Original Research Article

Synergistic effects of seed inoculation with *Piriformosporaindica* and foliar hormonal application on early flowering in rice bean(*Vigna umbellata)* variety Surabhi

ABSTRACT

This study aimed to evaluate the effectiveness of seed inoculation with *Piriformosporaindica* and various foliar hormonal treatments in promoting early flowering in fodder rice bean (*Vigna umbellata*Thunb.), variety Surabhi, conducted at the College of Agriculture, Vellayani. The experiment assessed the impact of different treatments on flowering and other biometric traits in the leguminous crop. The treatments included untreated control,seed inoculation with *Piriformospora indica* before sowing andfoliar applications of salicylic acid (100 ppm ; 150 ppm), GA_3 (200 ppm; 300 ppm), Paclobutrazol (10 ppm; 20 ppm) and KNO_3 (1%; 1.5%) at 30 days after sowing (DAS). Significant differences were observed among treatments for all thirteen biometric traits measured. Early flowering was recorded in plants treated withsalicylic acid 100 ppm(65.35 days), followed by GA_3 300 ppm (67.72 days), salicylic acid 150 ppm (67.81 days), and Paclobutrazol 10 ppm (69.87 days), whereas the control flowered last (80.96 days. The findings suggest that the application of specific concentrations of growth regulators and seed inoculation with *P.indica* can effectively reduce the time to flowering, enhancing the potential for improved seed production in fodder rice bean.

Keywords:Fodder rice bean,Piriformosporaindica,early flowering,salicylic acid.

1. INTRODUCTION

Rice bean (*Vigna umbellata*) is an often-overlooked legume, regarded as a minor food and fodder crop in northern and north-eastern India. It is grown on 20,000 hectares in India, yielding an average green fodder productivity of 15-30 tons per hectare. Its cultivation is primarily limited to the tribal areas of the north-eastern hills and the hilly regions of the Western and Eastern ghats.

Fodder rice bean is an excellent protein source, containing 20-25 percent protein on a dry weight basis, making it ideal for livestock, especially dairy cattle that need high protein levels for milk production. Besides protein, it is also rich in vitamins and minerals like vitamin A, vitamin B, iron, and calcium, contributing to the health and productivity of livestock[1].

Ricebean thrives in Kerala's climate, according to a study by Bhoomika [2] from Kerala Agricultural University. However, issues were observed with flowering and seed setting. Since ricebean is propagated by seeds, proper flowering and seed setting are crucial for producing high-quality seeds.

KAU released a fodder rice bean variety Surabhi in 2016. However, seed production for this variety has been inconsistent due to limited flowering. Applying exogenous hormones has been shown to successfully regulate flowering and improve seed set in various crops. This study aimed to identify effective hormonal treatments to enhance flowering(and seed set) in ricebean.

2. MATERIALSANDMETHODS

2.1.Plant materials and methods

The experimental material for the present study was fodder ricebean (*Vigna umbellata*(Thunb))variety Surabhi from KAU.The treatments included untreated control,seed inoculation with *Piriformospora indica* before sowing and foliar applications of salicylic acid (100 ppm ; 150 ppm), GA_3 (200 ppm; 300 ppm), Paclobutrazol (10 ppm; 20 ppm) and KNO_3 (1%; 1.5%) at 30 days after sowing (DAS). The research area was divided into 3 blocks, each block was subdivided into ten plots, and size of each plot was 3m × 2m (6.0 m^2). The study was laid out in Randomized Complete Block Design (RCBD) with three replications.

2.2. Weather conditions

The weather data on monthly average temperature,relative humidity and rainfall during research period were recorded regularly by the official website system of the Kerala Agricultural University(**Directorate of Information Systems (DIS), K.A.U., Thrissur**).The data regarding temperature(minimum,maximum,and mean),relative humidity and rainfall during the experimentation are presented in **Figure 1.**

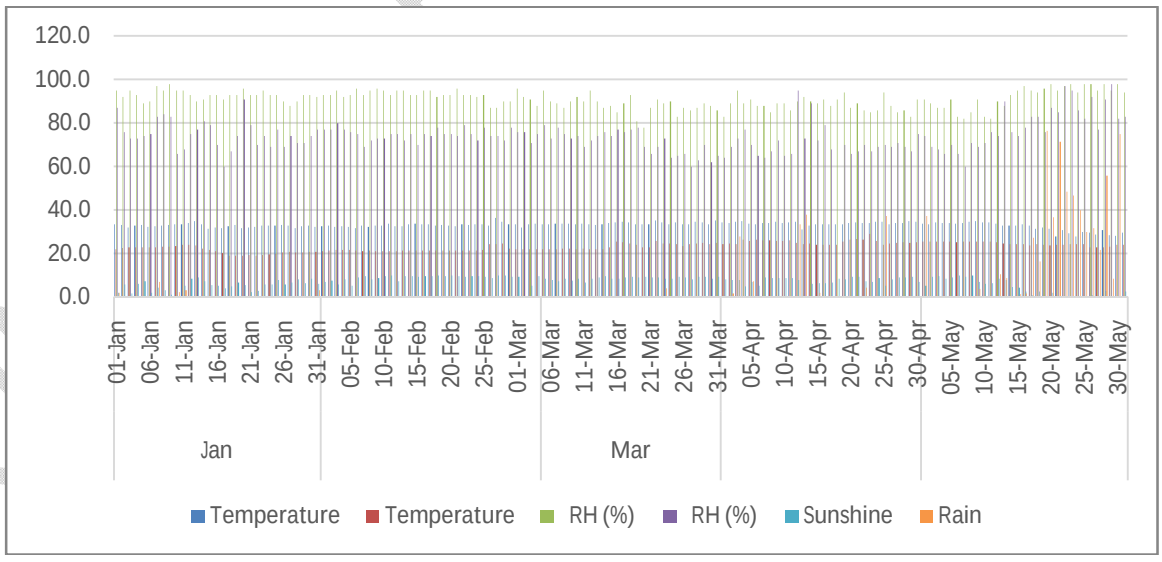

Figure 1: Monthly average temperature (minimum, maximum, and mean), relative humidity (%), and rainfall (mm) during the experiment.

3. RESULTSANDDISCUSSION

ANOVA

The analysis of variance revealed that mean sum of squares due to treatments was significant for all the characters.

Table1: Analysisof variancefor14charactersinfodderrice bean,var.Surabhi

Sl.No.	Characters	Mean sum of square		
		Replication	Treatment	Error
1	Leaf area index	0.053	0.053*	0.014
2	Number of branches	0.054	0.568*	0.182
3	Plant height	46.368	457.885*	48.627
4	Days to first flowering	23.593	95.916*	2.047
5	Days to 50 % flowering	24.771	116.356*	5.276
6	Number of pods per plant	13.528	41.341*	13.523
7	Days to maturity	159.612	80.553*	23.944
8	100 seeds weight	0.756	1.302*	0.423
9	Number of seeds per plant	911.322	1784.331*	693.445
10	Seeds yield per plant	12.395	34.538*	13.826
11	Seeds yield per plot	84.792	607.042*	61.752
12	Green fodder yield per plot	2.94	82.856*	1.022
13	Dry fodder yield per plot	0.173	3.272*	0.623

Superscript letters : significant at p ≤ 0.05

Effect of different treatments on days to first flowering in fodder rice bean

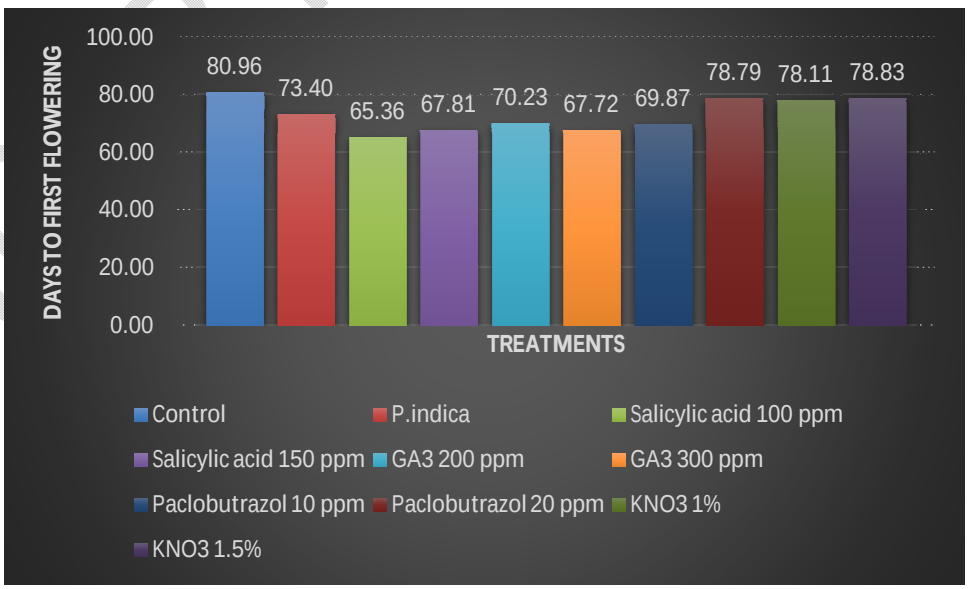

Fig 2: Effect of different treatments on days to first flowering in fodder rice bean(Var.Surabhi)

Table 2:Mean performance of various characters in rice bean(var.Surabhi)

Treatments	LAI	NB	HT	DF	DFF	PP	SPP	SYPP	SYPPL	100 SW	GFY	DFY	DM
Control(T_0)	4.18^{e}	4.03^{d}	104.20^{cd}	80.96^{a}	92.57^{a}	21.20^{d}	139.40^{d}	19.70^{d}	63.36^{b}	5.56^{a}	16.94^{d}	4.69^{bc}	109.67^{ab}
***Piriformosporaindica*(T_9)**	6.36^{a}	5.39^{a}	129.90^{a}	73.40^{c}	83.20^{cd}	32.62^{a}	214.36^{a}	29.61^{a}	81.88^{a}	5.03^{a}	29.16^{a}	7.85^{a}	103.73^{bc}
Salicylic acid 100ppm (T_1)	4.42^{d}	5.01^{abc}	107.73^{bc}	65.36^{f}	74.80^{f}	27.00^{abcd}	187.72^{abc}	25.93^{abcd}	84.38^{a}	3.89^{b}	17.07^{d}	4.67^{bc}	102.83^{bc}
Salicylic acid 150ppm (T_2)	4.05^{ef}	5.13^{ab}	104.07^{cd}	67.81^{def}	76.84^{ef}	24.30^{bcd}	165.27^{bcd}	22.87^{bcd}	47.88^{c}	5.21^{a}	16.87^{d}	4.46^{bc}	99.20^{c}
GA_3 200ppm (T_3)	6.18^{a}	5.30^{ab}	124.74^{a}	70.23^{d}	79.47^{de}	23.56^{bcd}	161.14^{bcd}	21.93^{cd}	55.09^{bc}	4.80^{ab}	26.95^{b}	5.81^{b}	104.43^{bc}
GA_3 300ppm(T_4)	6.25^{a}	5.02^{abc}	127.50^{a}	67.72^{ef}	77.80^{ef}	23.73^{bcd}	164.97^{bcd}	22.63^{bcd}	62.89^{b}	4.58^{ab}	28.08^{ab}	5.81^{b}	99.25^{c}
Paclobutrazol 10 ppm (T_5)	4.12^{ef}	4.64^{bcd}	102.63^{cd}	69.87^{de}	80.61^{de}	28.43^{abc}	195.39^{ab}	27.43^{abc}	85.34^{a}	5.32^{a}	16.75^{d}	4.62^{bc}	100.83^{c}
Paclobutrazol 20 ppm (T_6)	3.93^{f}	4.37^{cd}	93.43^{d}	78.79^{ab}	91.94^{a}	29.68^{ab}	199.97^{ab}	28.53^{ab}	64.09^{b}	3.75^{b}	15.86^{d}	4.42^{c}	114.57^{a}
KNO_3 1%((T_7)	4.71^{c}	5.25^{ab}	118.45^{ab}	78.11^{b}	84.64^{bc}	22.20^{cd}	150.03^{cd}	21.00^{d}	47.13^{c}	4.65^{ab}	19.14^{c}	5.27^{bc}	110.91^{ab}
KNO_3 1.5%(T_8)	5.01^{b}	4.97^{abc}	118.94^{ab}	78.83^{ab}	87.93^{b}	22.80^{cd}	156.33^{bcd}	22.70^{bcd}	59.67^{bc}	3.78^{b}	20.43^{c}	5.59^{bc}	106.81^{abc}
S.E.	0.069	0.247	4.026	0.826	1.326	2.123	15.204	2.147	4.537	0.376	0.584	0.456	2.825
C.D.(5%)	0.205	0.733	11.962	2.454	3.940	6.308	45.172	6.378	13.480	1.116	1.734	1.354	8.394

LAI-Leaf area index
NB-Number of branches
HT-Plant height
DF-days to first flowering
DFF-Days to 50% flowering
PP-Number of pods per plant
SPP-Number of seeds per plant
SYPP-Seeds yield per plant
SYPPL-Seeds yield per plot
100 SW-100 seeds weight
GFY-Green fodder yield per plot
DFY-Dry fodder yield per plot
DM-Days to maturity

The meanperformance of fodder rice bean(Var.Surabhi)in response to different treatments for all the characters studied are presented in the Table 2.

The leaf area index (LAI) varied with treatments and the maximum LAI recorded by the treatment *P. indica* (6.36) which was on par withGA_3 300 ppm (6.25) and GA_3 200 ppm(6.18) while the minimum LAI was observed in treatments with Paclobutrazol 20 ppm (3.93), SA 150 ppm (4.05) which was on par with Paclobutrazol 10 ppm (4.12), resulting in a mean performance of 4.921.Treatment with *P. indica* (5.39) exhibited the highest number of branches, followed by GA_3 200 ppm (5.30) which was on par with KNO_3 1% (5.25) while the lowest number was observed in the control (4.03)followed by Paclobutrazol 20 ppm (4.37) and Paclobutrazol 10 ppm (4.64), resulting in a mean performance of 4.91.The highest plant height was observed in plants treated with *P. indica* (129.9 cm), which was on par with GA_3 at 300 ppm (127.5 cm) and GA_3 at 200 ppm (124.74 cm), while the lowest plant height was recorded in treatments with Paclobutrazol at 20 ppm (93.43 cm), followed by Paclobutrazol at 10 ppm (102.63 cm) which was on par with SA at 150 ppm (104.07 cm) and control(104.20) with a mean performance of 113.16 cm.

Early flowering was observed in SA 100ppm treated plants (65.36 days), followed by GA_3 at 300 ppm (67.72 days), SA at 150 ppm (67.81 days), and Paclobutrazol at 10 ppm (69.87 days), while late flowering was recorded in the control (80.96 days), with a mean performance of 73.10 days.The treatment with SA at 100 ppm took minimum number of days to attain 50% flowering (74.8 days), while the maximum number of days was observed in the control (92.57 days)which was on par with Paclobutrazol 20ppm(91.94 days) with a mean of 82.98 days.The highest number of pods per plant was observed in the treatment with *P. indica* (32.62), followed by Paclobutrazol at 20 ppm (29.68) and Paclobutrazol at 10 ppm (28.43). The minimum number of pods was recorded in the control (21.2), followed by KNO_3 at 1% (22.2) which was on par with KNO_3 at 1.5% (22.8), with a mean value of 25.55.The highest 100-seed weight was observed in the control (5.56g)which was on par with Paclobutrazol at 10 ppm (5.32g) ,SA at 150 ppm (5.21g) and *P.indica*(5.03) while the lowest was recorded for Paclobutrazol at 20 ppm (3.75g) which was on par with KNO_3 at 1.5% (3.78g), with a mean value of 4.66g.The highest number of seeds per plant was recorded in the treatment with *P. indica* (214.36), followed by Paclobutrazol at 20 ppm (199.97) which was on par with Paclobutrazol at 10 ppm (195.39). The lowest number of seeds per plant was observed in the control (139.4), followed by KNO_3 at 1% (150.03) and KNO_3 at 1.5% (156.33), with a mean value of 173.46.The seed yield per plant was recorded the highest for plants treated with in *P. indica* (29.61 g), followed by Paclobutrazol at 20 ppm (28.53 g). The lowest seed yield per plant was observed in the control (19.70 g)which was on par with KNO_3 at 1% (21 g), with a mean value of 24.23 g.The highest seed yield per plot was recorded in Paclobutrazol at 10 ppm (85.34 g)which was on par with SA at 100 ppm (84.38 g) and *P. indica* (81.88 g), while the lowest yields were observed in KNO_3 at 1% (47.13 g)which was on par with SA at 150 ppm (47.88 g) followed by GA_3 at 200 ppm (47.89 g) with a mean value of 65.17 g.The maximum green fodder yield was recorded in *P. indica* (29.16 t ha^{-1}), followed by GA_3 at 300 ppm (28.08 t ha^{-1}) and GA_3 at 200 ppm (26.95 t ha^{-1}). The minimum green fodder yield was observed in Paclobutrazol at 10 ppm (16.75 t ha^{-1})which was on par with SA at 150 ppm (16.87 t ha^{-1}) and the control (16.95 t ha^{-1}), with a mean value of 20.72 t ha^{-1}.The highest dry fodder yield was recorded in *P. indica* (7.85 t ha^{-1}), followed by GA_3 at 200 ppm and GA_3 at 300 ppm (5.81 t ha^{-1}). The lowest dry fodder yield was observed in Paclobutrazol at 20 ppm (4.42 t ha^{-1}), followed by SA at 150 ppm (4.46 t ha^{-1}) which was on par with SA at 100 ppm (4.67 t ha^{-1}), with a mean value of 5.32 t ha^{-1}.Days to maturity among the treatments varied from 99.2 days to 114.57 days.Highest number of days to mature was taken by Paclobutrazol 20 ppm(114.57 days) followed by KNO_3 1%(110.91 days), whereas SA 150 ppm(99.2 days)matured first followed by GA_3 300 ppm(99.25 days)

In this study, among the treatments evaluated, plants treated with SA 100 ppm exhibited the earliest flowering (65.36 days), followed by GA_3 300 ppm,SA 150 ppm (67.81 days) and the Paclobutrazol 10 ppm (69.87 days). Similar effects were observed by Nicu*et al*. [3] in *Zinnia elegans*. Regarding GA_3 application, early flowering was noted in plants treated with GA_3 300 ppm (67.72 days) and GA_3 200 ppm (70.23 days) compared to the control (80.96 days), which is consistent with the findings of Mujadid*et al*. [4] in *Tageteserecta*.

Paclobutrazol 10 ppm treated plants flowered in 69.87 days, followed by 20 ppm (78.79 days), while the control flowered later, contradicting the results reported by Bably *et al.*[5] in *Jacobiniacarnea*. For KNO_3 treatments, plants treated with 1% KNO_3 flowered earlier (78.11 days) than those treated with 1.5% (78.83 days), with control plants

flowering last, in agreement with the conclusions of Padmalatha et al. (2013). Furthermore, rice bean inoculated with *Piriformosporaindica* exhibited earlier flowering (73.4 days) compared to control plants (80.96 days), which aligns with the findings of Pan *et al.*[6].

Overall, the use of plant growth regulators and inoculants effectively promoted earlier flowering across various treatments, highlighting their potential in regulating phenological events in crop plants.

4. CONCLUSION

This study demonstrated that the seed inoculation with *Piriformosporaindica* as well as foliar application of salicylic acid, gibberellic acid, Paclobutrazol, and KNO_3 at 30 DAS had a significant positive impact on early flowering in fodder rice bean plants compared to the control. The most pronounced effect on early flowering was observed with salicylic acid at 100 ppm, while untreated plants exhibited the least response. These findings suggest that the flowering time of fodder rice bean can be effectively manipulated through exogenous foliar applications of growth regulators and seed inoculation with *Piriformosporaindica*, which could enhance seed production efficiency in fodder rice bean cultivation.

6.COMPETITIVE INTERESTS

Authors have declared that no competing interests exists.

7.REFERENCES

1.Lawn, R. J. 1995.The Asiativ*Vigna*species.Chapter 65 in smart J and Simmonds, NW (Eds*) Evol. of crop plants*. Second edition. Legume scientific and technical, Harlow, UK. 326p.

2. Bhoomika BK. Genetic analysis in fodder rice bean (*Vigna umbellata*(Thunb.) for yield and quality. Doctoral dissertation, Department of Plant Breeding and Genetics, College of Agriculture, Vellayani. 2020; 130p.

3.Nicu C,MandaM.Response of zinnia plants to foliar application of salicylic acid. Scientific Papers. Series B. Hortic.2023; 67(2): 458-463.

4.Mujadidi A, Kumar M, Malik S, Prakash S, Singh B, Singh MK, Chaudhary V. Effect of time and concentrations of gibberellic acid application on growth and flowering of African marigold (*Tageteserecta* L.) CV. PusaNarangi. Progress. Agric.2019; 19(2): 293-297.

5.El-Bably SMZ, Zaky AA. Efficacy of paclobutrazol on the growth and flowering of *Jacobiniacarnea*(Lindl.) Nicholson. Egypt. J. Agric. Sci. 2009; 60(1): 86-98.

6.Padmalatha T, Reddy GS, Chandrasekhar R, Shankar AS, Chaturvedi A. Effect of pre planting treatment of corms with chemicals and plant growth regulators on vegetative growth, flowering and postharvest life in gladiolus. Indian J. Agric. Res. 2014; 48(4): 301-306.

7.Pan R, Xu L, Wei Q, Wu C, Tang W, Oelmüller R, Zhang W.*Piriformospora indica* promotes early flowering in *Arabidopsis* through regulation of the photoperiod and gibberellin pathways.PLoS One. 2017; 12(12): e0189791.