Research
Journal of
Botany

OPEN ACCESS

Bean Root Rot and Water Stress Impacting Yield After Applications of Salicylic Acid and Seaweed

[1]Bita Naseri, [2]Sara Beigzadeh, [2]Abbas Maleki and [3]Hooshmand Safari

[1]Department of Plant Protection Research, Kermanshah Agricultural and Natural Resources Research and Education Center, Agricultural Research, Education and Extension Organization, Kermanshah, Iran

[2]Department of Agronomy and Plant Breeding, College of Agriculture, Islamic Azad University of Ilam Branch, Ilam, Iran

[3]Department of Forests and Rangelands Research, Kermanshah Agricultural and Natural Resources Research and Education Center, Agricultural Research, Education and Extension Organization, Kermanshah, Iran

ABSTRACT

Background and Objective: The benefits of salicylic acid and seaweed for yield improvement are understood. However, the impacts of these materials on bean root rot diseases and productivity are little examined. Thus, this study examined associations of irrigation, salicylic acid, and seaweed with bean root rot and yield under field conditions. **Materials and Methods:** Bean root rot and yield were examined across experimental plots treated with irrigation, salicylic acid, and seaweed. The H-test, correlations, principal component analysis, and linear regression were used to examine datasets. The significance at 0.05 probability level was considered for H-test and correlations. **Results:** Irrigation intervals significantly affected bean traits, including enzyme activity, ion leakage, photosynthesis, root rot, and yield. Principal component analysis (74% variance) linked lower ion leakage and shorter irrigation to higher yield (46.16%), while catalase, superoxide dismutase, and salicylic acid correlated with severe root rot (15.98%). Photosynthesis rate increased with salicylic acid and lower seaweed concentration (11.71%). A multivariate regression model (95% variance) predicted yield based on salicylic acid, seaweed, ion leakage, irrigation interval, photosynthesis, and root rot severity. **Conclusion:** Findings encourage experts and growers to improve bean yield by adequate irrigation at six-day intervals and applications of salicylic acid plus seaweed as potential tools for sustainable management of root rot and water stresses.

KEYWORDS

Common bean, integrated crop management, legumes, sustainability, irrigation intervals, bean yield, root rot, enzyme activity, salicylic acid, seaweed extract, multivariate analysis

INTRODUCTION

Besides abiotic stresses, root rot pathogens threaten bean (*Phaseolus vulgaris* L.) production in particular when coincided with the drought stress[1]. Bean root rots are caused primarily by *Fusarium solani* and *Rhizoctonia solani* depending on the properties of farming systems[2]. Due to the well-documented detrimental effects of chemical applications, numerous findings on sustainable root rot management strategies involving agronomic and biocontrol methods have been reported[3]. However, incorporating further environmentally friendly procedures is still required to minimize root rots and maximize bean productivity.

ISSN: 2152-0461 (Online)
ISSN: 1816-4919 (Print)
https://doi.org/10.3923/rjb.2025.142.150

Received: 02 Feb. 2025
Accepted: 25 Feb. 2025
Published: 26 Feb. 2025

In addition to root rots as biotic stresses, it is required to manage those abiotic stresses that are influential on the disease development. Naseri and Moradi[2] observed that irrigating bean fields every 6-9 days restricted root rots at a large scale when compared to irrigations every 2-4 days. Beigzadeh *et al.*[4] added that irrigating white beans at 6-day intervals produced higher yield (kg/ha) levels compared to 9 and 12-day intervals at the field plot scale. Furthermore, spraying salicylic acid onto bean plants improved yield by 4.5%, irrespective of irrigation intervals and seaweed applications. In addition, the highest bean yield was detected in plots treated with every 6 days irrigation and 150 g/ha applications of seaweed[4]. Such subsidiary practices are desired to alleviate yield reductions due to deficient irrigation and drought stresses for sustainable and profitable production in semi-arid regions. The water stress can lower photosynthesis, synthesis of chlorophylls and proteins, and finally dry matter production[5]. There are some macromolecules like ascorbate peroxidase, catalase, and superoxide dismutase that alleviate yield reductions due to drought stresses[6]. Salicylic acid is one of the phenolic compounds that are produced in plants under different abiotic and biotic stresses[7]. Khodadadi *et al.*[8] also observed that applications of salicylic acid improved the activities of antioxidant compounds such as superoxide dismutase to expand the root system. This assists with the tolerance of plants to diverse stresses including drought stress and root rots in bean crops[4].

Abdel-Monaim[9] observed that the combined applications of salicylic acid and biocontrol agents, *Trichoderma viride* and *Bacillus megaterium*, significantly restricted root rot and wilt, and improved yield in broad beans at the scales of greenhouse and field. Moreover, these combined applications appeared more effective than singular applications of salicylic acid or each biocontrol agent. Al-Hakimi and Alghalibi[10] reported that foliar applications of salicylic acid alleviated adverse effects of root rot pathogens on bean growth rate. However, a better understanding of salicylic acid or other natural materials for the management of abiotic and biotic stresses in bean crops at the field-plot scale is highly needed. Hence, this plot scale investigation aimed to evaluate the development of root rots and bean yield (kg/ha) in field plots treated with salicylic acid, seaweed, and irrigation scenarios.

MATERIALS AND METHODS

Study area: During the 2017-2018 growing season, bean yield and root rot intensity were measured at the field scale under natural infections of the soil. The research was conducted at Kermanshah, Islamabad Gharb (Latitude 34˚7´N, Longitude 46˚28´E; 1,346 m a.s.l; 474.3 mm annual rainfall, 13.7°C annual mean temperature), and Lorestan, Khorramabad (Latitude 33˚30´N, Longitude 48˚18´E; 1,170 m a.s.l; 429.5 mm annual rainfall, 17.2°C annual mean temperature) stations.

Experimental design: The experiments were designed as a split-split plot involving the treatments as follows: (1) Irrigation regime (main plot) with the 60, 90 and 120 mm evaporation categories according to irrigations at 6, 9 and 12 days intervals, respectively; (2) Spraying seaweed fertilizer (subplot) at 0, 50, 100 and 150 g/ha concentrations; and two categories of spraying and non-spraying 1 m/mol salicylic acid (sub-sub plot; Merk, Germany). Experimental plots were treated with seaweed extract obtained from *Ascophyllum nodosum* (Czech Republic). White bean (cv. Almas) was seeded across experimental plots (3×3 m in size) replicated three times in late May (Islamabad Gharb) and early June (Khorramabad). Then, plots were hand-seeded for a planting density of 30 plants/m^2.

Parameter measurements: Photosynthesis was rated using photosynthesis meter Rcp 60 code: 1123[4]. The activity of ascorbate peroxidase was measured as described by Beigzadeh *et al.*[4] and Nakano and Asada[11]. Catalase and superoxide dismutase activities were also determined according to the methods developed by Beers and Sizer[12], and Giannopolitis and Ries[13], respectively. Ion leakage was detected based on Flinet *et al.*[14] and Beigzadeh *et al.*[4]. The incidence of bean root rot was recorded at the flowering-podding stage by digging up and examining the roots of five plants at random per plot[2]. The presence and percentage of rotted root tissues of five tested plants per plot were defined as disease incidence and severity, respectively. There was a 0-100 percentage scale used for either disease incidence (presence/absence of rotted root in five plants) or disease severity (percentage of rotted root tissues for each of five plants) based on a visual examination. At harvest, seed yield (kg/ha) was determined for each plot.

Statistical analysis: A total of 144 experimental plots at two study stations were studied for ascorbate peroxidase, bean root rot incidence and severity, ion leakage, catalase, photosynthesis rate, superoxide dismutase, and yield (kg/ha) based on the irrigation, salicylic acid, and seaweed treatments. Considering the non-significant effect of the two study stations, the datasets for the two locations were pooled to improve the degrees of freedom (GENSTAT, VSN International, Oxford, UK). The nonparametric test, Kruskal-Wallis one-way ANOVA was applied to datasets to rank the effects of irrigation, salicylic acid, and seaweed treatments on bean plants, root rot disease, and yield. This test provided a preliminary examination of a bean plant, root rot, and yield descriptors ranked according to the irrigation, salicylic acid, and seaweed treatments. Such information, which advanced the understanding of the importance of each treatment or factor in interaction with the bean plant or the disease, was uncertain when subjecting the datasets to a simple ANOVA earlier[4]. Furthermore, the H-test results confirmed variations in the disease development and the subsequent yield levels across plots that improved the predictability of the regression model as recommended earlier[15]. Hence, the datasets were subjected to more advanced statistical tests to evaluate the magnitude of associations among the different bean-disease-treatment-yield indicators.

PCA analysis: Simple correlations between the continuous variables of bean, disease, and yield descriptors were determined. Using a Principal Component Analysis (PCA), loading values $\geq$0.35 were noted as significant[16]. Based on the PCA results, a linear model of bean yield (kg/ha) was developed. This way of developing a multivariate regression model according to the PCA test minimizes the collinearity problem between independent variables, and thus, improves the predictability of model[16]. Predictors of their two-way interactions were involved in the linear model according to the loading values determined by the PCA. The graphical appraisal of normally distributed residuals, F-test, and R^2 were monitored for the best model fitted by considering the T-test results for the predictors[16].

RESULTS

Datasets: Bean plants exhibited varying physiological responses under different conditions. Ascorbate peroxidase averaged 59.85 with moderate variability, while ion leakage ranged from 13.77 to 35.50%. Catalase and superoxide dismutase showed low standard deviations, indicating stability. The photosynthesis rate averaged 3.06 with slight fluctuations. Root rot incidence and severity were highly variable, with maximum values reaching 100 and 95%, respectively. Yield remained relatively stable, averaging 1800.60 kg/ha, with minimal deviation seen in Table 1.

Treatments effects: Based on the H-test, none of the effects of salicylic acid and seaweed factors on plant and disease traits, and bean yield were statistically significant (Table 2). Therefore, field plots either treated or not treated with salicylic acid and seaweed did not differ in ascorbate peroxidase, ion leakage, catalase, photosynthesis rate, superoxide dismutase, root rot incidence and severity, and yield. The irrigation regime defined as the indicator of water stress was significantly effective on the ascorbate peroxidase (H adjusted = 3.62; Chi prob. = 0.064), ion leakage (H adjusted = 17.36; Chi prob. <0.001), catalase (H adjusted = 15.92; Chi prob. <0.001), photosynthesis rate (H adjusted = 10.51; Chi prob. = 0.005); superoxide dismutase (H adjusted = 13.61; Chi prob. <0.001); root rot incidence (H adjusted = 12.67; Chi prob. = 0.002) and severity (H adjusted = 10.05; Chi prob. = 0.007), and yield (H adjusted = 15.50; Chi prob. <0.001). Greater ($p\leq 0.05$) ascorbate peroxidase, ion leakage,

Table 1: Average, minimum, maximum, and standard deviation for continuous variables in bean plots treated with irrigation, salicylic acid, and seaweed

Variables	Average	Standard deviation	Minimum	Maximum	Kurtosis	Skewness
Plant						
Ascorbate peroxidase	59.85	15.42	25.16	89.11	-0.13	-0.26
Ion leakage (%)	23.77	6.09	13.77	35.50	-1.01	0.21
Catalase	0.38	0.04	0.31	0.45	-1.08	-0.27
Photosynthesis rate	3.06	0.71	1.48	4.44	-0.24	0.05
Superoxide dismutase	0.59	0.11	0.30	0.75	0.26	-0.66
Root rot						
Disease incidence	33.17	26.89	1.00	100.00	-0.18	0.81
Disease severity	32.12	29.51	1.00	95.00	-0.43	0.95
Yield (kg/ha)	1800.60	80.20	1680.00	1935.00	-1.30	0.30

Table 2: Analysis of bean factors in plots treated with irrigation, salicylic acid, and seaweed

		Bean plant					Root rot disease		
Factor	Factor levels	Asc	Ion	Cat	Pho	Sup	Incidence	Severity	Yield (kg/ha)
Irrigation	6 days interval	8.75	6.00	4.62	18.75	5.12	7.00	7.38	19.81
	9 days interval	13.50	11.00	18.12	11.25	14.88	11.19	11.69	11.69
	12 days interval	15.25	20.50	14.75	7.50	17.50	19.31	18.44	6.00
Mean adjusted H		3.62	17.36	15.92	10.51	13.61	12.67	10.05	15.50
Ranking Chi prob.		0.064	0.001	0.001	0.005	0.001	0.002	0.007	0.001
Salicylic acid	Applied	13.75	13.33	11.42	10.58	11.38	13.42	13.67	11.42
	Not applied	11.25	11.67	13.58	14.42	13.62	11.58	11.33	13.58
Mean adjusted H		0.75	0.33	0.57	1.77	0.61	0.41	0.66	0.57
Ranking Chi prob.		0.386	0.564	0.451	0.184	0.436	0.523	0.420	0.452
Seaweed	0-50 (g/ha)	12.58	14.67	12.58	13.04	12.04	12.17	12.12	11.88
	100-150 (g/ha)	12.42	10.33	12.42	11.96	12.96	12.83	12.88	13.12
Mean adjusted H		0.01	2.25	0.01	0.14	0.10	0.05	0.07	0.19
Ranking Chi prob.		0.954	0.133	0.954	0.707	0.751	0.816	0.794	0.664

Asc: Ascorbate peroxidase, Ion: Ion leakage, Cat: Catalase, Pho: Photosynthesis rate and Sup: Superoxide dismutase

superoxide dismutase, root rot incidence, and severity rankings for plots irrigated at 12-day intervals compared with more frequent irrigations at 6 and 9-day intervals. For catalase, a shorter ($p \leq 0.05$) irrigation interval at every 6 days indicated a lower ranking than longer irrigation intervals at every 12 and 9 days. A lower photosynthesis rate ranking was detected for irrigations at 12-day intervals compared to the shorter intervals. The lowest ($p \leq 0.05$) rankings of root rot incidence and severity were detected for irrigations at 6-day intervals. For bean yield, the ranking was reduced ($p \leq 0.05$) by increasing the length of irrigation interval from 6 to 12 days. Therefore, irrigations every 12 days increased ascorbate peroxidase by 42.62%, ion leakage by 70.73%, catalase by 68.68%, superoxide dismutase by 70.74%, root rot incidence by 63.75% and severity by 59.98% when compared to every six days irrigations. In addition, every six days irrigation improved photosynthesis rate and bean yield by 60.00 and 69.71%, respectively, in comparison with every 12 days of irrigations (Table 2).

Correlations: Correlation analysis revealed significant relationships among plant traits, disease incidence, and yield. Ion leakage showed a strong positive correlation with disease incidence (0.74) and severity (0.57) but negatively correlated with yield (-0.78). Photosynthesis rate positively influenced yield (0.63) while negatively correlating with disease incidence (-0.50). Catalase and superoxide dismutase were moderately correlated, with catalase (0.60) showing the highest association. Yield was negatively affected by ion leakage, catalase, and disease incidence, highlighting the impact of stress responses on productivity seen in Table 3.

Principal component analysis: The PCA based on a correlation matrix indicated associations of 11 variables of bean, disease, treatment, and yield with the three principal components representing linear combinations of the variables. The three principal components justified 73.85% of the variations in bean ascorbate peroxidase, ion leakage, catalase, photosynthesis rate, superoxide dismutase, root rot incidence,

Table 3: Correlations between continuous variables in bean plots treated with irrigation, salicylic acid, and seaweed

Variables	Ascorbate peroxidase	Ion leakage	Catalase	Photosynthesis rate	Superoxide dismutase	Incidence	Severity	Yield
Bean plant								
Ascorbate peroxidase	1.00							
Ion leakage	0.37	1.00						
Catalase	**0.37**	**0.42**	1.00					
Photosynthesis rate	-0.28	**-0.46**	**-0.42**	1.00				
Superoxide dismutase	**0.40**	**0.45**	**0.60**	**-0.41**	1.00			
Disease								
Incidence	**0.44**	**0.74**	**0.36**	**-0.50**	0.18	1.00		
Severity	0.24	**0.57**	0.21	**-0.39**	-0.05	**0.91**	1.00	
Yield (kg/ha)	-0.31	**-0.78**	**-0.47**	**0.63**	**-0.47**	**-0.56**	**-0.43**	1.00

Bold numbers refer to significance at a 0.05 probability level

Table 4: Principal component analysis of bean variables in plots treated with irrigation, salicylic acid, and seaweed

	Principal component		
Variables	1	2	4
Bean			
Ascorbate peroxidase	0.24	0.05	-0.01
Ion leakage (%)	**0.39**	-0.11	0.22
Catalase	0.29	**0.35**	0.09
Photosynthesis rate	-0.31	-0.04	**0.48**
Superoxide dismutase	0.27	**0.52**	0.02
Root rot			
Disease incidence	**0.37**	-0.31	0.02
Disease severity	0.29	**-0.46**	-0.01
Treatments			
Irrigation	**0.42**	0.15	0.03
Salicylic acid	-0.07	**0.42**	**0.49**
Seaweed	-0.05	0.30	**-0.69**
Yield (kg/ha)	**-0.37**	-0.02	-0.05
Eigenvalues	5.08	1.76	1.29
Variation (%)	46.16	15.98	11.71
Accumulated variation (%)	46.16	62.14	73.85

A bold number indicates a significant loading value $\geq$0.35

and severity, and yield in plots treated with irrigation, salicylic acid and seaweed (Table 4). The first principal component, which explained 46.16% of variations, provided the positive loadings for the ion leakage, root rot incidence, and irrigation interval. The yield descriptor negatively contributed to this principal component. Thus, the first principal factor was defined as the bean-disease-irrigation-yield factor. This suggested that a greater ion leakage, wider root rot spread (greater root rot severity), and longer irrigation interval produced lower yield levels.

The second principal component, which explained 15.98% of variations in bean-disease-treatment-yield datasets, showed significantly positive associations of catalase, superoxide dismutase, and salicylic acid. The disease severity negatively contributed to the second principal component. Hence, the second principal component was defined as the factor of bean, disease, and salicylic acid treatment. Furthermore, this factor suggested that higher levels of catalase superoxide dismutase, and salicylic acid application were associated with more severe bean root rots.

The third principal component, which explained 11.71% of variations in the bean-disease-treatment-yield datasets, received significant contributions from photosynthesis rate, salicylic acid, and seaweed (Table 4). This factor provided significantly positive contributions to the photosynthesis rate and salicylic acid. Seaweed was negatively linked to the third principal component. This also determined the reverse associations of seaweed with the photosynthesis rate and salicylic acid. Therefore, the third principal component was defined as the salicylic acid and seaweed treatments in interaction with the

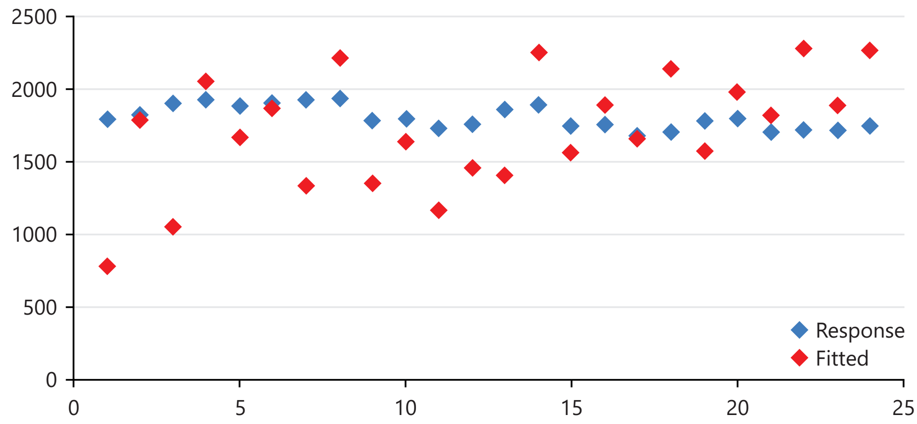

Fig. 1: Fitted and response values of yield (kg/ha) based on ion leakage, photosynthesis rate, and root rot severity under different treatments
X-axis: Plot number and Y-axis: Yield (kg/ha)

Table 5: Multiple regression model (R^2 = 0.95) for bean yield based on physiological and disease parameters under different treatments

Predictors	Parameter estimate	Standard error	*t*-probability
Disease severity	4.76	3.97	0.245
Ion leakage×irrigation	0.19	0.09	0.047
Photosynthesis rate×salicylic acid	173.40	29.60	0.001
Seaweed	4.25	4.25	0.009

photosynthesis rate of bean plants. Hence, a higher photosynthesis rate corresponded with the application of salicylic acid and lower concentrations of seaweed (Table 4).

Multivariate bean yield model: Regression analysis identified key predictors influencing plant response. Photosynthesis rate×Salicylic acid had the strongest effect (p = 0.001), followed by **seaweed application (p = 0.009). Ion leakage×Irrigation also showed a significant impact (p = 0.047), while disease severity was not statistically significant (p = 0.245).

The current model (F probability = 0.001; R^2 = 0.95) described 95% of variations in bean yield examined across 144 field plots treated with the irrigation regime, salicylic acid, and seaweed. The two bean plant predictors, three experimental treatments, and one root rot disease variable were used to model bean yield (Table 5). Disease severity, ion leakage, irrigation intervals, photosynthesis rate, salicylic acid, and seaweed predictors described significant bean yield. The two-way interaction of photosynthesis rate and salicylic acid provided the highest relationship with bean yield, followed by the seaweed predictor. The lack of significant difference between the response and fitted values of bean yield demonstrated that this model development and variable selection were performed properly (Fig. 1). This model suggested that a higher bean yield corresponded with a lower ion leakage, more frequent irrigations, higher photosynthesis rate, and further application of salicylic acid and seaweed in bean plants studied under field conditions. The positive association of root rot severity with bean yield was a surprising observation (Table 5).

DISCUSSION

Although recent findings on the environmentally friendly cultivation of beans have been promising[1], a better insight into integrated crop management is crucial for the sustainable production of this profitable crop. Hence, explored in the current investigation that, how strongly bean yield is associated with ascorbate peroxidase, ion leakage, catalase, photosynthesis rate, superoxide dismutase, root rot incidence and severity in field plots treated with irrigation, salicylic acid, and seaweed. After evaluating the effects of these three treatments, the predictive values of crop, disease, and treatment variables were determined to estimate bean yield. This suggested the best predictors of yield in bean crops treated with salicylic acid and seaweed under water stress conditions at field scale. The PCA and regression model demonstrated the remarkable associations of irrigation, salicylic acid, and seaweed on bean plants, root rot development, and yield under field conditions. Furthermore, irrigations at longer intervals, 9 and 12 days, increased ascorbate peroxidase, ion leakage, catalase, superoxide dismutase, root rot incidence, and severity in field plots treated with salicylic acid and seaweed. Moreover, irrigations as frequent as every six days improved photosynthesis rate and bean yield. These findings are in agreement with an earlier report on photosynthesis rate and yield improvements following irrigations every six days in beans treated with salicylic acid and seaweed[4]. The current study also supported observations from Jain *et al.*[6] on the improved tolerance to water stress and subsequent productivity following increases in ascorbate peroxidase, catalase, and superoxide dismutase. Additionally, irrigations at every six-day intervals restricted bean root rot which supports previous findings reported by Naseri and Moradi[2] and Khodadadi *et al.*[8] found that applications of salicylic acid increased antioxidant compounds such as superoxide dismutase which expanded the root system. This improved the plant's tolerance to not only drought stress but also root rots. However, none of the previous documents assessed the current array of bean plant properties in conjunction with the root rot disease and yield in plots treated with irrigation, salicylic acid, and seaweed. The present relationships of irrigation intervals with ion leakage, root rot incidence, and yield, detected by the current H-test, were also confirmed by the first principal factor accounting for 46% of the variability in the bean-disease-treatment-yield interaction. To the best of our knowledge, such novel findings determined the noticeable impacts of salicylic acid and seaweed on restricting water and root rot stresses, which reduced bean yield under field conditions. This finding appears to suggest the applications of salicylic acid and seaweed as potential tools in the sustainable management of root rots in bean farming systems.

Based on the current regression model, the surprising association of a greater bean yield with a more intensified root rot development could be attributed to interrelationships among the independent variables. Such unexpected associations commonly occur in multivariate regression models involving complex associations of multiple variables as reported previously[2,16]. In such situations, it is recommended to refer to simple correlation results which provide useful information on a univariate regression between the dependent and independent variables. Moreover, the PCA results also agreed with univariate regressions and the first principal component indicating reverse associations of root rot incidence and severity with bean yield. For this reason, simple correlations and PCA tests are often performed before regression analyses to simplify interpretations of predictors associations particularly based on the PCA results, as a powerful statistical method[16].

Al-Hakimi and Alghalibi[10] observed the alleviation of bean growth inhibited by root rot pathogens due to foliar applications of salicylic acid. Furthermore, Al-Hakimi and Alghalibi[10] reported the most noticeable restrictions of root rot and wilt and a subsequent improvement of bean yield following applications of salicylic acid along with *T. viride* and *B. megaterium* under greenhouse and field conditions. However, these studies focused on the sustainable management of bean root rots using biocontrol agents plus salicylic acid which resulted in no estimation of bean yield improvement at the field scale. Hence, the current findings provided detailed information on bean yield improved due to restricting water and root rot stresses in plants treated with irrigation, salicylic acid, and seaweed. As a result, water stress following irrigations every 12 days induced ascorbate peroxidase (43%), ion leakage (71%), catalase (69%), and superoxide dismutase (71%) in bean plants tested. Moreover, this abiotic stress intensified the biotic stress, root rot incidence by 64% and severity by 60% compared to irrigations every six days. Finally, such a noticeable development of root rot following this water deficiency reduced the photosynthesis rate and bean yield by 60 and 70%, respectively. It should be also noticed here that all the analyses of the H-test, correlations, PCA, and yield model suggested the notable association of irrigation treatment with the other two treatments, salicylic acid and seaweed. One might conclude that salicylic acid and seaweed applications increased the efficiency of irrigations every six days to reduce root rot (biotic) and water (abiotic) stresses and thus, improve bean productivity. This research encourages experts and bean growers to improve yield build-up due to irrigating at six-day intervals and applications of salicylic acid and seaweed. It developed an integrated method to manage not only root rots without fungicide usage but also water stress using natural materials. On the other hand, Naseri and Moradi[2] attributed restricted bean root rots to irrigating every 6-9 days and avoiding urea and fungicide use at large scale. Therefore, these novel findings appear to be valuable from an economic bean production viewpoint. The profitability of an integrated crop management program can also reinforce the sustainability of agricultural systems.

CONCLUSION

Finally, the remarkable associations of proper irrigation, seaweed, and salicylic acid usages with reducing biotic (root rots) and abiotic (drought) stresses, and improving yield demonstrated the appropriate selection of these crop management tools. According to the present findings, the principal component analysis and regression model justified 74 and 95% of variations, respectively, in the bean-disease-treatment-yield datasets. This information suggested noticeable contributions of the treatments used in the present research to improve bean growth and yield by lowering the disease and drought. Future research can extend the outcomes of this study to examine the efficiency of such natural products to minimize applications of other agrochemicals in particular fertilizers and insecticides across different geographical areas.

SIGNIFICANCE STATEMENT

This study discovered the beneficial effects of proper irrigation, seaweed, and salicylic acid applications in mitigating biotic (root rot) and abiotic (drought) stresses, which can be beneficial for improving bean yield and sustainable crop management. This study will help researchers uncover the critical areas of natural stress management strategies that many researchers were not able to explore. Thus, a new theory on integrating natural products to minimize agrochemical dependence may be arrived at.

REFERENCES

1. Naseri, B., 2023. The Potential of Agroecological Properties in Fulfilling the Promise of Organic Farming: A Case Study of Bean Root Rots and Yields in Iran. In: Organic Farming: Global Perspectives and Methods, Sarathchandran, M.R. Unni, S. Thomas and D.K. Meena (Eds.), Woodhead Publishing, Cambridge, England, ISBN: 9780323991452, pp: 203-236.
2. Naseri, B. and P. Moradi, 2015. Farm management strategies and the prevalence of rhizoctonia root rot in bean. J. Plant Dis. Prot., 122: 238-243.
3. Dehghani, A., N. Panjehkeh, H.A. Rahmani, M. Salari and M. Darvishnia, 2018. Effectiveness of simultaneous application of indigenous rhizobium and arbuscular mycorrhiza on root rot disease and yield of red bean (*Phaseolus vulgaris* L.) in Lorestan Province. J. Biocontrol Plant Prot., 6: 43-58.
4. Beigzadeh, S., A. Maleki, M.M. Heydari, A. Rangin and A. Khorgami, 2020. Effects of salicylic acid and seaweed (*Ascophyllum nodosum*) extracts application on some physiological traits of white bean (*Phaseolus lanatus* L.) under drought stress conditions. J. Crop Ecophysiology, 14: 21-44.
5. Akbarabadi, A., D. Kahrizi, A. Rezaizad, G. Ahmadi, M. Ghobadi and M. Molsaghi, 2015. Study of variability of bread wheat lines based on drought resistance indices. Biharean Biologist, 9: 88-92.
6. Jain, V., S. Vart, E. Verma and S.P. Malhotra, 2015. Spermine reduces salinity-induced oxidative damage by enhancing antioxidative system and decreasing lipid peroxidation in rice seedlings. J. Plant Biochem. Biotechnol., 24: 316-323.
7. Zanjani, K.E., A.H.S. Rad, A.M. Agdam and T. Taherkhani, 2013. Effect of salicylic acid application under salinity conditions on physiologic and morphologic characteristics of Artemisia (*Artemisia annua* L.). J. Crop Ecophysiology, 6: 415-428.

8. Khodadadi, S., M.A. Chegini, A. Soltani, H.A. Norouzi and S.S. Hemayati, 2020. Influence of foliar-applied humic acid and some key growth regulators on sugar beet (*Beta vulgaris* L.) under drought stress: Antioxidant defense system, photosynthetic characteristics and sugar yield. Sugar Tech, 22: 765-772.
9. Abdel-Monaim, M.F., 2013. Improvement of biocontrol of damping-off and root rot/wilt of faba bean by salicylic acid and hydrogen peroxide. Mycobiology, 41: 47-55.
10. Al-Hakimi, A.M.A. and S.M.S. Alghalibi, 2007. Thiamin and salicylic acid as biological alternatives for controlling broad bean rot disease. J. Appl. Sci. Environ. Manage., 11: 125-131.
11. Nakano, Y. and K. Asada, 1981. Hydrogen peroxide is scavenged by ascorbate-specific peroxidase in Spinach chloroplasts. Plant Cell Physiol., 22: 867-880.
12. Beers, Jr. R.F. and I.W. Sizer, 1952. A spectrophotometric method for measuring the breakdown of hydrogen peroxide by catalase. J. Biol. Chem., 195: 133-140.
13. Giannopolitis, C.N. and S.K. Ries, 1977. Superoxide dismutases. I. Occurrence in higher plants. Plant Physiol., 59: 309-314.
14. Flint, H.I., B.R. Boyce and D.J. Beattie, 1967. Index of injury-a useful expression of freezing injury to plant tissues as determined by the electrolyte method. Can. J. Plant Sci., 47: 229-230.
15. Kranz, J., 2003. Comparison of Temporal Aspects of Epidemics: The Disease Progress Curves. In: Comparative Epidemiology of Plant Diseases, Kranz, J. (Ed.), Springer, Berlin, Heidelberg, ISBN: 978-3-662-05261-7, pp: 93-134.
16. Tabande, L. and B. Naseri, 2020. How strongly is rhizobial nodulation associated with bean cropping system? J. Plant Prot. Res., 60: 176-184.