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Performance of Plant Aqueous Extracts for Organic Weed Management in Groundnut (*Arachis hypogaea*)

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ABSTRACT

Different crops were raised and harvested at physiological maturity and weeds were collected at flowering stages during *Kharif* 2017 for preparing plant aqueous extracts at wet land farm of Sri Venkateswara Agricultural College, Tirupati. A field experiment was conducted to evaluate the performance of different plant aqueous extracts and paddy straw mulch for organic weed management in a randomized block design and replicated thrice during *Rabi*, 2017-18 and The predominant weed species observed were *Cyperus rotundus* L. (45%), *Digitaria sanguinalis* (L.) Scop. (15%), *Borreria hispida* (L.) K. Schum. (7%). All chemical weed management practices recorded significantly lesser weed density and dry weight than organic weed management practices. Among the organic weed management practice, application of paddy straw mulch at 5 t ha^{-1} recorded significantly lesser density and dry weight of weeds with higher weed control efficiency, apart from enhancing the yield components and pod yield of groundnut. Among the plant aqueous extracts, sorghum plant aqueous extract spray 15 L ha^{-1} at 15 and 30 DAS proved to be the best in controlling weeds and increasing pod yield. The performance of parthenium and purple nutsedge aqueous extracts each applied at 15 L ha^{-1} at 15 and 30 DAS were very poor in controlling weeds and promoting pod yield of groundnut. The reduction in pod yield of groundnut due to unchecked weed growth was 52.53 and 37.18% compared to pendimethalin 1 kg ha^{-1} + HW at 30 DAS and paddy straw mulch at 5 t ha^{-1}, respectively. Paddy straw mulch at 5 t ha^{-1} recorded significantly higher count of effective rhizobium nodules plant^{-1} and soil microorganisms *viz*., bacteria, fungi and actinomycetes.

Key words: Groundnut, Microbial population, Plant aqueous extracts, Pod yield, Weed management.

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) 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 small 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). Modernized methods of weed management is the need of the day through introduction of herbicides 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 increasing emphasis is placed on sustainable agriculture and concerns about the adverse effect of extensive use of farm chemicals.

There is an exigency to develop natural and ecological strategies for controlling weeds. 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. The application of allelopathic aqueous extract of sorghum 25 L ha^{-1} twice at 15 and 30 DAS resulted in reduced weed density as compared to all other plant aqueous extract treatments in cotton grown in clay loam soils of Peshwar, Pakistan (Kandhro *et al* ., 2015). In this context, there is a need to evaluate the performance of different plant aqueous extracts for weed management in groundnut and their effect in soil microorganisms in sandy loam soils.

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MATERIALS AND METHODS

Different crops were raised and harvested at physiological maturity and weeds were collected at flowering stages during *Kharif* 2017 for preparing plant aqueous extracts and a field experiment was conducted during *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 pH 7.7, organic carbon (0.23 %), available N (128 kg ha^{-1}), available P_2O_5 12 kg ha^{-1}, available potassium (225 kg ha^{-1}) and EC of 0.65 dS m^{-1}. The experiment was laid out in randomized block design with ten treatments and repeated thrice. The treatments consisting of six plant aqueous extracts *viz*., sorghum (*Sorghum bicolor* L.), sunflower (*Helianthus annus* L.), rice straw (*Oryza sativa* L.), parthenium (*Parthenium hysterophorus* L.), lantana (*Lantana camara* L.) and purple nutsedge (*Cyperus rotundus* L.) each applied at 15 L ha^{-1} twice at 15 and 30 DAS, paddy straw mulch at 5 t ha^{-1}, pendimethalin 1 kg ha^{-1} + HW at 30 DAS, imazethapyr 75 g ha^{-1} and unweeded check. The entire plant of sorghum, sunflower, rice carrot grass lantana and tubers of purple nutsegde were harvested at flowering stage and then shade dried during *Kharif* 2017 for preparing plant aqueous extracts. 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°C, at a ratio of 1:10 (w/v) and the same was filtered through 10 and 60 mesh sieve according to procedure laid down by Cheema *et al.* (2003). These plant aqueous extracts separately boiled at 100°C to concentrate up to 20 times for easy handling and storage.

Groundnut variety, Dharani (TCGS-1043) was treated with mancozeb 3 g kg^{-1} of seed and sown with seed rate of 180 kg ha^{-1} at a spacing of 22.5 cm between the rows and 10 cm between the plants. The required quantities of plant aqueous extracts and herbicides were applied as per the treatments by using spray fluid of 500 L ha^{-1} with the help of knapsack sprayer fitted with flat fan nozzle. Paddy straw mulch at 5 t ha^{-1} was applied at 5 DAS after emergence of the crop. The groundnut crop was supplied with recommended dose of fertilizer *i.e.* 30 kg N, 40 kg P_2O_5 and 50 kg K_2O ha^{-1} through 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 $plant^{-1}$. Analysis of soil for microbial load *viz.,* bacteria, fungi and actinomycetes in all the treatments was carried out at 40 DAS and at harvest by serial dilution plate count technique as per the method suggested by Pramer and Schemidt, (1965).

RESULTS AND DISCUSSION

Weed growth

The major weed flora associated with groundnut were *Cyperus rotundus* (45%), *Digitaria sanguinalis* (15%), *Borreria hispida* (7%), *Digera arvensis* (6%), *Boerhavia erecta* (5%), *Cleome viscosa* (3%), *Dactylactenium aegypticum* (4%), *Trichodesma indicum* (4%), *Phyllanthus niruri* (4%) and other weed species consist of 7% in unweeded check plots. All chemical weed management practices recorded significantly lesser weed density and dry weight than organic weed management practices (Table 1). Among the organic weed management practices, paddy straw mulch at 5 t ha^{-1} showed a significant suppression of weed growth due to increased albedo and decreased 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 (Khan *et al*., 2014). Among the plant aqueous extracts, sunflower aqueous extract resulted in lesser density and dry weight of weeds, which was in parity with sorghum aqueous extract. The inhibitory effect of sunflower aqueous extracts on weed growth was possibly due to their readily available and solubilized form of allelomones *viz*., *annuinones A, B, annuolide E, leptocarpin, heliannuols, isochlorogenic acid* and *scopolin*, which might have affected the water and nutrient uptake, chlorophyll biosynthesis, hormone biosynthesis, membrane permeability and protein metabolism (Rice, 1984). Among the organic weed management practices, the maximum weed control efficiency was computed with application of paddy straw at 5 t ha^{-1} (74.50%) followed by sunflower (62.97%) and sorghum (57.83%) plant aqueous extracts, but these organic weed management practices registered less weed control efficiency than chemical weed management practices of pedimethalin (86.21%) and imazethapyr (76.65%).

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 $plant^{-1}$, hundred pod weight and hundred kernel weight of groundnut were recorded with pre-emergence application of pendimethalin 1 kg ha^{-1} + HW at 40 DAS due to effective control of weeds. Among the organic weed management practices, the highest values of the above said parameters were registered with paddy straw mulch at 5 t ha^{-1} followed by sunflower aqueous extract 15 L ha^{-1} 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

Table 1: Effect of different organic and chemical weed management practices on weed growth, yield attributes and yield of groundnut.

Weed management practices	Time of application (DAS)	Weed density (No.m^{-2})	Weed dry weight (g m^{-2})	WCE (%)	DMP (kg ha^{-1})	No. of filled pods /plant	100- pod weight (g)	100-kernel weight (g)	Pod yield (t ha^{-1})	Haulm yield (t ha^{-1})	Harvest index (%)	Benefit-Cost ratio
Sorghum aqueous extract at 15 L ha^{-1}	15 and 30	83.67(9.17)	47.40(6.92)	57.83	5172	11.40	129.08	53.87	1.85	2.49	42.60	2.08
Sunflower aqueous extract at 15 L ha^{-1}	15 and 30	67.66(8.29)	41.37(6.47)	62.97	5220	11.67	138.29	54.63	1.90	2.51	43.12	2.23
Rice straw aqueous extract at 15 L ha^{-1}	15 and 30	101.34(10.09)	64.50(8.09)	43.05	5075	10.73	123.95	52.57	1.61	2.46	39.60	1.83
Parthenium aqueous extract at 15 L ha^{-1}	15 and 30	111.93(10.61)	71.19(8.47)	36.65	4658	10.00	118.89	46.87	1.39	2.38	36.95	1.57
Lantana aqueous extract at 15 L ha^{-1}	15 and 30	92.33(9.63)	62.35(7.96)	53.42	5050	10.93	126.46	52.67	1.72	2.48	40.85	1.92
Purplenut sedge aqueous extract at 15 L ha^{-1}	15 and 30	111.41(10.60)	69.69(8.38)	37.99	4928	10.33	122.58	51.53	1.42	2.39	37.29	1.58
Paddy straw mulch at 5 t ha^{-1}	5	39.99(6.36)	28.65(5.40)	74.50	5340	12.53	143.94	55.87	2.10	2.58	44.48	2.15
Pendimethalin 1 kg ha^{-1} + HW	1 and 30	21.03(4.64)	15.50(4.00)	86.21	5644	13.33	146.15	59.37	2.77	2.65	51.10	3.04
Imazethapyr 75 g ha^{-1}	20	34.67(5.93)	26.23(5.17)	76.65	5396	11.80	144.01	56.87	2.55	2.60	49.53	2.85
Unweeded check (Control)	-	226.00(15.05)	112.39(10.62)	-	4084	8.93	108.53	42.20	1.32	2.17	37.68	1.56
LSD (P=0.05)		1.68	0.98		126	0.49	5.60	2.25	0.16	0.11	1.79	0.12

Data in parentheses indicate the square root transformed values. WCE: Weed control efficiency, DMP: Dry matter production.

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 above said yield parameters were at their lowest with parthenium and purple nutsedge aqueous extract spray due to their poor performance in controlling all the categories of weeds and increased competition for growth resources.

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 significantly lesser yields than chemical weed management practices. Application of paddy straw mulch at 5 t ha^{-1} produced significantly higher pod and haulm yield with higher harvest index followed by sunflower aqueous extract and sorghum aqueous extract spray each 15 L ha^{-1} applied at 15 and 30 DAS 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 pre-emergence application of pendimethalin 1 kg ha^{-1} + HW at 30 DAS, paddy straw mulch at 5 t ha^{-1}and sunflower aqueous extract 15 L ha^{-1}, respectively. Similar results were also reported by Naeem *et al.* (2016) with sorghum + sunflower aqueous extracts each 15 L ha^{-1} applied at 20 DAS in maize. The sustainability of any weed management practices ultimately lies in its economic returns and the cost involved and also its impact on the environment. Among the organic weed management practices, sunflower aqueous extract spray realized the highest benefit-cost ratio, which was statistically similar to paddy straw mulch at 5 t ha^{-1} which in turn at par with sorghum aqueous extract spray 15 L ha^{-1} due to increased pod yield with reduced cost of cultivation in these treatments. The lowest pod and haulm yield with lower harvest index was obtained with parthenium aqueous extract, which was at par with purple nutsedge aqueous extract. Channapagoudar *et al.* (2005) also reported that seedling length and seedling vigour index of groundnut was significantly reduced due to purple nutsedge and *Commelina benghalensis* aqueous extracts.

Soil microorganisms

There was a significant influence of different weed management practices on number of effective rhizobium nodules plant^{-1} and soil microbial population at 40 DAS and at harvest (Table 2). Pre-emergence application of pendimethalin 1 kg ha^{-1} + HW at 30 DAS recorded significantly higher number of effective rhizobium nodules plant^{-1}, which was comparable with paddy straw mulch at 5 t ha^{-1}. Sharma *et al.* (2017) reported that pre-emergence application of pendimethalin 0.75 kg ha^{-1} supplemented with HW recorded significantly higher number of rhizobium nodules plant^{-1} in soybean as pendimethalin created better

Table 2: Effect of different organic weed management practices on soil microbial population in groundnut.

Weed management practices	Time of application (DAS)	Rhizobium nodules (No.plant^{-1})		Bacteria (x10^{6}) cfu g^{-1} soil		Fungi (x10^{3}) cfu g^{-1} soil		Actinomycetes (x 10^{4}) cfu g^{-1} soil	
		40 DAS	At harvest	40 DAS	At harvest	40 DAS	At harvest	40 DAS	At harvest
Sorghum aqueous extractat 15 L ha^{-1}	15 and 30	58.40	5.53	34.67	47.33	21.33	24.33	12.67	16.33
Sunflower aqueous extractat 15 L ha^{-1}	15 and 30	58.53	5.60	36.67	52.33	22.67	26.33	11.67	15.00
Rice straw aqueous extract at 15 L ha^{-1}	15 and 30	58.07	5.33	35.00	48.67	19.00	23.00	14.67	14.33
Parthenium aqueous extract at 15 L ha^{-1}	15 and 30	57.53	5.07	35.33	47.67	21.33	21.33	14.67	15.00
Lantana aqueous extract at 15 L ha^{-1}	15 and 30	58.40	5.47	34.33	48.67	20.67	22.00	13.67	18.67
Purplenut sedge aqueous extract at 15 L ha^{-1}	15 and 30	57.67	5.20	31.67	44.33	19.67	22.33	13.67	15.67
Paddy straw mulch at 5 t ha^{-1}	5	60.40	5.73	41.00	52.67	26.00	27.67	19.00	20.67
Pendimethalin 1 kg ha^{-1} + HW	1 and 30	60.27	5.80	30.00	42.33	14.67	27.00	9.67	14.00
Imazethapyr 75 g ha^{-1}	20	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

Initial microbial population: Bacteria: 14.67 $\times$ 10^{6} cfu g^{-1} soil, Fungi : 9.0 $\times$ 10^{3} cfu g^{-1} soil and Actinomycetes : 6.0 $\times$ 10^{4} cfu g^{-1} soil.

environment for growth and development of the crop plants due effective and season long weed control, which in turn increased the number of effective rhizobium nodules plant^{-1}. Application of paddy straw mulch 5 t ha^{-1} might have increased the rhizosphere bacterial population due to favourable environment and increased organic matter content of the soil followed by sunflower and sorghum aqueous extracts.

Paddy straw mulch at 5 t ha^{-1} recorded significantly higher count of bacteria, fungi and actinomycetes at 40 DAS and at harvest than chemical weed management practices. The increase in microbial colonies may be due to paddy straw mulch 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 at 6 t ha^{-1}. Sunflower and sorghum aqueous extracts recorded significantly higher population of soil microorganisms, among the plant extracts. The proliferation of effective rhizobium nodules plant^{-1}, bacterial and fungal counts were significantly lesser with parthenium aqueous extract. These results are in line with Raut and Pukale, (2010). Significantly lower actinomycetes population was noticed with sunflower aqueous extract spray as the allelomones present in this extracts might have showed inhibitory effect. The lowest soil microbial count was registered with post-emergence application of imazethapyr 75 g ha^{-1}, which might have showed the inhibitory effect on growth and proliferation of soil microorganisms.

CONCLUSION

Results indicated that paddy straw mulch at 5 t ha^{-1} recorded significantly lower density and dry weight of weeds followed by sunflower aqueous extract 15 L ha^{-1} applied at 15 and 30 DAS, but these two organic weed management practices were inferior in reducing density and dry weight of weeds than pendimethalin 1 kg ha^{-1}. Among the organic weed management practices, higher values of yield components and yield were registered with paddy straw mulch at 5 t ha^{-1} followed by sunflower aqueous extract 15 L ha^{-1} twice at 15 and 30 DAS. The reduction in pod yield of groundnut due to unchecked weed growth was 37.18 and 38.84% compared to paddy straw mulch at 5 t ha^{-1} and sunflower aqueous extract 15 L ha^{-1}, respectively. Pre-emergence application of pendimethalin 1 kg ha^{-1} + HW at 30 DAS recorded significantly higher number of effective rhizobium nodules plant^{-1} whereas paddy straw mulch at 5 t ha^{-1} recorded significantly higher count of soil microorganisms *viz*., bacteria, fungi and actinomycetes followed by sunflower aqueous extract at 40 DAS and at harvest. Application of plant aqueous extracts of parthenium and purple nutsedge each 15 L ha^{-1} applied 15 and 30 DAS was comparatively less effective in controlling weeds and increasing productivity of groundnut.

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