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Effect of selected weeds and organic emulsions on seed germination, seedling growth and biochemical content in rice (*Oryza sativa*)

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Allelopathy is a biological phenomenon by which an organism produces one or more biochemicals that influence the germination, growth, survival and reproduction of other organisms (Stamp and Nancy 2003). Rice (*Oryza sativa* L.) is one of the major food crop in the world. The continuous expansion of the human population, limited land for agriculture, and decreasing soil fertility will result in food shortage that will raise a serious concern for human survival. So, there is a need for alternate ways to enhance crop productivity, without using harmful chemicals. In recent years, researchers tried to find new combinations to enhance agricultural productivity by using different weed's allelopathic capabilities and different products made from organic waste. Some are used to control pest and some are used to provide nutrition to enhance productivity.

Parthenium hysterophorus emerges as a problematic weed throughout the world. It possesses certain allelochemicals like oils, polyphenols, alkaloids, terpenes etc. (Wang and Gan 2020). These biochemicals have pesticidal, growth regulation and nitrification properties (Pandey 2009). *Moringa oleifera* leaves contains alkaloids, protein, quinine, cytokinin, antioxidants, macro and micronutrients (Paikra and Gidwani 2017). These biochemicals helps plants in metabolic activities, defence and plant growth. *Ascophyllum nodosum* is a rich source of various bioactive phenolic compounds such as phlorotannins and unique polysaccharides, which act as a UV protector, prevent stress and herbivory and important for cell structure (Moreira *et al.* 2017). *Medicago denticulata* is rich in alkaloids, flavonoids, naphthoquinones, and saponins (Kowalska *et al.* 2007). These compounds protect the plants from predators and microbes. Vermiwash contains several enzymes, plant growth hormones like cytokinin, gibberellins and vitamins along with micro and macronutrients (Buckerfield *et al*. 1999). Panchgavya is a mixture of five derivatives for cow, viz. cow dung, cow urine, milk, curd and ghee, in definite proportions. Also have many chemicals which have anti-microbial, nutritive properties, and helps in plant growth.

Earlier many studies have been done in the field of allelopathy of weeds and organic emulsions on different agricultural crops. However, they are mainly focused on physical aspects related to the targeted organisms. The current study aimed to investigate the overall impact of treatments on rice seedling.

An experiment was conducted during 2021–2022 at the laboratory of School of Crop Health Biology Research (CHBR), ICAR-National Institute of Biotic Stress Management, Raipur, Chhattisgarh. Seeds of a hybrid rice variety (13555) were selected for the study. The experiment was laid out in completely randomized design (CRD) with 3 replicates and 18 treatments, consisting of 3 different concentrations, viz. 5%, 10% and 15% extracts of 4 weeds (*Parthenium hysterophorus*, *Moringa oleifera, Ascophyllum nodosum* and *Medicago denticulata)* and 2 organic emulsions (vermiwash and panchgavya) (Table 1). The vermiwash and panchgavya were prepared by the standard method proposed by ICAR. The prepared fine paste of fresh weeds and organic emulsion were mixed with water in the ratios of 1.5:10, 1:10 and 0.5:10 on a w/v basis respectively, to prepare the 15, 10 and 5% solution of weeds extract and solutions of organic emulsion. The floating method was used to determine the seed viability. Germination and seedling growth were observed in controlled conditions during 9-days experiment, having optimum temperature 27 ± 2ºC and relative humidity 65–70%.

Calculation: To determine the relative germination percentage and seedling growth, the standard formulae was used. If the result shows positive (+) value or negative (-) value, it is concluded as an increment or reduction respectively. Standard error was also taken into the

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consideration by using the standard formula. Total nitrogen was estimated by the micro-Kjeldahl method as per the procedure suggested by AOAC (1995).

Estimation of Crude protein (CP) content: Based on the assumptions that nitrogen constitutes 16% of protein.

Crude protein content (%) = micro-Kjeldahl nitrogen content (%) × 6.25

Determination of seedling vigour: Seedling vigour was determined by using the standard vigour index formula (Abdul-Baki and Anderson 1973).

Vigour index (GSL) = Germination % × (Shoot length + Root length)

The new formula was proposed by Supriya V (2016), as per the guideline of ISTA:

Vigour index (GTDM) = Germination % × Total dry matter of seedlings

However, in the present study, a new formula is formulated and used to calculate vigour index more precisely:

Vigour index (GSLTDM) = (G – M) × {(PL/2) + (TDM/2)}

where G, Germination (%); M, Mortality (%); PL, Plant length; TDM, Total dry biomass.

Parthenium hysterophorus's impact: In present study, we found that treatment T_3, overall has negative impact on rice crop, it reduces the germination by 21.27% and protein content in seedlings by 9.81%, also stunted, slender and pale coloured seedlings were observed. But treatment T_1 increases the germination by 23.41%, biomolecule content by 6.13% and seedlings vigour by 60.77% of rice crop (Table 2). These capabilities of some crops to tolerate and benefitted from *P. hysterophorus,* were also reported by Javaid and Shah (2010).

Table 1 Treatment details

Notation	Treatment details
C	Water
T_1	5% extract of *Parthenium hysterophorus* (L.)
T_2	10% extract of *Parthenium hysterophorus* (L.)
T_3	15% extract of *Parthenium hysterophorus* (L.)
T_4	5% extract of *Moringa oleifera* leaves
T_5	10% extract of *Moringa oleifera* leaves
T_6	15% extract of *Moringa oleifera* leaves
T_7	5% solution of Vermiwash
T_8	10% solution of Vermiwash
T_9	15% solution of Vermiwash
T_{10}	5% solution of Panchgavya
T_{11}	10% solution of Panchgavya
T_{12}	15% solution of Panchgavya
T_{13}	5% extract of *Ascophyllum nodosum*
T_{14}	10% extract of *Ascophyllum nodosum*
T_{15}	15% extract of *Ascophyllum nodosum*
T_{16}	5% extract of *Medicago denticulata*
T_{17}	10% extract of *Medicago denticulate*
T_{18}	15% extract of *Medicago denticulate*

Moringa oleifera's *impact*: Rice crop was responded positively toward the treatment T_4, increases the germination by 25.53%, biomolecule content by 17.79% and seedlings vigour 120.29%, also greenish, healthy seedlings were observed. But treatment T_6 had detrimental impact on germination, it delayed and reduces germination by 8.50% and having non-significant impact on other aspects like 12.26% increment in biomolecule content (Fig. 1) and 17.10% increment in vigourness of seedlings (Fig. 2). The positive impact of *M. oleifera* in lower concentration was also reported by Mona *et al.* (2017) for other crops.

Ascophyllum nodosum's *impact*: The study indicated that rice crop was benefitted from the treatment $T_{13,}$ recorded non-significantly 6.38% higher germination, 1.22% more biomolecule content and 29.75% extra vigourness than control. But treatment T_{15}, rice crop showed a highly negative response towards it. It inhibits the germination by 78.72%, reduces biomolecule content by 42.33% and vigourness by 88.60%. The similar results were also concluded by Ramya *et al*. (2015) for brinjal crop.

Medicago denticulata's *impact*: The rice crop was negatively affected by the *M. denticulata* extracts (T_{16}), (T_{17}) and (T_{18}) as the concentration increases, it decreases the germination by 8.50%, 29.78% and 40.42%. It adversely impacts the vigourness of seedlings by 29.32%, 48.31% and 59.05% respectively. While biomolecule content was only reduced by T_{17} and T_{18} (12.88% and 15.33% lesser than control) and also higher seedling mortality were observed. The cause of this is flavonoids present in *Medicago denticulata* extract have allelopathic actions against other plants (Jiang *et al.* 2016). Also delayed and stunted seedling growth were observed but no pale or discolored seedlings.

Impact of vermiwash: Rice crop, responded positively toward different concentrations of vermiwash (T_7), (T_8) and (T_9), and they increase the germination by 17.02%, 19.15% and 21.28%, vigourness by 102.83%, 86.66%, and 109.06% respectively. While biomolecule content was reduced by treatment T_8 and T_9 (29.44% and 4.29% lesser than control), and pale coloured seedlings were observed in high numbers. The same results were also recorded by Nadana *et al.* (2020).

Panchgavya's impact: The germination was affected adversely when applied in higher concentration (T_{12}). It decreases germination by 2.12%. Treatment T_{10}, T_{11} and T_{12} reduces the biomolecule content by 25.15%, 19.01% and 39.26% respectively, also pale coloured seedlings and stunted growth with shrink leaves were observed. Unlike seedlings vigour, increased by 79.63%, 25.89% and 12.16% respectively. Also increased germination was recorded, in case of lower concentration, as also reported by Swaminathan *et al*. (2007).

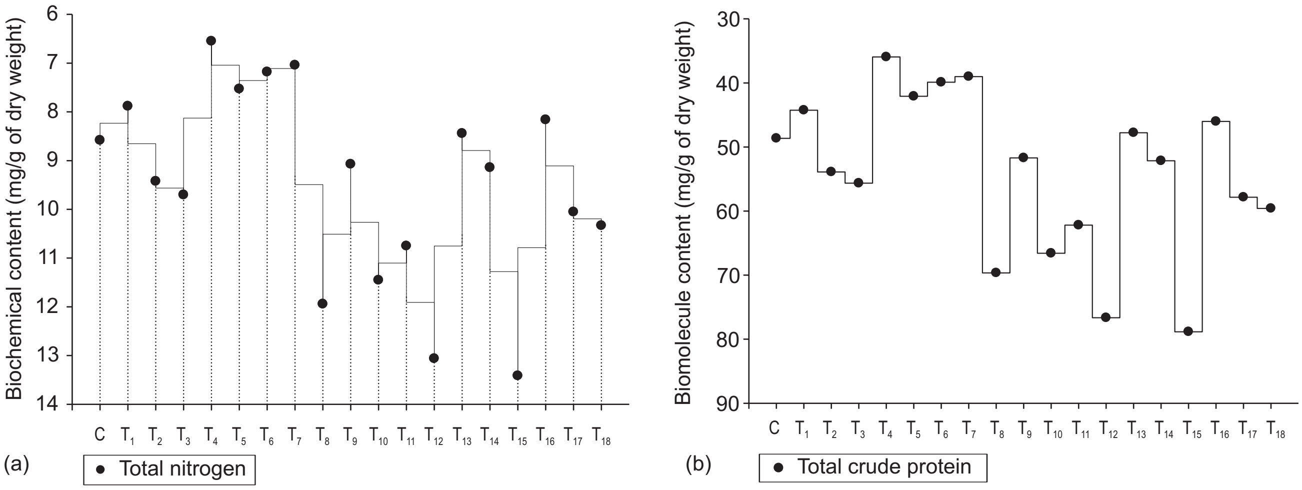

Fig. 1 Impact of different treatments on biomolecule content (a) total nitrogen and (b) total crude protein in dry mass of rice seedlings.

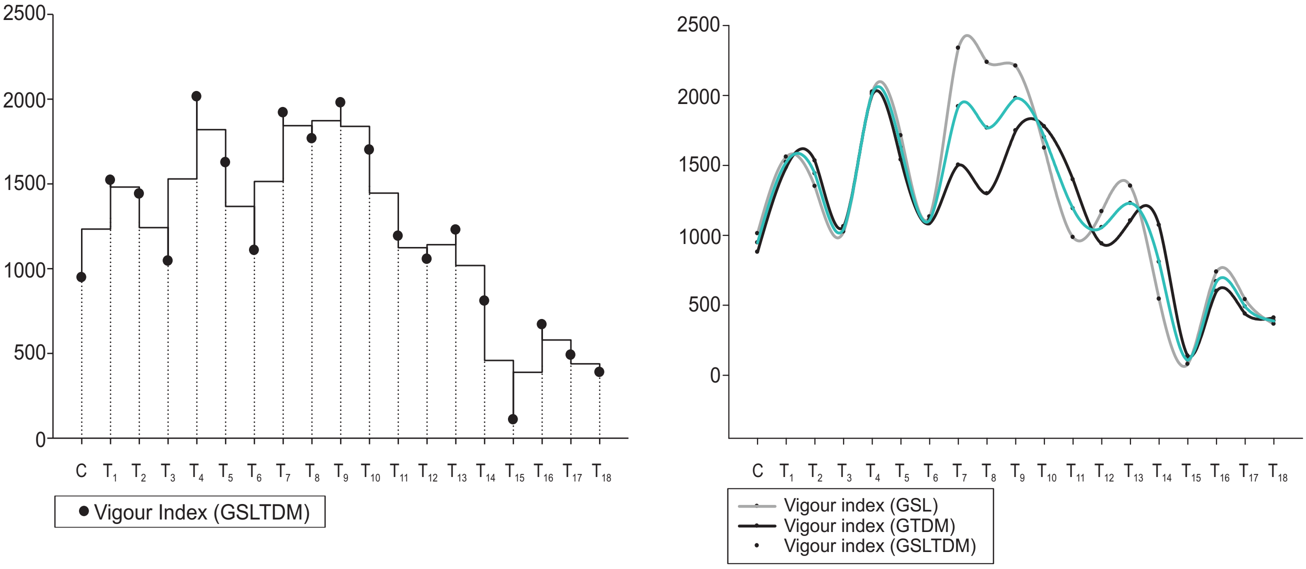

Fig. 2 Impact of different treatments on seed vigour index (a) VI (GSLTDM) and (b) comparison between all three vigour index values obtained from different formulas in dry mass of rice seedlings.

The effect of different treatments on germination and growth parameters of rice crops were analyzed and results indicate that the impact of 5% solution of *M. oleifera* extract (+120.29%), 15% solution of vermiwash (+109.06%) and 5% solution of vermiwash (+102.83%) had a significant positive impact on the germination and growth parameters of rice as compared to control, and 15% solution of *A. nodosum* extract (-88.60%), 15% solution of *M. denticulata* extract (-59.05%) and 10% solution of *M. denticulata* extract (-48.31%) produced a significant negative impact on rice crop.

The impact on biomolecule content of rice crop was examined carefully, the impact of 5%, 15% solution of *M. oleifera* extract (+17.79%) and (+12.26%), 5% solution of vermiwash (+13.49%) had a significant positive impact on the biomolecule content of rice.

SUMMARY

An experiment was conducted during 2021–22 at ICAR-National Institute of Biotic Stress Management, Raipur, Chhattisgarh, to understand the allelopathic impact of 4 selected weeds and 2 organic products on germination, seedling growth and biochemical content in rice in laboratory condition in a completely randomized design (CRD). The results indicate that 15% solution of *Ascophyllum nodosum* extract (T_{15}) and 15% solution of *Medicago denticulate* extract (T_{18}), inhibits the germination by 78.72 and 40.42%, respectively and 5% solution of *Moringa oleifera* extract (T_4), 5% solution of *Parthenium hysterophorus* extract (T_1) and 15% solution of vermiwash (T_9) increased the germination by 25.53, 23.41, and 21.28% respectively as compared to control. Treatment T_4 and T_9 increased the seedling's vigour by 112.8 and 109.08%, while among them

Table 2 Impact of different treatments as compared to control on rice seedlings (mean ± SE)

Treatment	Germination (%)	SL (cm)	RL (cm)	Total FW (mg)	Total DW (mg)	Total N (mg/g)	Total CP (mg/g)	SVI (GSR)	SVI (GTDW)	SVI (GS-RTDW)
C	78.33 ± 4.40	8.3 ±1.58	4.63 ± 0.51	112.36 ± 1.07	11.23 ± 0.58	11.41	71.36	1013.1	880.2	946.6
T_1	96.67 ± 1.66 (+23.41)	11.23 ± 0.84 (+35.34)	4.9 ± 0.96 (+5.76)	120.04 ± 0.87* (+6.83)	15.35 ± 1.59 (+36.63)	12.11	75.74 (6.13)	1559.5	1484.1	1521.85 (+60.77)
T_2	83.33 ± 4.40 (+6.38)	11.53 ± 0.54 (+38.95)	4.66 ± 0.47 (+0.72)	104.27 ± 0.80* (-7.20)	18.39 ± 1.06** (+63.66)	10.57	66.10 (-7.361)	1350	1532.5	1441.25 (+52.25)
T_3	61.67 ± 4.40* (-21.27)	11.9 ± 0.17 (+43.37)	4.73 ± 0.94 (+2.16)	109.07 ±1.72 (-2.93)	17.23 ± 0.85* (+53.39)	10.29	64.35 (-9.81)	1025.7	1062.9	1044.3 (+10.32)
T_4	98.33 ± 1.66 * (25.53)	16.33 ± 1.38* (96.78)	4.26 ± 1.27 (-7.90)	148.02 ± 2.08** (31.74)	20.39 ± 0.5** (81.48)	13.44	84.06 (17.79)	2024.6	2005.3	2014.94 (+112.8)
T_5	90 ± 5 (14.89)	15.4 ± 2.66* (85.54)	3.63 ± 1.13 (-21.57)	117.44 ± 1.21 (4.52)	17.1 ± 0.98* (52.20)	12.46	77.93 (9.20)	1712.7	1539.3	1625.99 (+71.77)
T_6	71.66 ± 6.00 (-8.50)	12.43 ± 0.94 (49.79)	3.36 ± 0.84 (-27.33)	142.8 ± 1.38** (27.09)	15.13 ± 0.24 (34.70)	12.81	80.11 (12.26)	1132.3	1084.7	1108.56 (+17.10)
T_7	91.67 ± 3.33 (17.03)	15.56 ± 0.72* (87.55)	9.93 ± 0.38** (114.4)	130.36 ± 0.71** (16.02)	16.39 ± 0.46* (45.89)	12.95	80.995 (13.49)	2337.5	1502.7	1920.11 (+102.8)
T_8	93.33 ± 3.33 (19.15)	14.3 ± 1.12 (72.28)	9.66 ± 0.34* (108.65)	114.14 ± 0.76 (1.58)	13.9 ± 0.70 (23.70)	8.05	50.34 (-29.44)	2236.8	1297.3	1767.11 (+86.67)
T_9	95 ± 2.88* (21.28)	14.5 ± 1.21 (74.69)	8.76 ± 1.71* (89.22)	149.68 ± 1.36** (33.22)	18.4 ± 2.0** (63.74)	10.92	68.29 (-4.294)	2210.3	1748	1979.16 (+109.0)
T_{10}	93.33 ± 1.66 (19.15)	12.86 ± 2.05 (55.02)	4.53 ± 0.17 (-2.15)	152.13 ± 0.56** (35.39)	19.04 ± 0.97** (69.44)	8.546	53.41 (-25.15)	1624	1777	1700.5 (+79.64)
T_{11}	85 ± 5.77 (8.51)	8.63 ± 1.47 (4.01)	2.96 ± 1.01 (-35.96)	114.44 ± 3.16 (1.85)	16.44 ± 0.06* (46.33)	9.24	57.79 (-19.01)	986	1397.6	1191.84 (+25.90)
T_{12}	76.66 ± 1.66 (-2.12)	12.3 ± 0.66 (48.19)	2.96 ± 0.46 (-35.96)	128.91 ± 2.11** (14.72)	12.26 ± 1.83 (9.16)	6.93	43.34 (-39.26)	1170.4	940.44	1055.43 (+11.49)
T_{13}	83.33 ± 4.40 (6.38)	13 ± 0.32 (56.62)	3.23 ± 0.49 (-30.21)	83.27 ± 1.09** (-25.88)	13.24 ± 2.14 (17.88)	11.55	72.23 (1.22)	1352.7	1103.8	1228.3 (+29.75)
T_{14}	68.33 ± 4.40 (-12.76)	6.2 ± 1.07 (-25.30)	1.76 ± 0.40 (-61.86)	96.30 ± 2.09** (-14.29)	15.69 ± 1.13 (39.69)	10.85	67.86 (-4.90)	544.38	1072.6	808.49 (-14.59)
T_{15}	16.66 ± 6.66** (-78.72)	3.4 ± 0.55* (-59.03)	1.3 ± 0.11 (-71.94)	85.10 ± 1.55** (-24.25)	8.25 ± 0.24 (-26.57)	6.58	41.15 (-42.33)	78.33	137.5	107.91 (-88.60)
T_{16}	71.67 ± 4.40 (-8.50)	6.46 ± 0.80 (-22.08)	3.83 ± 0.23 (-17.26)	86.45 ± 1.26** (-23.06)	8.37 ± 0.66 (-25.51)	11.8	73.99 (3.68)	738.16	599.85	669.00 (-29.32)
T_{17}	55 ± 5* (-29.78)	5.5 ± 0.66 (-33.73)	4.4 ± 1.05 (-5.02)	85.65 ± 3.52** (-23.76)	7.96 ± 0.08 (-29.16)	9.94	62.16 (-12.88)	540.8	437.8	489.31 (-48.30)
T_{18}	46.67 ± 4.40** (-40.42)	4.63 ± 0.52 (-44.17)	3.2 ± 0.20 (-30.93)	98.02 ± 3.27** (-12.76)	8.77 ± 0.90 (-21.89)	9.66	60.41 (-15.3)	365.5	409.57	387.56 (-59.05)

One-way RM ANOVA was applied. '*' and "**" indicate significance at $P<0.05$ and $P<0.01$ level respectively, and figures in parentheses indicate the reduction (-) or increase (+) percentage as compared to the control percentage.

SL, Shoot length; RL, Root length; FW, Fresh weight; DW, Dry weight; N, Nitrogen; CP, Crude protein; SVI, Seedling vigour index. Refer to the methodology for treatment details.

treatments, viz. 15% solution of *A. nodosum* extract (T_{15}) and 15% solution of *M. denticulate* extract (T_{18}) decreased the vigourness by -88.60% and -59.05% respectively. Treatment T_4 and 5% solution of vermiwash (T_7) increased the biochemical content by 17.79% and 13.49% respectively, while 15% solution of panchgavya (T_2), and treatment T_{15} were significantly decreased the biochemical content by 39.26 and 42.33% respectively. Based on findings, it may be concluded that negative correlation was found between the response of rice crop and increasing concentrations of weed extracts and panchgavya unlike vermiwash. But lower concentration of *M. oleifera* and vermiwash showed most positive impact on rice seedlings.

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