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Research Article

Effect of pulse sprout spray as a foliar nutrition to enhance seed yield and quality in barnyard millet (*Echinochloa frumentacea* l.)

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Abstract
Millets are rich in valuable nutrients such as carbohydrates, proteins, dietary fibre, minerals and vitamins. The uninterrupted and disproportionate use of chemical fertilizers over a longer period has resulted in deterioration of soil health and reduced yield. Foliar spray is a very easy way to supply valuable nutrients to plants. With this background, an experiment was conducted to see the effect of pulse sprout extract spray as a foliar spray on the seed crop Barnyard millet (*Echinochloa frumentacea* L.). The seed crop given foliar treatment with 2% horse gram pulse sprout extract spray recorded higher growth attributes namely plant height (172.8 cm), total chlorophyll content (1.560 mg/g) and yield attributes *viz.,* seed yield per plant (26.5 g), seed yield per plot (2.54 kg), seed yield per hectare (2506 kg), 1000 seed weight (3.28 g), quality parameters viz., germination (89%), vigour index (2461) and biochemical parameters of resultant seeds in both *kharif* and *rabi* seasons. The crop given with foliar nutrition of 2% horse gram sprout extract spray showed a low number of days to flower initiation (45 days) and 50% flowering (54 days) when compared to control followed by 2% cowpea sprout extract. Hence it was hypothesized that application of the nutrient extract from the sprouted pulses in the form of foliar spray would enable better crop growth and productivity of Barnyard millet.

Keywords: Barnyard millet, Foliar spray, Horse gram, Cowpea sprout extract

INTRODUCTION

Millets occupy a vital position in providing nutrition to the ever-growing population of the world. Small millets are highly energetic and supply nutritious foods comparable to other cereals (Himanshu *et al.*, 2018). They are particularly low in phytic acid and rich in dietary fibre, iron, calcium and vitamin B (Sujatha *et al.*,2013). Barnyard millet *(Echinochloa frumentacea* L.) is also known as *sawa* millet. It is well adapted to low and moderate rainfall areas (500-700 mm) due to its early maturity character. It is an excellent source of dietary fibre (13 g/100 g) with good amounts of soluble (4.66 g/100 g) and insoluble (8.18 g/100 g) fractions and fair source of highly digestible (81.13 g/100 g digestibility) protein (Veena *et al.,* 2005).

Over the last decade, scientists were working more towards the determination of the biological value of the nutritional sprouts (Penas *et al*., 2008). Organic farming is not mere non-chemical in agriculture, but it is a system of farming based on an integral relationship in nature (Jayanthi *et al.,* 2013). In order to get the maximum productivity, the mother plants should be added with nutrients using the foliar application. This will reduce the loss through absorption, leaching and other process associated with soil uses (Geetharani *et al.,* 2008). Foliar application is credited quick and efficient utilization of nutrients (Abid *et al.,* 2019).

Sprouting of grains for a limited period leads to increased activities of hydrolytic enzymes, improvement in the contents of essential amino acids, total sugars, B-group vitamins and decrease in dry matter, starch and antinutrients (Saira *et al.*, 2011). The foliar spray with horse gram sprout extract and cowpea sprout extract at 3% level could record the highest germination, vigour

and yield parameters when compared to control (dry seeds) and water-soaked seeds in rice (Vijayalakshmi, 2009), cotton (Sakthivel, 2010) and green gram, black gram (Gomathi, 2011). The present work was conducted on barnyard millet *(E. frumentacea* L.*)* to study the effect of pulse sprout extract spray to improve the seed quality and seed yield.

MATERIALS AND METHODS

Field experiments were carried out at Department of Seed Science and Technology, Agricultural College and Research Institute, Madurai on seed crop of in Barnyard millet (*E. frumentacea* L.) during *kharif* and *rabi* 2016-17, to determine the effect of pulse sprout extract spray as mother crop nutrition.

Pulse sprout milk was extracted by soaking the horse gram and cowpea seeds for 12 h followed by incubation of 12 h in a wet cloth to permit sprouting of seeds. The sprouted seeds were ground in a mixer - grinder after adding ice-cold water @ 1:1 (g / ml) and squeezed through cloth to extract the milk of 100 per cent concentration (Jayanthi, 2008).

Treatment details: The three concentrations viz; 1, 2, 3% horse gram sprout extract and 1, 2, 3% cowpea sprout extract were explored as a foliar spray to field trials for evaluating their effect on crop growth and productivity of Barnyard millet (*E. frumentacea* L.) var.CO (KV)2. T1 – Control; T2 – Cowpea sprout extract 1%; T3 – Cowpea sprout extract 2%; T4 – Cowpea sprout extract 3%; T5 – Horse gram sprout extract 1%; T6 – Horse gram sprout extract 2% ; T7 – Horse gram sprout extract 3%; T8 – DAP 2%. The foliar spray was applied in three stages viz; 60 Days after sowing, 75 Days after sowing and 90 Days after sowing.

Layout of the experiment: Two field trials were conducted at S1 - *Kharif* 2016; S2 - *Rabi* 2016-17 with three replications and a plot size of 3 x 3 m and 4 x 3m. The following observations were made on crop growth and yield factors.

Growth parameters: Plant height was measured from ground level to tip of the leaf at active tillering, flowering and harvest stages, and the mean height was expressed in cm.

Total chlorophyll content was computed using the following formula (Arnon, 1949) and expressed as mg g-1 of a fresh leaf (Yoshida *et al.,* 1976). The optical density of the extract was read in an ELICO UV-VIS Spectrophotometer (Model SL-159).

$$\text{Total chlorophyll} = \frac{\text{OD value at 652} \times 1000 \times V}{34.5 \times W \times 1000} \times 100 \quad \text{..... Eq.1}$$

Where,

V = Final volume of acetone extract; W = Fresh weight of sample in gram (g)

The number of days taken for first flowering and for 50% flowering was assessed in five plants selected at random in each replication, and the mean value was expressed in days.

Yield attributes: Seeds obtained from all the five randomly tagged plants were weighed after drying to 10 ± 0.5 per cent moisture content, and seed yield per plant was expressed in g. Seeds obtained from the net plot area of each treatment were dried, cleaned and weighted and Seed yield per plot expressed as kg The seed yield recorded in each plot was computed for hectare yield and expressed in kg/ha.

Seed quality parameters: One thousand seeds from each treatment were chosen at random, and their weight was recorded on electronic balance as per ISTA procedure (Anonymous, 1999), and an average of 1000 seed weight was expressed in g. Germination test was conducted by following the procedure outlined in ISTA (2012) by roll towel method with 8 replication 400 seeds under controlled conditions in which 25±2ºC and 95±2 % of temperature and RH, respectively were maintained. On 10^{th} day, no. of normal seedlings were counted and expressed as a percentage. Ten normal seedlings were selected randomly, and root length (cm) was measured from the collar region to the tip of the primary root and shoot length (cm) from the collar region to the tip of primary leaves. Same seedlings used for growth measurement were placed in a paper cover, shade dried for 24 h and then kept in a hot air oven maintained at 85 ± 1˚C for 24 h and cooled in a desiccator for 30 min. The dried seedlings were weighed, and the mean was expressed as mg / 10 seedlings. Seedling vigour index was calculated using the following formula as described by Abdul-Baki and Anderson (1973) and expressed in the whole number.

Vigour index = Germination percentage x Total seedling length in cm. ….. Eq.2

Biochemical analysis of harvested seeds: Protein content was estimated by adopting the protocol of Ali-Khan and Youngs, 1973. The amount of amino acid in barnyard millet seed leachate was estimated in following the method described by Moore and Stein (1948), and the amount of sugar was analyzed as per the method of Somogyi (1952). The data was analyzed statistically adopting the procedure given by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

Foliar feeding of nutrients has become an established procedure in seed production to increase the seed yield and quality, and it also minimizes environmental pollution and improves nutrient utilization. (Abou-El-nour, 2002).

Sprout spray is an inexpensive and effective technology for improving the nutritional quality of cereals and

grain legumes (Frias *et al*., 2005). Germination unfolds and enzymes trigger elaborate biochemical changes. Proteins break into amino acids. Water-soluble vitamins such as B complex and vitamin C are created (Vidal-Valverde *et al*., 2002). Fats and carbohydrates are converted into simple sugars. Weight increases as the seed absorb water and minerals, sprouting induce biosynthesis of vitamin C. Thiamin and Niacin are readily available through sprouts. Vitamin A content of seeds is improved considerably after sprouting. Germination increases the bioavailability of minerals and vitamins (Chingakham *et al.,* 2015).

Thus, pulse sprouts are a sustainable source of nutrition owing to the rich nutrient content augmented upon sprouting and the considerably low cost of pulses such as horse gram and cowpea (Vega *et al*., 2010). Hence, it was hypothesized that application of the nutrient extract from the sprouted pulses in the form of foliar spray would enable better crop growth and productivity of rice (Jayanthi *et al*., 2013).

The present showed that the plant height was a direct index to assess the growth and vigour of the plant. Plant height of barnyard millet was found to increase slowly up to 60 DAS, thereafter it increased linearly up to 90 DAS, and it occurred at a diminishing rate under all irrigation regimes (Table.1). The increase in plant height by sprout extract spray might be due to bioactive substances like enzyme inhibitors, lectin and phenolic compounds (Vega *et al*., 2010). In addition, the readily available form of nutrients in foliar spray would assist the efficient absorption and subsequent transport enhancing growth parameters (Vijayalakshmi *et al*., 2019) in rice.

To achieve the highest yield, the total chlorophyll content must be higher (Table.2) to intercept more light energy and culminating in higher dry matter production (Renuka *et al.,* 2007). Pulse sprout extract contains various enzymes like α-amylase, phytase like compounds. It enhances the leaf chlorophyll content in plants and a reduction in chlorophyll degradation (Gomathi, 2011).

The present study indicated that pulse sprout extracts not only increased the vegetative growth of the plant but also triggered the early flowering and maturation in crops. Days to first flowering and 50% flowering were hastened in pulse sprout sprayed plants than the control in both the seasons. Between the seasons, the plants took a lesser number of days for first flowering in *rabi,* when compared to *kharif,* and this may be due to the seasonal effects in barnyard millet (Table.3).

The yield increase in pulse sprout extract sprayed plant are thought to be associated with the hormonal substances present in the extracts, especially cytokinins. Cytokinins in vegetative plant organs are associated with nutrient partitioning; whereas in reproductive

Table 1. Effect of foliar nutrition of pulse sprout extract spray on plant height (cm) in barnyard millet cv. CO (KV) 2.

Treatments	S1				S2				Pooled mean			
	D1	D2	D3	Mean	D1	D2	D3	Mean	D1	D2	D3	Mean
T1	146.6	165.7	174.9	162.4	70.0	104.0	117.2	97.1	108.3	134.9	146.1	129.7
T2	147.0	167.6	177.3	164.0	72.6	113.7	123.7	103.3	109.8	140.7	150.5	133.7
T3	154.2	173.9	186.1	171.4	76.7	117.6	126.1	106.8	115.5	145.8	156.1	139.1
T4	150.2	169.8	181.0	167.0	78.0	119.4	129.1	108.8	114.1	144.6	155.0	137.9
T5	148.0	168.5	178.7	165.1	75.5	117.4	125.7	106.2	111.8	143.0	152.2	135.6
T6	155.4	175.2	187.9	172.8	82.3	125.1	132.7	113.4	118.9	150.2	160.3	143.1
T7	152.4	172.1	183.8	169.4	76.9	118.7	126.2	107.3	114.7	145.4	155.0	138.3
T8	149.5	169.0	179.7	166.1	77.4	119.1	126.7	107.7	113.5	144.1	153.2	136.9
Mean	150.4	170.2	181.2		76.2	116.9	125.9		113.3	143.6	153.6	
Grand mean				167.3				106.3				136.8
	D		T	D x T		D	T	D x T		D	T	D x T
SEd	1.32		2.16	3.74		0.69	1.12	1.95		1.00	1.64	2.86
CD(P=0.05)	2.66**		4.35**	NS		1.39**	2.27**	NS		2.03**	3.31**	NS

Table 2. Effect of foliar nutrition of pulse sprout extract spray on total chlorophyll content (mg g-1) in barnyard millet cv. CO (KV) 2.

Treatments	S1				S2				Pooled mean			
	D1	D2	D3	Mean	D1	D2	D3	Mean	D1	D2	D3	Mean
T1	0.829	0.936	0.834	0.866	0.590	0.710	0.581	0.627	0.710	0.823	0.708	0.747
T2	0.910	1.068	0.990	0.989	0.631	0.742	0.550	0.641	0.771	0.905	0.770	0.815
T3	1.339	1.521	1.391	1.417	1.237	1.185	1.470	1.297	1.288	1.353	1.431	1.357
T4	1.473	1.694	1.519	1.562	0.910	1.069	0.990	0.990	1.192	1.382	1.255	1.276
T5	1.268	1.473	1.284	1.342	0.829	0.936	0.834	0.866	1.049	1.205	1.059	1.104
T6	1.687	1.748	1.523	1.653	1.328	1.699	1.375	1.467	1.508	1.724	1.449	1.560
T7	1.420	1.671	1.482	1.524	1.040	1.234	1.112	1.129	1.230	1.453	1.297	1.327
T8	1.426	1.682	1.496	1.535	0.840	0.976	0.953	0.923	1.133	1.329	1.225	1.229
Mean	1.294	1.474	1.315		0.926	1.069	0.983		1.110	1.272	1.149	
Grand mean				1.361				0.993				1.177
	D	T	D x T	D	T	D x T	D	T	D x T			
SEd	0.01	0.02	0.03	0.01	0.01	0.02	0.01	0.02	0.02			
CD (P=0.05)	0.02**	0.03**	0.06**	0.02**	0.02**	0.04**	0.02**	0.03**	0.04**			

Table 3. Effect of foliar nutrition of pulse sprout extract spray on days to first flowering and 50% flowering (days) in barnyard millet cv. CO (KV) 2.

Treatments	Days to first flowering (days)			Days to 50% flowering (days)		
	S1	S2	Pooled	S1	S2	Pooled
T1	50	43	47	55	56	56
T2	49	43	46	54	55	54
T3	49	42	46	56	55	56
T4	49	42	45	55	55	55
T5	49	42	46	55	55	55
T6	48	42	45	54	55	54
T7	50	42	46	54	55	54
T8	48	42	45	54	55	54
Mean	49	42	46	55	55	55
SEd	1.09	1.19	1.14	1.12	1.05	1.09
CD(P=0.05)	NS	NS	NS	NS	NS	NS

Table 4. Effect of foliar nutrition of pulse sprout extract spray on seed yield per plant (g), seed yield per plot (Kg) and seed yield ha-1 (kg) in barnyard millet.

Treatments	Seed yield per plant (g)			Seed yield per plot (kg)			Seed yield per hectare (kg)		
	S1	S2	Pooled mean	S1	S2	Pooled mean	S1	S2	Pooled mean
T1	27.5	20.1	23.8	2.52	2.03	2.27	2797	1688	2242
T2	28.5	21.5	25.0	2.53	2.23	2.38	2814	1861	2338
T3	30.5	22.4	26.4	2.77	2.22	2.49	3081	1847	2464
T4	30.2	22.3	26.3	2.72	2.17	2.44	3024	1806	2415
T5	29.7	21.9	25.8	2.65	2.10	2.37	2940	1750	2345
T6	30.6	22.4	26.5	2.78	2.30	2.54	3092	1919	2506
T7	30.3	22.3	26.3	2.76	2.14	2.45	3066	1784	2425
T8	29.9	22.3	26.1	2.69	2.24	2.46	2987	1867	2427
Mean	29.6	21.9	25.8	2.68	2.18	2.43	2975	1815	2395
SEd	0.72	0.36	0.54	0.05	0.05	0.05	58.51	49.79	54.15
CD (P=0.05)	1.55**	0.78**	1.17**	0.11**	0.10**	0.11**	125.5**	106.8**	116.1**

Table 5. Effect of foliar nutrition of pulse sprout extract spray on resultant seed germination (%), Vigour index and 1000 seed weight (g) in barnyard millet.

Treatments	Germination (%)			Vigour Index			1000 seed weight (g)		
	S1	S2	Pooled mean	S1	S2	Pooled mean	S1	S2	Pooled mean
T1	82 (64.92)	79 (62.75)	82 (64.88)	2058	1936	1997	2.76	2.89	2.83
T2	85 (67.22)	81 (64.21)	83 (65.71)	2176	2033	2105	2.96	2.97	2.97
T3	88 (69.84)	86 (68.17)	87 (68.90)	2455	2339	2397	3.31	3.13	3.22
T4	87 (68.64)	84 (66.50)	86 (68.17)	2314	2184	2249	3.07	3.10	3.09
T5	86 (68.17)	82 (64.88)	84 (66.45)	2227	2075	2151	2.98	2.98	2.98
T6	90 (70.23)	87 (68.90)	89 (70.68)	2529	2393	2461	3.37	3.18	3.28
T7	88 (69.70)	86 (68.17)	87 (68.90)	2455	2339	2397	3.21	3.11	3.16
T8	87 (68.64)	84 (66.50)	86 (68.17)	2306	2176	2241	3.01	3.01	3.01
Mean	87 (68.64)	84 (66.50)	85 (67.22)	2315	2184	2250	3.08	3.05	3.07
(Figures in parentheses indicate arc sine value)									
SEd	1.02	1.02	1.02	50.5	46.8	48.7	0.06	0.07	0.07
CD (P=0.05)	2.16**	2.16**	2.16**	107.1**	99.3**	103.2**	0.13**	0.15**	0.14**

organs linked with nutrient mobilization (Zodape *et al.,* 2008). Among the treatments, horse gram pulse sprout extract 2% foliar spray registered its superiority in both *kharif* and *rabi* seasons (Table.4). Increase in seed yield was mainly due to an increase in a number of productive tillers, panicle length and as well as 1000 seed weight (Vijayalakshmi *et al.,* 2019) in rice. Yield enhancement effect due to improved chlorophyll content in leaves of various crop plants has been attributed to the phytase present in the pulse sprout extract (Vega *et al.,* 2010).

The present study observed that spraying of pulse sprout extract on barnyard millet CO (KV) 2 in two stages viz., flowering and 50% flowering also improved the quality of resultant seeds, in terms of germination per cent, shoot length (cm), root length (cm) and vigour index. Pulse sprout extracts resultant seed recorded higher 1000 seed weight (g) compared to control in barnyard millet (Table 5). The protein content of the resultant seed of the crop sprayed with 2% horse gram pulse sprout extract was maximum (11.2%) which was 19 % higher compared to control, and the leachate amino acid and leachate sugars were minimum in the pooled analysis (Table 6).

Pulse sprouts are a rich source of enzymes, proteins and water-soluble vitamins (Vidal Valverde *et al.,* 2002; Oloyo, 2003). Shinde and Bhilare (2003) have described that even if less amount of nutrients are added through foliage 2-3 times at different growth stages of crops was sufficient enough to satisfy the nutrient requirements of the crops with low-cost input. He also reported that foliar application of fertilizers was widespread among the agricultural crop production, as it seems to be more eco friendly in comparison with soil fertilization (Kuepper, 2003). Jaskulski (2007) has shown the positive economic effect of foliar fertilization in growing vegetables, having a direct impact on increasing yield.

Conclusion

The field experiments on the effect of pulse sprout spray through foliar spraying at a vegetative and flowering stage has proved that pulse sprout sprays irrespective of concentrations could improve the seed yield of Barnyard millet (*E. frumentacea* L.). However, the maximum improvement in seed yield and quality can be realized by spraying horse gram 2% extract. The yield enhancement may be due to the presence of bioactive substances in sprouted horse gram, and cowpea extracts were found effective towards yield aximization in barnyard millets.

Table 6. Effect of foliar nutrition of pulse sprout extract spray on resultant seed protein content (%), total amino acid and total free sugar (g 100 g-1) in barnyard millet cv. CO (KV) 2.

Treatments	Protein content (%)			Total amino acids (g 100 g^{-1})			Sugar content (g 100 g^{-1})		
	S1	S2	Pooled mean	S1	S2	Pooled mean	S1	S2	Pooled mean
T1	9.4 (17.85)	9.4 (17.85)	9.4 (17.85)	0.25	0.27	0.25	0.27	0.29	0.28
T2	9.6 (18.05)	9.5 (17.95)	9.6 (18.05)	0.24	0.25	0.24	0.26	0.27	0.27
T3	10.6 (19.03)	10.5 (18.93)	10.6 (19.03)	0.21	0.22	0.21	0.22	0.23	0.23
T4	10.6 (19.03)	10.3 (18.71)	10.5 (18.93)	0.21	0.23	0.21	0.23	0.25	0.24
T5	9.9 (18.34)	9.9 (18.34)	9.9 (18.34)	0.22	0.23	0.22	0.25	0.28	0.27
T6	11.2 (19.53)	11.1 (19.45)	11.2 (19.53)	0.19	0.21	0.20	0.20	0.22	0.21
T7	10.9 (19.25)	10.5 (18.93)	10.7 (19.15)	0.21	0.24	0.21	0.23	0.25	0.24
T8	10.2 (18.61)	10.1 (18.52)	10.2 (18.61)	0.22	0.24	0.22	0.24	0.27	0.26
Mean	10.3 (18.72)	10.2 (18.61)	10.2 (18.61)	0.22	0.25	0.23	0.24	0.26	0.25
(Figures in parentheses indicate arc sine value)									
SEd	0.17	0.25	0.21	0.01	0.004	0.01	0.005	0.006	0.01
CD(P=0.05)	0.36**	0.54**	0.45**	0.02**	0.01**	0.02**	0.010**	0.012**	0.02**

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