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RESEARCH NOTE

Impact of weed management practices on weed growth, crop yield and soil microbes in groundnut

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ABSTRACT

A field experiment was conducted in a randomized block design with different organic weed management treatments including water extracts of sorghum, sunflower, Parthenium, Lantana and purplenut sedge plants, each 15 L/ha applied at 15 and 30 days after seeding (DAS) alongwith paddy straw mulch 5 t/ha. The predominant weed species were *Cyperus rotundus* L. (45%), *Digitaria sanguinalis* (L.) Scop. (15%), *Borreria hispida* (L.) K. Schum. (7%). Application of paddy straw mulch 5 t/ha proved to be best in controlling weeds and promoting yield components and yield of groundnut as well as realizing higher returns followed by sunflower water extract spray 15 L/ha. The efficacy of Parthenium water extract and purple nutsedge water extracts were poor in controlling weeds and enhancing yield of groundnut. The reduction in groundnut pod yield due to unchecked weed growth was 52.53% and 37.18% compared to pendimethalin 1.0 kg/ha + hand weeding (HW) at 30 DAS and paddy straw mulch 5 t/ha, respectively. Pre-emergence application of pendimethalin1.0 kg/ha followed by HW recorded significantly higher number of effective Rhizobium nodules/ plant whereas paddy straw mulch 5 t/ha recorded significantly higher count of soil microorganisms.

Keywords: Groundnut, Organic weed management, Plant water extracts, Soil microbes, Pod yield

Groundnut (*Arachis hypogaea* L.) is grown throughout the year during rainy (*Kharif*), winter (*Rabi*) and summer seasons in one or other parts of the India due to diversified climate. Groundnut is grown under tropical climate with hot and humid weather and hence confronted by repeated flushes of various grasses and broad-leaved weeds throughout its growing period. Though, groundnut is a hardy crop, it is highly susceptible to weed preponderance due to lower height of canopy and slow initial growth. The critical period of crop weed competition in groundnut was around 4-9 weeks after sowing in sandy loam soils (Wesley *et al.* 2008). In groundnut, weeds compete with crop plants for nutrients and remove more than 50% of applied nutrients under un-weeded conditions resulting in significant yield reduction (Naveen Kumar *et al.* 2021). Improvisation in methods of weed management is the need of the day for effective weed control to meet the labour shortage during peak period of demand and increased cost of weeding. Weed control with herbicides is expensive and pose detrimental effect on the environment. The toxic herbicides are polluting the surface and ground water for livestock as well as human beings while their residues released from the plants as well as from the soil move into the nutrition cycle and ultimately become perilous for descendants (Judith *et al.* 2001). In recent years, the increased emphasis is placed on sustainable agriculture and concerns about the adverse effect of extensive use of farm chemicals and on reducing the dependence upon synthetic herbicides and finding alternative strategies for weed management in general and in organic and sustainable agricultural systems in particular. There is an exigency to develop natural and ecological strategies for controlling weeds due to the consumer preference on organic products in recent years. Allelopathy is utilizing natural allelochemicals for weed management. Unlike synthetic herbicides, such compounds are produced naturally in the plants and used directly as herbicides. A number of secondary metabolites/allelomones produced by some of the plants act as potential natural herbicides with considerable crop selectivity, which could be directly used in the form of aqueous plant water extracts for weed management in organic and sustainable agriculture systems (Ray *et al.* 2022). The application of allelopathic water extract of sorghum 25 L/ha twice at 15 and 30 DAS resulted in less weed density as compared to all other plant aqueous extracts in cotton grown on clay loam soils of Peshawar,

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Pakistan (Kandhro *et al.* 2015). In this context, the present field experiment was conducted to study the efficacy of different plant water extracts for control of mixed weed flora associated with groundnut in sandy loam soils and compare them with efficacy of commonly used herbicides.

A field experiment was conducted during winter (*Rabi*), 2017-18 at wetland farm of Sri Venkateswra Agricultural College, Tirupati campus of Acharya N.G. Ranga Agricultural University, Andhra Pradesh, India which is geographically situated at 13.5°N and 79.5°E with an altitude of 182.9 m above the mean sea level. The experimental soil was sandy loam in texture with soil p^H 7.7, organic carbon (0.23 %), available N (128 kg/ha), P 12 kg /ha, potassium (225 kg/ha) and EC of 0.65 dS/m. The experiment was laid out in randomized block design with ten treatments replicated thrice. The treatments consisting of five plant water extracts *viz*., sorghum, sunflower, Parthenium, rice, Lantana and purplenut sedge each at 15 L/ha applied at 15 and 30 days after seeding (DAS) and paddy straw mulch 5 t/ha each, pre-emergence application (PE) of pendimethalin 1.0 kg/ha followed by (*fb*) hand weeding (HW) at 30 DAS, post-emergence application (PoE) of imazethapyr 75 g/ha and unweeded check. The entire plant of sorghum (*Sorghum bicolor* L.), sunflower (*Helianthus annus* L.), rice (*Oryza sativus* L.), carrot grass (*Parthenium hysterophorus* L.), Lantana (*Lantana camara* L.) and tubers of purple nutsegde (*Cyperus rotundus* L.) were harvested at flowering and then shade dried. The dried plant material was chopped with power operated fodder chaff cutter into 2 cm pieces, separately. The chopped plant material was soaked in distilled water for 24 hours at room temperature of 21^0C at a ratio of 1:10 (w/v) and the same was filtered through 10 and 60 mesh sieves according to procedure laid down by Cheema *et al.* (2003). The initial volume of distilled water for soaking was 10 litres for every one kilogram of chopped material and after filtration the final volume of filtrate was seven litres. These plant water extracts separately boiled at 100 ^{0}C to concentrate up to 20 times for easy handling, storage and application convenience as per the treatments. Healthy and matured seeds of groundnut variety, *Dharani (TCGS-1043)* were treated with mancozeb 3 g/kg of seed. The sowing was carried out on 22nd December, 2017 with seed rate of 180 kg/ha at a spacing of 22.5 cm between the rows and 10 cm between the plants. The required quantities of plant water extracts were applied at 15 and 30 DAS and pendimethalin was applied at one DAS and imazethapyr was applied at 15 DAS by using spray fluid of 500 L/ha with the help of knapsack sprayer fitted with flat fan nozzle. Paddy straw mulch 5 t/ha was applied at 5 DAS after emergence of the crop. The groundnut crop was applied with recommended dose of fertilizer *i.e.* 30 kg N, 40 kg P and 50 kg K/ha using urea, single super phosphate and muriate of potash, respectively to all the plots. Two third of nitrogen and entire dose of phosphorous and potassium were applied as basal at the time of sowing. The remaining one third of nitrogen was top dressed at 25 DAS. Weed density and weed dry weight was recorded by adopting standard procedures and weed control efficiency (WCE) was calculated as per the formula suggested by Mani *et al.* (1973) at 60 DAS. Yield attributes and yield of groundnut were recorded from net plot area at harvest. The weather during the crop period was most congenial for better performance and did not deviate much from the normal values of decennial mean of the experimental area. Groundnut plants were uprooted at 40 DAS and at harvest for recording number of effective rhizobium nodules/plant. The nodules which release pink colour liquid by pressing were considered as effective nodules. Microbial analysis of soil in all the treatments was carried out at 40 DAS and at harvest for estimation of microbial load in the soil *viz.*, bacteria, fungi and actinomycetes by serial dilution plate count technique as per the method suggested by Pramer and Schemidt (1965). The soil samples were cultured with suitable media *i.e* nutrient agar for bacteria, potato dextrose agar for fungi and actinomycetes agar for actinomycetes. The initial bacteria, fungi and actinomycetes population were 14.67 x 10^6, 9.0 x 10^3 and 6.0 x 10^4 cfu/g soil, respectively.

Effect on Weeds

The major weed flora associated with groundnut were *Cyperus rotundus* (45%), *Digitaria sanguinalis* (15%), *Borreria hispida* (7%), *Digera arvensis* (6%), *Boerhavia erecta* (5%), *Cleome viscose* (3%), *Dactyloctenium aegyptium* (4%), *Trichodesma indicum* (4%), *Phyllanthus niruri* (4%) and other weed species consist of 7% in unweeded check. The dominance of purple nutsedge continued in the present experiment was due to its perennial nature coupled with excellent persistence mechanism under irrigated dry conditions. All the weed management practices registered significantly lesser density and dry weight of weeds than unweeded check (**Table 1**). Among, all the organic weed management treatments tested, paddy straw mulch 5 t/ha recorded significantly lower density and biomass of weeds as paddy straw mulch might have increased the albedo and decreased the solar energy flux to the soil, which

in-turn reduce germination and growth of weeds. Further, paddy straw mulch might have released allelomones, *viz.* momilactone B, p- hydroxyl benzoic acid, vanillic acid, p- coumaric and ferulic acids which were identified as natural herbicides to control weeds. The weed smothering efficiency of paddy straw was also reported by Khan *et al.* (2014). Among the plant water extracts, sunflower water extract 15 L/ha twice at 15 and 30 DAS resulted in lesser density and biomass of weeds, which was in parity with sorghum water extract, but all the above organic weed management practices were inferior in reducing the density and biomass of weeds than pre-emergence application of pendimethalin 1.0 kg/ha PE. The herbicides showed their superiority in controlling weeds more effectively than plant water extracts and paddy straw mulch. The inhibitory effect of sunflower water extracts on weed growth was possibly due to their readily available and solubilized form of allelomones, which might have affected the water and nutrient uptake, chlorophyll biosynthesis, hormone biosynthesis, membrane permeability and protein metabolism (Rice 1984). The inhibitory effect of sunflower water extracts on weed growth due to presence of higher concentrations of annuinones A, B, annuolide E, leptocarpin, Heliannuols, Isochlorogenic acid and Scopolin, which are considered as natural herbicides. Among the organic weed management practices, the maximum weed control efficiency was computed with application of paddy straw 5 t/ha (74.50 %) followed by sunflower (62.97 %) and sorghum (57.83 %) plant water extracts, but these organic weed management practices registered lesser weed control efficiency than chemical weed management of pendimethalin (86.21 %) as PE and imazethapyr (76.65%) asPoE. Application of plant water extracts of Parthenium and purple nutsedge were found to be less effective in controlling weeds than rest of the plant water extracts. Similar results were also reported by Khaliq *et al* (2012) in their field experiment in wheat as the maximum density of weeds was recorded with Parthenium water extract, which was at par with unweeded check.

Effect on crop growth and yield

All the weed management practices significantly influenced the dry matter production and yield component of groundnut (**Table 1**). Significantly higher dry matter production and yield components, *viz.* number of filled pods/plant, hundred pod weight and hundred kernel weight were recorded with pendimethalin 1.0 kg/ha PE *fb* HW at 40 DAS. Among the organic weed management practices, the highest values of the above said parameters were registered with paddy straw mulch 5.0 t/ha followed by sunflower water extract 15 L/ha twice at 15 and 30 DAS. This might be due to maintenance of better source-sink relations owing to adequate availability of growth resources as a result of less weed competition, which in-turn enhanced the translocation of photosynthates from source to developing kernel lead to increased hundred pod and kernel weight. The positive effect of paddy straw mulch on growth and yield attributes in groundnut was also reported by Mahita *et al.* (2014). The values of the above yield parameters were at their lowest with Parthenium water extract spray, which were in parity with purple nutsedge water extract spray due to their poor performance in controlling all the categories of weeds as reported by Parthasarathi *et al.* (2012).

All the organic weed management practices significantly influenced the pod and haulm yield as well as harvest index of groundnut (**Table 1**), but all the organic weed management practices recorded

Table 1. Weed growth, yield components and yield of *Rabi* (winter) groundnut as influenced by different organic weed management practices

Weed management practices	Weed density (no./m^2)	Weed biomass (g/m^2)	WCE (%)	DMP (t/ha)	No. of filled pods/ plant	100-pod weight (g)	100-kernel weight (g)	Pod yield (t/ha)	Haulm yield (t/ha)	Harvest index (%)	B:C
Sorghum water extract 15 L/ha 15 and 30 DAS	83.7(9.17)	47.4(6.92)	57.83	5.17	11.40	129.08	53.87	1.85	2.49	42.60	2.08
Sunflower water extract 15 L/ha 15 and 30 DAS	67.7(8.29)	41.4(6.47)	62.97	5.22	11.67	138.29	54.63	1.90	2.51	43.12	2.23
Rice straw water extract 15 L/ha 15 and 30 DAS	101.3(10.09)	64.5(8.09)	43.05	5.07	10.73	123.95	52.57	1.61	2.46	39.60	1.83
Parthenium water extract 15 L/ha 15 and 30 DAS	111.9(10.61)	71.2(8.47)	36.65	4.66	10.00	118.89	46.87	1.39	2.38	36.95	1.57
Lantana water extract 15 L/ha 15 and 30 DAS	92.3(9.63)	62.3(7.96)	53.42	5.05	10.93	126.46	52.67	1.72	2.48	40.85	1.92
Purple nutsedge water extract 15 L/ha 15 and 30 DAS	111.4(10.60)	69.7(8.38)	37.99	4.93	10.33	122.58	51.53	1.42	2.39	37.29	1.58
Paddy straw mulch 5 t/ha 7 DAS	40.0(6.36)	28.6(5.40)	74.50	5.34	12.53	143.94	55.87	2.09	2.58	44.48	2.15
Pendimethalin 1000 g/ha PE *fb* HW 1 and 30 DAS	21.0(4.64)	15.5(4.00)	86.21	5.64	13.33	146.15	59.37	2.77	2.65	51.10	3.04
Imazethapyr 75g/ha PoE 15 DAS	34.7(5.93)	26.2(5.17)	76.65	5.40	11.80	144.01	56.87	2.55	2.60	49.53	2.85
Unweeded check (control)	226.0(15.05)	112.4(10.62)	-	4.08	8.93	108.53	42.20	1.32	2.17	37.68	1.56
LSD (p=0.05)	1.68	0.98		0.13	0.49	5.60	2.25	0.16	0.11	1.79	0.12

Data in parentheses indicate the square root transformed values.; PE = pre-emergence application; PoE = post-emergence application
fb = followed by; HW= hand weeding; DAS = days after seeding

significantly lesser yields than chemical weed management practices. Application of paddy straw mulch 5.0 t/ha produced significantly higher pod and haulm yield as well as harvest index due to better weed control. The next best organic weed management practice in producing higher pod yield was sunflower water extract spray 15 L/ha twice at 15 and 30 DAS, which was at par with sorghum water extract spray 15 L/ha due to maintenance of weed free environment at early stages of crop growth, which might have increased the growth and yield contributing parameters and finally recorded higher pod yield. The reduction in pod yield of groundnut due to unchecked weed growth was 52.53, 37.18 and 38.84% compared to pendimethalin 1.0 kg /ha PE *fb* hand weeding at 30 DAS, paddy straw mulch 5.0 t/ha and sunflower water extract 15 L/ha, respectively. Similar results were also reported by Naeem *et al* (2016) with sorghum and sunflower water extracts sprays each 15 L/ha in combination applied at 20 DAS in maize. Among the organic weed management practices, sunflower water extract spray realized the highest benefit-cost ratio, which was statistically similar to paddy straw mulch 5.0 t/ha which in-turn at par with sorghum water extract spray 15 L/ha due to increased pod yield with reduced cost of cultivation. The sustainability of any weed management practices ultimately lies in its economic returns and the cost involved and also its impact on the environment.

Effect on soil microorganisms

There was a significant influence of different weed management practices on number of effective rhizobium nodules/plant and soil microbial population at 40 DAS and at harvest (**Table 2**). *Rhizobium* nodules/plant was maximum at 40 DAS due to better growth and development of crop and then declined towards harvesting due to senescence. Pendimethalin 1.0 kg/ha PE *fb* HW at 30 DAS recorded significantly higher number of effective *Rhizobium* nodules/plant which was comparable with paddy straw mulch 5.0 t/ha as reported by Sharma *et al* (2017) since pendimethalin created better environment for growth and development of the crop due to effective weed control, which in turn increased the number of effective *Rhizobium* nodules/plant. Application of paddy straw mulch 5.0 t/ha might have increased the rhizosphere bacterial population due to favourable environment and increased organic matter content of the soil.

Soil microorganisms *viz.*, bacteria, fungi and actinomycetes colonies were tends to increase from 40 DAS to harvest. Paddy straw mulch 5.0 t/ha recorded significantly higher count of bacteria, fungi and actinomycetes followed by sunflower water extract at 40 DAS and at harvest. The increase in microbial colonies may be due to paddy straw mulching as it modifies hydrothermal regime, recycles plant nutrients and add organic matter to soil. The present findings are in-line with Bhagat *et al.* (2016) and they reported that higher population of plant growth promoting rhizobacteria and fungal population were noticed with paddy straw mulch 6 .0 t/ha. The lowest soil microbial count was registered with chemical weed management practices *i.e.* imazethapyr 75 g/ha PoE, which might have showed the inhibitory effect on growth and proliferation of bacterial population. Among the plant water extracts, the lowest number of effective *Rhizobium* nodules/ plant, bacterial and fungal counts were observed with Parthenium water extract, which was however comparable with purple nutsedge water extract spray confirming findings of Raut and Pukale (2010). However, lower actinomycetes population in soil was noticed with sunflower water extract spray followed by sorghum water extract spray as the allelomones present in these water extracts might have showed inhibitory effect on actinomycetes growth and development.

Table 2. Effect of different herbicides and plant water extracts on soil microbial population in groundnut

Weed management practices	Rhizobium nodules/plant		Bacteria ($x10^6$) cfu/g soil		Fungi ($x10^3$) cfu/g soil		Actinomycetes ($x\ 10^4$) cfu/g soil	
	40 DAS	At harvest	40 DAS	At harvest	40 DAS	At harvest	40 DAS	At harvest
Sorghum water extract 15 L/ha 15 & 30 DAS	58.40	5.53	34.67	47.33	21.33	24.33	12.67	16.33
Sunflower water extract 15 L/ha 15 & 30 DAS	58.53	5.60	36.67	52.33	22.67	26.33	11.67	15.00
Rice straw water extract 15 L/ha 15 & 30 DAS	58.07	5.33	35.00	48.67	19.00	23.00	14.67	14.33
Parthenium water extract 15 L/ha 15 & 30 DAS	57.53	5.07	36.33	47.67	21.33	21.33	14.67	15.00
Lantana water extract 15 L/ha 15 & 30 DAS	58.40	5.47	34.33	48.67	20.67	22.00	13.67	18.67
Purple nutsedge water extract 15 L/ha 15 & 30 DAS	57.67	5.20	31.67	44.33	19.67	22.33	13.67	15.67
Paddy straw mulch 5 t/ha 7 DAS	59.40	5.73	41.00	52.67	26.00	27.67	19.00	20.67
Pendimethalin 1000 g/ha PE *fb* HW 1 & 30 DAS	60.27	5.80	30.00	42.33	14.67	27.00	9.67	14.00
Imazethapyr 75g/ha PoE 15 DAS	59.00	5.60	27.67	36.33	14.67	28.33	9.33	15.33
Unweeded check (control)	58.00	4.80	33.33	45.00	20.61	43.67	13.33	16.67
LSD (p=0.05)	0.48	0.33	2.14	2.56	2.32	2.40	1.36	NS

It was concluded that the paddy straw mulch 5.0 t/ha followed by sunflower water extract 15 L/ha applied at 15 and 30 DAS caused significantly lower density and biomass of all the categories weeds in groundnut; highest values of groundnut yield components and pod yield. However, benefit-cost ratio was comparable with each other among the organic weed management practices. Pre-emergence application of pendimethalin1.0 kg/ha + HW at 30 DAS recorded significantly higher number of effective *Rhizobium* nodules/ plant whereas paddy straw mulch 5/0 t/ha recorded significantly higher count of soil microorganisms *viz*., bacteria, fungi and actinomycetes, at 40 DAS and at harvest.

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