

COMPARATIVE EFFICACY OF PURPLE NUTSEDGE ALLELOPATHY AND OTHER METHODS ON WEED MANAGEMENT IN BARLEY (*HORDEUM VULGARE* L.)

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ABSTRACT

This research was carried out in order to compare the impact of purple nutsedge allelopathy and other approaches on weed management in barely at Students' Experimental Farm, Department of Agronomy, Sindh Agriculture University, Tandojam for weed as well as barely parameters having eight treatments with three replications. The data revealed that the maximum weed control (91.3%) was recorded under T₇ = Puma super 7.5% emulsifiable water at 0.625 liters ha⁻¹, 50% reduced (30 Days after sowing) + Purple nutsedge water extract at 15 liters ha⁻¹ (45 Day after sowing). The barley crop's results revealed that maximum tillers (355.6 m⁻²), plant height (106.3 cm), spike length (11.5 cm), grains spike⁻² (47.3), seed index (51 g), biological yield (11737 kg ha⁻¹), grain yield (4493 kg ha⁻¹) and harvest index (41.9%) were recorded under T₇ = Puma super 7.5% emulsifiable water at 0.625 liters ha⁻¹ 50% reduced (30 Days after sowing) + Purple nutsedge water extract at 15 liters ha⁻¹ (45 Days after sowing). Hence, it was suggested that application of puma super 7.5% emulsifiable water at 0.625 liters ha⁻¹, 50% reduced (30 Days after sowing) + Purple nutsedge water extract at 15 liters ha⁻¹ (45 Days after sowing) apply for getting higher yield (4493 kg ha⁻¹) of barley crop. It was finalized that this study will be very fruitful for the future progress of barley yield.

Keywords: Allelopathy, Barley, Comparative efficacy, Purple nutsedge, Weed management

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INTRODUCTION

In cereals, barley is an important cereal crop which ranks fourth by production and fifth by cultivation all over the world (Thalooth *et al.*, 2012). The crop is used mainly for animal feed and is also considered as salinity as well as drought tolerant crop. It is also utilised in the manufacture of bread and other foods and drinks for humans. It can perform better in adverse condition as well as in rainfed areas (Kamali *et al.*, 2014). A large number of living and non-living factors have been observed for the decrease in the yield of cereals, but of them, weeds tops in it. Due to this cause, weeds bring an imbalance in the ecosystem in the field of agriculture (Ross and Lembi 2008).

Molisch was the first scientist who defined the term allelopathy in 1937 as the chemical interaction between plants and microorganism. But in 1984, rice changed the definition with all direct effects of a plant on another plant or on a microorganism owing to the release of biochemicals into the environments. Currently, allelopathy internationally is known as any process in which plants, fungi, algae or bacteria generated secondary metabolites for impacting the agricultural and biological system growth and development.

Allelopathy is very beneficial for us; this is why, it has ability to be dominant over the effects of weeds in the control of field crops (Jabran *et al.*, 2015). Allelopathy is also utilized as growth regulators in the form of allelochemicals which has been of a great interest (He *et al.*, 2019). Allelochemicals are regards as the best materials in the form of compounds which mainly emerge from unsuitable plants (Cheema *et al.*, 2003 and Hamayun *et al.* (2005). On the other hand, negative effects of allelopathy had been discussed upon seed germination and crop growth and development (Belel and Belel, 2015). Purple nutsedge is a kind of a weed which harms crops a lot. Approximately, 52 crops have been reported invaded by this weed in 92 countries of the world (Rao, 2000; Chris *et al.*, 2003).

In our homeland, a number of crops have been studied for allelopathy which had articulated positive responses to crops in favour of agriculture. In Sindh, crops are manually, mechanically and chemically protected against weeds (Chachar *et al.*, 2009).

Therefore, this investigation was put into practice to study the effect of purple nutsedge (a weed) allelopathy, manual and chemical methods on weed suppression and enhancement of barley yield and to find out the best treatment for effective weed control and maximum yield of barley.

MATERIALS AND METHODS

This research was carried out in order to compare the impact of purple nutsedge allelopathy and other approaches on weed management in barely at Students' Experimental Farm, Department of Agronomy, Sindh Agriculture University, Tandojam having eight treatments with three replications during winter season of 2017-2018. The plot size was kept as 5 × 3 m (15 m²). The treatments included.

T₁ = No weeding (control)

In this treatment, no application of weedicide and weeding was used.

T₂ = Purple nutsedge water extract at 15 liters ha⁻¹ (30 DAS)

In this treatment, 15 liters of purple nutsedge extract was used as an aqueous solution per hectare after 30 days of sowing.

T₃ = Purple nutsedge water extract at 15 liters ha⁻¹ (30 and 45 DAS)

In this treatment, 15 liters of purple nutsedge extract was used as an aqueous solution per hectare after 30 and 45 days of sowing.

T₄ = Purple nutsedge water extract at 20 liters ha⁻¹ (30 DAS)

In this treatment, 20 liters of purple nutsedge extract was used as an aqueous solution per hectare after 30 days of sowing.

T₅ = Purple nutsedge water extract at 20 liters ha⁻¹ (30 and 45 DAS)

In this treatment, 20 liters of purple nutsedge extract was used as an aqueous solution per hectare after 30 and 45 days of sowing.

T₆ = Puma super 7.5% EW at 1. 25 liters ha⁻¹ (30 DAS)

In this treatment, 1. 25 liters of puma super 7.5% was used as an emulsifiable water per hectare after 30 days of sowing.

T₇ = Puma super 7.5% EW at 0.625 liters ha⁻¹ (30 DAS) + Purple nutsedge water extract at 15 L ha⁻¹ (45 DAS)

In this treatment, 0.625 liters of puma super 7.5% and 15 liters of purple nutsedge were together used as an emulsifiable water and an aqueous solution per hectare after 30 and 45 days of sowing.

T₈ = Hand weeding (30 and 45 DAS)

In this treatment, two hand weedings were practiced after 30 and 45 days of sowing.

Observations were recorded:

1. Weed flora: All infesting weed species were recorded and their local names, botanical names and families are mentioned.

2. Weed density (m⁻²): The weeds were counted at 60 DAS by using wooden frame of one square meter in all plots of each treatment at one location and calculated as (m⁻²). It was estimated according to formula given by Gupta (1998).

$$WD (m^{-2}) = \frac{Tt \text{ No. of weeds}}{\text{Number of replication}}$$

3. Weed fresh weight (g m⁻²): Weeds fresh weight was taken from randomly selected areas of one meter square at one stage at 60 DAS.

4. Weed dry weight (g m⁻²): Weeds dry weight sample taken for fresh weight was dried at 70 °C for 72 hours.

5. Weed control (%): It was calculated according to Mani *et al.* (1973)

$$WC = \frac{WCD - GTD}{\text{Weed check density}} \times 100$$

6. Tillers (m⁻²): From each selected plant, tillers meter⁻¹ was counted.

7. Plant height (cm): At maturity, the height of plants was taken from bottom to top with the assistance of measurement tape.

8. Spike length (cm): The length of spikes was taken by using inch tape.

9. Grains spike⁻¹: Spikes were threshed and number of grains were counted.

10. Seed index (1000 grains weight, g): After threshing the experimental crop

for each plot separately, the 1000 grains from each plot were taken and weighed by electronic top loading balance in grams.

11. Biological yield (kg ha⁻¹): After maturity and harvest of the crop, following formula was put into practice according to Inamullah *et al.* (2011).

$$BY (kg \text{ ha}^{-1}) = \frac{BY (\text{plot}^{-1})}{\text{Plot size (m}^{-1})} \times 10,000$$

12. Grain yield (kg ha⁻¹): This was calculated formula of Inamullah *et al.* (2011).

$$GY (kg \text{ ha}^{-1}) = \frac{GY (\text{plot}^{-1})}{\text{Plot size (m}^{-1})} \times 10,000$$

13. Harvest index: It was calculated according to the formula given by Reddy (2004).

$$HI (\%) = \frac{GY (kg \text{ ha}^{-1})}{BY (kg \text{ ha}^{-1})} \times 100$$

Statistical analysis

Collected data were brought under the statistical analysis by using Statistix. 8.1 2006. ANOVA was computed as suggested by Gomez and Gomez (1984) and the least significant difference test was applied according to the methods developed by Steel and Torrie (1960) to compare treatments superiority

RESULTS AND DISCUSSION**Weed flora**

Weed flora as affected by comparative efficacy of purple nutsedge allelopathy and other methods on weed management in barley crop are given in Table 1. Following narrow and broad leaf weeds were present in experiment area.

Table 1. Weed flora of barley as affected by purple nutsedge allelopathy and other methods

Local name	English name	Botanical name	Weed frequency (%)
Jhil	Lamb's squarter	<i>Chenopodium album</i> L.	8
Sinjh	White sweet clover	<i>Melilotus alba</i> L.	7
Jangli javi	Wild oat	<i>Avena fatua</i> L.	25
Dumbi sati	Little canarygrass	<i>Phalaris minor</i> (Retz.)	4
Kabah	Purple nutsedge	<i>Cyprus rotundus</i> L.	11
Chabbar	Bermuda grass	<i>Cynodon dactylon</i> L.	6
Naro	Field bind weed	<i>Convolvulus arvensis</i> L.	10
Basri	Wild onion	<i>Asphodelius tenuifolius</i> L.	12
Peeli sinjh	Indian clover	<i>Melilotus indica</i> L.	8
Jangli palak	Dock broad Leaf	<i>Rumex dentatus</i> L.	6

Weed number (m⁻²)

The result showed that maximum weed number (45.6 m⁻²) was recorded under no weeding (control) followed by (33.6 m⁻²) under Purple nutsedge water extract at 15 L ha⁻¹ (30 DAS). Whereas, the minimum weed number was observed under (8.0 m⁻²) Puma super 7.5% EW at 0.625 L ha⁻¹, 50% reduced (30 DAS) + Purple nutsedge water extract at 15 L ha⁻¹ (45 DAS) and (10.6 m⁻²) Hand weeding (30 and 45 DAS), respectively. Such results were also informed by Tawaha et al. (2002). Many weeds are present in the field which threaten plants and make trouble for a sustainable production (Zohary et al., 2012). The same findings have been reported by Jabran (2017) and he advised that weeds may be reduced by planting these highly allelopathic cultivars.

Weed fresh weight (g m⁻²)

The result directed that the highest fresh weight (20.6 g m⁻²) was verified under No weeding (control) followed by (16.3 g m⁻²) under Purple nutsedge water extract at 15 ha⁻¹ (30 DAS). However, the least weed fresh weight (5.6 g m⁻² and 7.6 g m⁻²) was noted under Puma super 7.5%

EW at 0.625 L ha⁻¹, 50 % reduced (30 DAS) + Purple nutsedge water extract at 15 L ha⁻¹ (45 DAS) and Hand weeding (30 and 45 DAS), respectively (Table 2). Weed resistance also studied by Heap (2013). Weston and Duke (2003) and Raghvendra et al. (2016) who emphasized that allelopathy could be the most promising tool for substantial production by suppressing the weed growth and prevention of weed resistance to toxic chemical herbicides.

Weed dry weight (g m⁻²)

The results showed that the most weed dry weight (6.3 g m⁻²) was documented under No weeding (control) followed by (5.6 g m⁻²) under Purple nutsedge water extract at 15 L ha⁻¹ (30 DAS), whereas the least weed dry weight (2.6 g m⁻²) was noted under Puma super 7.5% EW at 0.625 L ha⁻¹, 50% reduced (30 DAS) + Purple nutsedge water extract at 15 L ha⁻¹ (45 DAS) and Puma super 7.5% EW at 1.25 L ha⁻¹ (30 DAS) (3.30 g m⁻²) and Hand weeding (30 and 45 DAS) (3.30 g m⁻²), respectively (Table 2). Weed impact can be reduced by applying integrated weed management so as to save plants from damage (Monaco et al., 2002). Our results

were in agreement with Hansen (2007). The final finding was in agreement with Kandhro et al. (2016), who found that weeds interfere not only with crop plant, but also with allelopathy.

Weed control (%)

The results presented that more weed control (91.3%) was noticed in Puma super 7.5% EW at 0.625 L ha⁻¹, 50% reduced (30 DAS) + Purple nutsedge water extract at 15 L ha⁻¹ (45 DAS) followed by (85.0 %) under Hand weeding (30 and 45 DAS), yet the lowest weed control (00.00%) was observed in No weeding (control) and Purple nutsedge water extract at 15 L ha⁻¹ (30 DAS) (52.3 %), respectively. Biotic and abiotic factors decline cereal production in which the weed has been the most important factor (Rose and Lembi, 2008). Significant effect of treatments was also discovered by Didar and Ali (2016) on a wide range of physio-morphological attributes.

Tillers (m⁻²)

The result displayed that more tillers (355.6 m⁻²) were estimated under T₇ = Puma super 7.5% EW at 0.625 L ha⁻¹, 50% reduced (30 DAS) + Purple nutsedge water extract at 15 L ha⁻¹ (45 DAS) followed by (315.0 m⁻²) under T₈ = Hand weeding (30 and 45 DAS). On the other hand, less tillers (235.0 m⁻²) were assessed under T₁ = No weeding (control) and T₂ = Purple nutsedge water extract at 15 L ha⁻¹ (30 DAS) ((260.3 m⁻²) (Table 3). Stimulatory and inhibitory effects of allelochemicals rely upon the concentration of allelochemical compounds (Bhowmik and Inderjiit, 2003). Barley is very tolerant due to the presence of better performance in adverse agro climatic conditions (Kamali et al., 2014). Further favouring allelopathy, Arif et al. (2015) defined allelopathy as both a companion and an organic weed-control technique.

Plant height (cm)

The result revealed that the tallest plants (106.3 cm) were reported in T₇ = Puma super 7.5% EW at 0.625 L ha⁻¹, 50% reduced (: 30 DAS) + Purple nutsedge

water extract at 15 L ha⁻¹ (45 DAS) followed by (99.0 cm) under T₈ = Hand weeding (30 and 45 DAS). While, the most dwarf plants (60.9 cm and 70.5 cm) were demonstrated in T₁ = No weeding (control) and T₂ = Purple nutsedge water extract at 15 L ha⁻¹ (30 DAS), respectively (Table 3). It was suggested that the weeds are a big source of allelochemicals having the ability to alter the rhizospheric system of nearby plants in the field (Cheema et al., 2003). In the experiment of El-Rokiek et al. (2010) Imen et al. (2014), barley varieties and landraces articulated different allelopathic activities on weeds.

Spike length (cm)

The result exhibited that the longest spikes (11.5 cm) were expressed under T₇ = Puma super 7.5% EW at 0.625 L ha⁻¹, 50% reduced (30 DAS) + Purple nutsedge water extract at 15 L ha⁻¹ (45 DAS) followed by (10.4 cm) under T₈ = Hand weeding (30 and 45 DAS), nevertheless the shortest spikes (7.1 cm and 8.8 cm) were presented in T₁ = No weeding (control) as well as in T₂ = Purple nutsedge water extract at 15 L ha⁻¹ (30 DAS). The length of a spike is very vital character to increase the yield of the crop. The worst weed in the globe is Purple nutsedge which is scattered in 52 crops and 92 countries (Rao, 2000). According to Rasmussen (1991) and Khaliq et al. (2011), weed suppression has many benefits acquired by soil incorporation of crop residues and such suppression is believed to be allelopathic in nature.

Seed index (1000-grain weight)

The result showed that the maximum seed index (51.0 g) was recorded in T₇ = Puma super 7.5% EW at 0.625 L ha⁻¹, 50% reduced (30 DAS) + Purple nutsedge water extract at 15 L ha⁻¹ (45 DAS) followed by (48.6 g) in T₆ = Puma super 7.5% EW at 1.25 ha⁻¹ (30 DAS), nonetheless the lowest seed index (36.0 g) was detected under T₁ = No weeding (control) and T₂ = Purple nutsedge water extract at 15 L ha⁻¹ (30 DAS) (39.6 g), respectively (Table 3). Preventive methods in the form of organic weed management (Beberi, 2002) like crop retention (Bond

and Grundy, 2001), application of fertilizers (Rasmussen, 1991) and cultivation of resistant species and varieties (Lemerle *et al.*, 2001) have been able to control the weeds, whereas curative methods namely weed harrowing during pre and post emergence in the same form have also been very advantageous for the maintenance of the weed population (Kurstiens and Kropff, 2001). Cheema *et al.* (2003) did an experiment on weeds and informed about them that they were a bid source of allelochemical.

Biological yield (kg ha⁻¹)

Biological and grain yield are two important characters. Biological yield is the total weight of a plant, whereas grain yield is defined as the total weight of number of grains per plant. The result exposed that more biological yield (11737 kg ha⁻¹) was documented under T₇ = Puma super 7.5% EW at 0.625 L ha⁻¹, 50% reduced (30 DAS) + Purple nutsedge water extract at 15 L ha⁻¹ (45 DAS) followed by (10720 kg ha⁻¹) in T₆ = Puma super 7.5% EW at 1.25 L ha⁻¹ (30 DAS). While, the least biological yield (5500 kg ha⁻¹) was witnessed in T₁ = No weeding (control) and under T₂ = Purple nutsedge water extract at 15 L ha⁻¹ (30 DAS) (5782 kg ha⁻¹) (Table 3). Current results were also in agreement with Bryson *et al.* (2003) and Chachar *et al.* (2009) who used chemical method for the control of weeds and allelopathy activity.

Grain yield (kg ha⁻¹)

The result disclosed that the maximum grain yield (4493.00 kg ha⁻¹) was observed under T₇ = Puma super 7.5% EW at 0.625 L ha⁻¹, 50% reduced (30 DAS) + Purple nutsedge water extract at 15 L ha⁻¹ (45 DAS) followed by (4335 .0 kg ha⁻¹) under T₈ = Hand weeding (30 and 45 DAS), however the minimum grain yield (1936.6 kg ha⁻¹) was perceived under T₁ = No weeding (control) and T₂ = Purple nutsedge water extract at 15 L ha⁻¹ (30 DAS) (2156.6 kg ha⁻¹), respectively (Table 3). Such results had also been articulated by Cheema *et al.* (2003) and Kremer and Ben-Hammouda (2009). A limited number of allelochemicals contributing allelopathic effectiveness on barely were also identified by Robert and Hammouda (2009).

Harvest index (%)

The result showed that the maximum harvest index (41.9%) was verified under T₈ = Hand weeding (30 and 45 DAS) followed by (39.9 %) under T₆ = Puma super 7.5% EW at 1.25 L ha⁻¹ (30 DAS), nonetheless the minimum harvest index (26.0% and 32.3 %) was notified in T₃ = Purple nutsedge water extract at 15 L ha⁻¹ (30 and 45 DAS) and T₅ = Purple nutsedge water extract at 20 L ha⁻¹ (30 and 45 DAS), respectively (Table 3). Good effects of allelopathy were also obtained by Kong *et al.* (2006) and Murimwas *et al.* (2019)

Table 2. Different weed observations of barley as affected by purple nutsedge allelopathy and other methods

Treatments	Weed number	Weed fresh weight	Weed dry weight	Weed control
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	(m⁻²)	(g m⁻²)	(g m⁻²)	(%)
T ₁ . No weeding (control)	45.6	20.6	6.3	0.0
T ₂ . Purple nutsedge water extract at 15 L ha ⁻¹ (30 DAS)	33.3	16.3	5.6	52.3
T ₃ . Purple nutsedge water extract at 15 L ha ⁻¹ (30 and 45 DAS)	29.0	12.6	4.3	73.0
T ₄ . Purple nutsedge water extract at 20 L ha ⁻¹ (30 DAS)	22.6	14.3	4.6	65.3
T ₅ . Purple nutsedge water extract at 20 L ha ⁻¹ (30 and 45 DAS)	15.0	9.0	4.0	76.3
T ₆ . Puma super 7.5% EW at 1.25 L ha ⁻¹ (30 DAS)	11.0	8.0	3.3	83.0
T ₇ . Puma super 7.5% EW at 0.625 L ha ⁻¹ , 50% reduced (30 DAS) + Purple nutsedge water extract at 15 L ha ⁻¹ (45 DAS)	8.0	5.6	2.6	91.3
T ₈ . Hand weeding (30 and 45 DAS)	10.6	7.6	3.3	84.0
SE ±	1.0983	0.8286	0.5156	1.0370
LSD 0.05	2.3557	1.7771	1.1059	2.2242
CV %	6.14	8.61	14.71	1.93

Table 3. Different barley observations as affected by purple nutsedge allelopathy and other methods

Treatments	Tillers (m ⁻²)	Plant height (cm)	Spike length (cm)	Grain spike ⁻¹	Seed index (g)	Biological yield (kg ha ⁻¹)	Grain yield (kg ha ⁻¹)	Harvest index (%)
T ₁ . No weeding (control)	235.0	60.9	7.1	23.0	36.0	5500	1936.6	35.2
T ₂ . Purple nutsedge water extract at 15 L ha ⁻¹ (30 DAS)	260.3	70.5	8.8	29.3	39.6	5782	2156.7	37.4
T ₃ . Purple nutsedge water extract at 15 L ha ⁻¹ (30 and 45 DAS)	284.3	87.3	9.8	35.0	46.3	9273	2415.9	26.0
T ₄ . Purple nutsedge water extract at 20 L ha ⁻¹ (30 DAS)	272.0	84.0	9.12	30.0	43.0	8055	2733.1	34.1
T ₅ . Purple nutsedge water extract at 20 L ha ⁻¹ (30 and 45 DAS)	293.6	91.0	9.9	38.6	47.3	10357	3348.3	32.3
T ₆ . Puma super 75 EW at 1.25 L ha ⁻¹ (30 DAS)	312.6	96.6	10.3	42.6	48.6	10720	4286.7	39.9
T ₇ . Puma super 75 EW at 0.625 L ha ⁻¹ , 50% reduced (30 DAS) + Purple nutsedge water extract at 15 L ha ⁻¹ (45 DAS)	355.6	106.3	11.5	47.3	51.0	11737	4493.0	41.9
T ₈ . Hand weeding (30 and 45 DAS)	315.0	99.0	10.4	42.3	48.3	10717	4335.0	37.0
SE ±	2.0558	1.6185	0.4707	1.7829	1.6726	410.85	63.483	1.7531
LSD 0.05	4.4092	3.4712	1.0085	3.8238	3.5874	881.19	136.16	3.7600
CV (%)	0.86	2.28	5.98	6.06	4.55	5.58	2.42	6.05

CONCLUSION AND RECOMMENDATIONS

It was concluded that application of Puma super 7.5% EW at 0.625 L ha⁻¹, 50% reduced (30 DAS) + Purple nutsedge water extract at 15 L ha⁻¹ (45 DAS) were the most effective for getting higher yield of (4493.0 kg ha⁻¹) of crop barley. More studied are not only recommended to experiment with the allelopathy potential with this crop barely, but also with other crops. Because if the allelopathic effects are useful and more effective for controlling weeds, the utilization of artificial herbicides can be reduced in order to save the life of many useful species for our crops in the future.

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