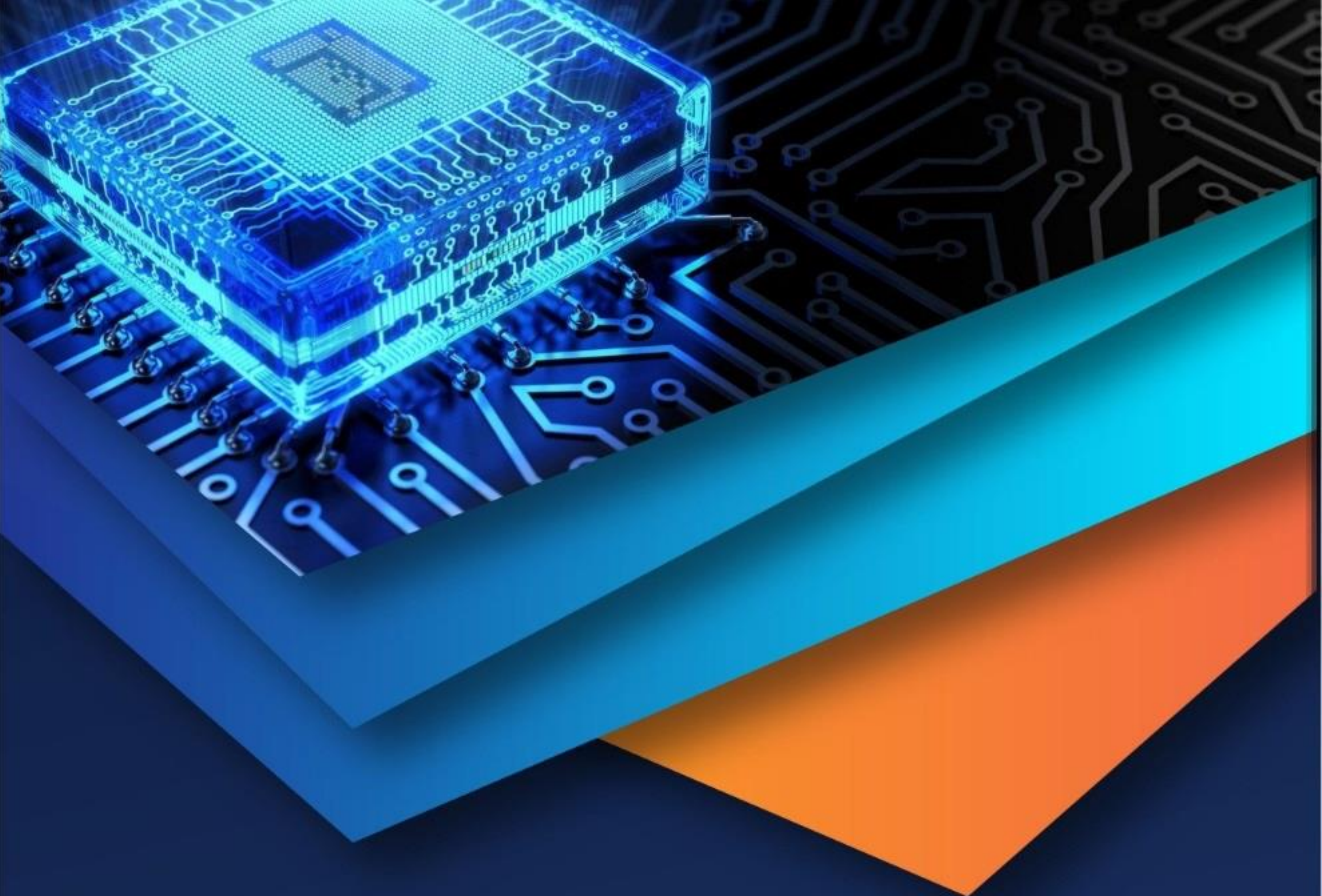


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