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Effect of irrigation and weed management practices on nutrient removal by weeds and weed control efficiency in groundnut (*Arachis hypogaea* L.)

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Abstract
The field experiment was conducted during *kharif* 2021 at Oilseeds Farm of Agricultural College and Research Institute, Coimbatore. The experiment with 15 treatment combinations was laid out in split plot design with three replications. Main plot constitutes three irrigation methods (M_1: Surface, M_2: Drip and M_3: Rain hose) and subplot comprised of five weed management practices (S_1: Pre-emergence *fb* Hand weeding + Earthing up, S_2: Pre-emergence *fb* Post emergence *fb* Earthing up, S_3: Pre-emergence *fb* Post emergence *fb* Post emergence, S_4: Post emergence *fb* Post emergence *fb* Earthing up and S_5: Hand weeding *fb* Hand weeding + Earthing up). Groundnut variety Co 7 was used as a test crop. The results revealed that irrigation provided through drip system recorded lower weed dry matter and showed a higher weed control efficiency in combination of pre-emergence (pendimethalin @ 1.0 lit ha^{-1}) *fb* post emergence (imazethapyr @ 75 g a.i. ha^{-1} + quizalofop-ethyl @ 50 g a.i. ha^{-1}) *fb* earthing up which was followed by rain hose irrigation with pre and post emergence herbicide spray over surface method of irrigation. Nutrient removal by weeds was reduced in herbicide sprayed treatments over hand weeding until critical weed period of 40 DAS. Hence, the irrigation methods and weed management practices significantly influenced on weed dry matter production, weed control efficiency and nutrient removal by weeds.

Keywords: Weeds management, weed dry matter, weed control efficiency, nutrient removal by weeds, soil moisture content distribution, drip irrigation, rain hose irrigation

Introduction

Oilseeds are the second most important component of Indian agriculture after cereals and accounted for 19% of the world's oilseed area and 2.7% of oilseed production (Reddy and Immanuel raj 2017) [20]. The diversified agro-ecological condition of the country is favourable for the cultivation of different oilseed crops such as groundnut, rapeseed and mustard, sunflower, sesame, soybean, safflower, castor, linseed and Niger along with two perennials (coconut and palm oil). Groundnut is the most important food and cash crops of tropics and sub tropics which grow well in Indian conditions. It is considered as King of oilseeds, which is most important source of protein (26%) and oil (49%) widely grown in areas ranging from latitude 40°N to 40°S (Suseendran *et al*., 2019) [24]. It is not only a major source of edible oil, but its kernel and oilcake serve as a good source of digestible protein and nitrogen, hence it is popularly known as "Wonder nut" and "poor man's cashew nut". The most important groundnut growing countries in the world are India, China, Nigeria, Senegal, Sudan, Myanmar and United States. It is a major oilseed crop in India and plays an important role in vegetable oil deficit in the country. In India, it ranks first in area (4.94 m ha), second in production (6.69 mt) and rank 4 in productivity (1,335 kg ha^{-1}). In Tamil Nadu, it occupies 3.46 lakh ha producing 10.33 lakh tonnes with an average productivity of 2980 kg ha^{-1}. Among the states in India, Gujarat (16.88 lakh ha) and Rajasthan (7.39 lakh ha) are the top two states with maximum area under cultivation, with highest production of 46.45 lakh tonnes (Gujarat) and 16.19 lakh tonnes (Rajasthan) and productivity was highest in Tamil Nadu (2980 kg ha^{-1}) and Gujarat (2751 kg ha^{-1}) (Indiastat, 2019-20) [14].

During the early stages (7 to 10 days), the growth is slow and also due to a slow growth rate up to 45 days after sowing, the crop is severely affected by weeds (Mohapatra, 2005) [15]. The groundnut yield has been reduced by 51% due to less canopy during the early stage of first 6 weeks in which the competition favours weeds (Akobundu 1987) [1].

The yield of groundnut during summer and *rabi* is not stable due to the infestation of weeds (Kori *et al*., 1997) [9]. Weeds are one of the main constraints which limit the productivity of groundnut as it is confronted with repeated flushes of various grassy and broad-leaved weeds throughout its growing season (Jat *et al*., 2011) [8]. The reserve of viable seeds of weeds in the soil and scattered throughout the soil profile is referred as weed seed bank (Singh *et al*., 2012; Begum *et al*., 2006) [22, 2]. It comprises of older seeds that have persisted in the soil from previous years as well as new weed seeds recently shed. The soil weed seed bank also consists the tubers, bulbs, rhizomes, and other vegetative structures through which some of the most serious perennial weeds self-propagates. Agricultural soils can accommodate thousands of weed seeds and a dozen or more vegetative weed propagules per square foot (Menalled, 2013) [13]. The emergence of weed seedlings strongly depend on the weed seed bank, which in undisturbed soils is characterised by the existence of a large proportion of weed seeds in the superficial layer. Essentially, potential emergence is an indicator of the non-dormant seed bank. According to some authors (Grundy *et al*. 1996; Hilhorst 1998) [5, 7], only the seeds that are in the top layer of the soil, approximately within the top 5 cm contribute significantly to the emerging population.

Thus, emergence of weed seedlings is conditional to soil environmental factors that are water (Roberts 1984; Spitters 1989; Grundy and Mead 2000; Marginet *et al*. 2000) [21, 23, 6, 11], temperature (Forcella *et al*. 2000) [4], composition of air (oxygen, carbon dioxide, water vapour and ethylene) and the quality of the light. Thus, this study was carried out to examine the effect of different irrigation methods and weed management options on weed emergence and nutrient removal.

Materials and Methods

Study area

The present investigation was carried out during *kharif* 2020 at Oilseeds Farm, Department of Agronomy, Agricultural College and Research Institute, Coimbatore located in the Western Agro-climatic zone of Tamil Nadu at 11° North latitude and 77° East longitude at an altitude of 426.72 m above mean sea level. Field possess a soil texture of red sandy loam with pH 8.53.

Irrigation methods (treatments)

In this study, three different irrigation methods were used, *viz.,* surface, drip and rain hose. Based on the climatological approach irrigation was scheduled.

Daily pan evaporation rate was recorded from the standard USWB class A open pan evaporimeter at Agro-meteorological observatory of Tamil Nadu Agricultural University, Coimbatore. Based on the pan evaporation reading subsequent irrigations were given to the plots as per the treatment schedule, during each irrigation 5 cm depth of water was applied. Irrigation was provided when the cumulative pan evaporation (CPE) value reached the level of 62.5 mm, which is in congruent with 0.8 of IW/CPE ratio (Rank. 2007) [18].

In drip irrigation and rain hose method, the irrigation was given once in three days based on the daily pan evaporation (CPE). The amount of water applied was calculated by using the coefficients of Class A Pan (Kpcs) and the canopy cover as a percentage, and measured by means of flow-meters. In rain hose method, irrigation was given once in six days based on the daily pan evaporation (CPE).

Experimental treatments

The experiment design was split plot with irrigation methods as main plots *viz.*, M_1: Surface irrigation, M_2: Drip irrigation, M_3: Rain hose and weed management as sub plots *viz.*, S_1: Pre-emergence *fb* Hand weeding + Earthing up, S_2: Pre-emergence *fb* Post emergence *fb* Earthing up, S_3: Pre-emergence *fb* Post emergence *fb* Post emergence, S_4: Post emergence *fb* Post emergence *fb* Earthing up and S_5: Hand weeding *fb* Hand weeding + Earthing up. Pendimethalin applied @ 1.0 litre ha^{-1} as pre-emergence, Imazethapyr @ 75 g + Quizalofop-ethyl @ 50 g a.i. ha^{-1} applied as Post emergence and first hand weeding was done on 25 DAS and hand weeding cum earthing up was done on 40 DAS.

Weed dry matter production

Those weeds falling within the quadrant frame were collected and categorized into individual weed species, shade dried and then dried in hot-air oven at 70 ºC till a constant weight was observed, recorded separately and expressed in g m^{-2}.

Nutrient removal by weeds

The weed samples removed for dry matter estimation were dried in hot air oven at 80ºC and ground into a fine powder in a Willey mill and used for chemical analysis to estimate the uptake of N, P and K at 15, 20, 40 and 60 DAS. The nutrient content of the samples was multiplied with their respective dry matter production to calculate the nutrient uptake and expressed in kg ha^{-1}.

Weed control efficiency (%)

Weed Control Efficiency was computed based on the formula suggested by Mani *et al.* (1973) [10].

$$\mathrm{WCE} = \frac{\mathrm{WDWc} - \mathrm{WDWt}}{\mathrm{WDWc}} \, X\ 100$$

Data analysis

The experimental data obtained at different growth stages of crop and weeds were compiled and were subjected to statistical analysis by adopting Fischer's method of analysis of variance technique. The significance was tested at a 5% α level across all variables. The mean value of main plot, sub plot and interactions were separately subjected to the Least Significant Difference (LSD) using the corresponding error mean sum of squares and degrees of freedom. The data pertaining to weeds (density and dry biomass) were subjected to square root transformation [(x + 1)1/2] due to non-normality of data.

Results and Discussion

Weed dry weight

Lowest weed dry weight was registered in drip irrigation system when compared to rain hose and surface irrigation (Table 1). This might be due to reduced weed number and unavailability of sufficient moisture for weed growth. This was followed by rain hose irrigation and the highest weed weight was observed under surface irrigation. In 15, 40 and 60 DAS drip irrigation produced least weed dry matter (2.03, 2.88 and 3.27 g m^{-2}) which was followed by rain hose (2.18, 3.17 and 3.67 g m^{-2}), while surface irrigation produced highest weed dry weight. But in 20 DAS, rain hose irrigation rain hose irrigation produced lesser weedy dry weight (2.46 g

m^{-2}). Under different weed management practices it varied over different stages. At 15 DAS, pre-emergence (pendimethalin @ 1.0 lit ha^{-1}) spray significantly reduced the weed dry weight which showed least value of 1.44 g $plant^{-1}$(S_2) which was on par with S_1 (1.48 g m^{-2}) and S_3 (1.51 g m^{-2}). Whereas at 20 DAS, S3 (pre-emergence *fb* post-emergence *fb* post-emergence) recorded lowest weed dry weight which was comparable with S_2 (pre-emergence *fb* post-emergence *fb* earthing up) than other practices. In 40 DAS, weed free plots (two hand weeding) (2.67 g m^{-2}) produced lower weed dry weight which was on par with S_3 (pre-emergence *fb* post-emergence *fb* post-emergence) (2.79 g m^{-2}). This was due to post emergence application of imazethapyr + quizalofop-ethyl inhibited the weed growth. It is in line with the observation of Chaitanya *et al*. (2012) [3]. There was significant interaction between the irrigation and weed control methods. Drip irrigation with pre-emergence *fb* post emergence *fb* earthing up registered the lowest weed dry weight at all stages. This was due to restricting the excess moisture which favours the weed emergence. Thus created a least opportunity for weeds growth and resulted in lesser weed dry matter production.

Table 1: Effect of irrigation methods and weed management practices on weed dry weight

Treatments	15 DAS	20 DAS	40 DAS	60 DAS
Surface irrigation (M_1)	2.56 (7.68)	2.97 (9.14)	3.63 (7.68)	3.99 (7.68)
Drip irrigation (M_2)	2.03 (4.33)	2.67 (6.86)	2.88 (4.33)	3.27 (4.33)
Rain hose irrigation (M_3)	2.18 (4.89)	2.46 (6.30)	3.17 (4.89)	3.67 (4.89)
S.Ed	0.05	0.05	0.07	0.13
CD(P=0.05)	0.15	0.13	0.20	0.36
Pre-emergence *fb* Hand weeding + Earthing up (S_1)	1.48 (1.71)	2.27 (4.73)	3.41 (1.71)	2.54 (1.71)
Pre-emergence *fb* Post emergence *fb* Earthing up (S_2)	1.44 (1.61)	2.16 (4.24)	2.83 (1.61)	2.60 (1.61)
Pre-emergence *fb* Post emergence *fb* Post emergence (S_3)	1.51 (1.80)	2.16 (4.22)	2.79 (1.80)	6.90 (1.80)
Post emergence *fb* Post emergence *fb* Earthing up (S_4)	3.41 (11.38)	2.83 (7.59)	4.43 (11.38)	2.86 (11.38)
Hand weeding *fb* Hand weeding + Earthing up (S_5)	3.45 (11.66)	4.08 (16.36)	2.67 (11.66)	3.33 (11.66)
S.Ed	0.07	0.06	0.07	0.17
CD(P=0.05)	0.14	0.12	0.14	0.36
MxS				
S.Ed	0.12	0.10	0.13	0.30
CD(P=0.05)	0.26	0.23	0.29	0.66
SxM				
S.Ed	0.12	0.10	0.12	0.30
CD(P=0.05)	0.25	0.21	0.24	0.62

Weed control efficiency

Significant difference was observed under different irrigation methods and weed management practices (Fig. 1.). Among irrigation methods, at 15 DAS drip irrigation showed higher weed control efficiency (75.13%) followed by rain hose method (71.87%) and least was recorded under surface irrigation (55.87%). During 20 DAS, rain hose irrigation achieved highest WCE (77.73%) which was on par with drip irrigation (75.76%); and lower weed control efficiency was obtained in surface irrigation (67.73%). While at 40 DAS, again drip irrigation achieved higher WCE (83.56%) which was on par with rain hose (80.13%) and least WCE was obtained under surface irrigation (73.95%). Among weed management practices, at 15 DAS treatments experiencing pre-emergence *fb* post emergence *fb* earthing up (S_2) (90.76%) which was comparable with pre-emergence *fb*hand weeding + earthing up (S_1) (90.19%) and pre-emergence *fb* post emergence *fb* post emergence (S_3) (89.65%). At 20 DAS which was on par with pre-emergence *fb* post emergence *fb* earthing up (S_2) (89.65%). At 40 DAS, treatment with two hand weeding achieved highest WCE (86.67%) which was on par with pre-emergence *fb* post emergence *fb* post emergence (S_3) (85.36%) and pre-emergence *fb* post emergence *fb* earthing up (S_2) (84.90%) and it was followed by pre-emergence *fb* hand weeding + earthing up (77.04%); and the lowest WCE was attained in post emergence *fb*post emergence *fb* earthing up (S_2) (62.08%). Reasons for obtaining highest weed control efficiency under drip irrigation with other weed management practices might be due to significant interaction effect by minimizing weed dry matter accumulation and weed competition faced by groundnut crop as reported by Rao *et al.* (2011) [19].

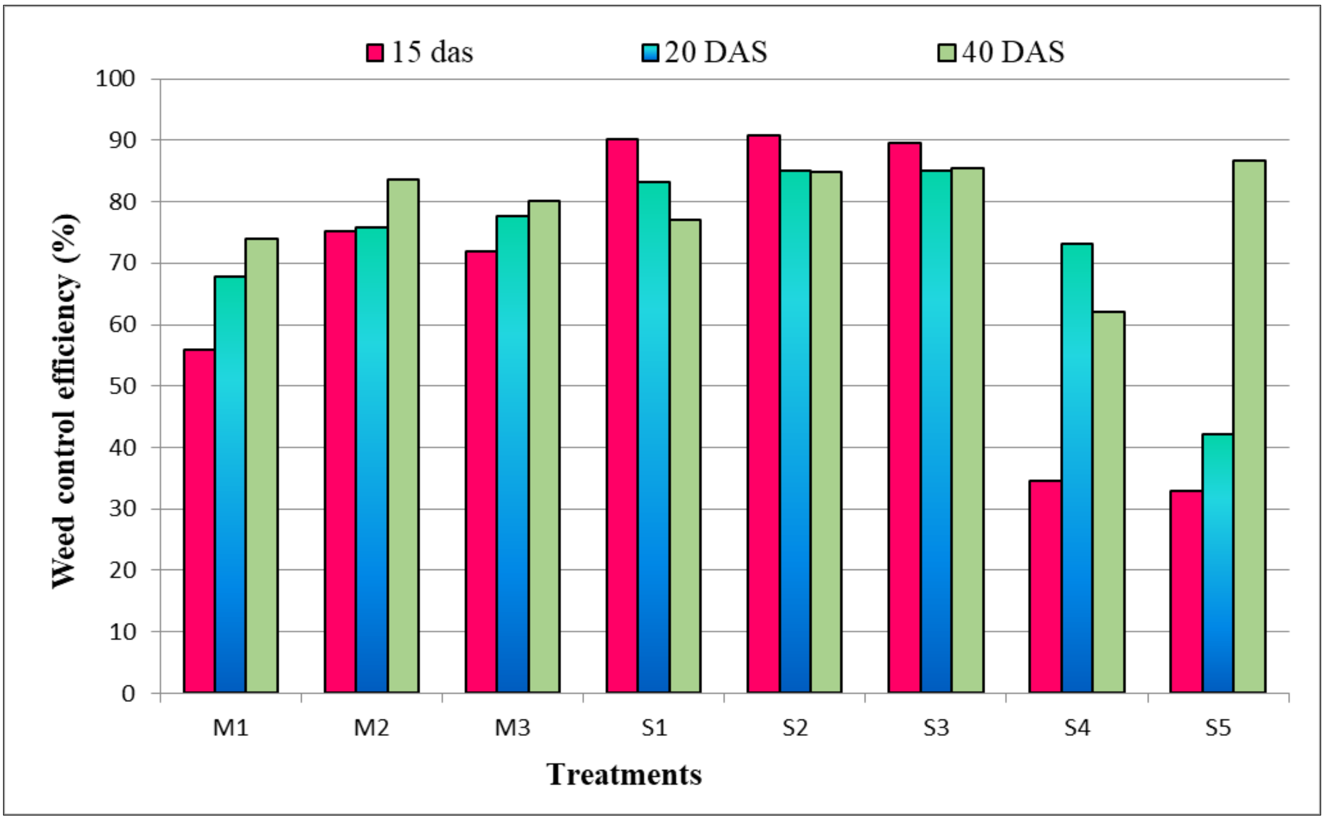

Fig 1: Effect of irrigation methods and weed management practices on weed control efficiency

Nutrient removal by weeds

Nitrogen

The nitrogen depletion by weeds were recorded at 15, 20, 40 and 60 DAS (Table 2). There was a significant variation in nitrogen depletion by weeds among different treatments during the crop season. At 15 DAS drip irrigation (M_2) recorded the least nitrogen removal (0.75 kg ha^{-1}) compared to other irrigation methods and this was followed by rain hose irrigation (M_3) (0.87 kg ha^{-1}) and the highest nitrogen was removed in surface irrigation (M_1) (1.28 kg ha^{-1}). While in weed management practices pre-emergence (pendimethalin @ 1.0 ltr ha^{-1}) *fb* post emergence (imazethapyr @ 75 g a.i. ha^{-1} + quizalofop-ethyl 50 g a.i. ha^{-1}) *fb* earthing up (S2) recorded the lowest nitrogen removal (0.40 kg ha^{-1}) compared to other weed management practices which was on par with pre-emergence *fb* hand weeding + earthing up (S_1) (0.42 kg ha^{-1}) and pre-emergence (pendimethalin @ 1.0 ltr ha^{-1}) *fb* post emergence *fb* post emergence (S_3) (0.45 kg ha^{-1}). The highest was recorded by two post emergence *fb* earthing up (S_4) (1.77 kg ha^{-1}) and two hand weeding + earthing up (S_5) (1.79 kg ha^{-1}). At 20 DAS, rain hose recorded the lowest nitrogen removal (1.05 kg ha^{-1}) which was followed by drip irrigation (1.23 kg ha^{-1}) and the highest was recorded in surface irrigation (1.50 kg ha^{-1}). Under weed management practices pre-emergence (pendimethalin @ 1.0 ltr ha^{-1}) *fb* post emergence *fb* post emergence (0.95 kg ha^{-1}) recorded lowest which was on par with S_2, S_1 and S_4. The highest was recorded in two hand weeding + earthing up (2.28 kg ha^{-1}). At 40 DAS drip irrigation (M_2) recorded the least nitrogen removal (1.12 kg ha^{-1}) compared to other irrigation methods and this was followed by rain hose irrigation (M_3) (1.33 kg ha^{-1}) and the highest nitrogen was removed in surface irrigation (M_1) (1.77 kg ha^{-1}). While in weed management practices weed free plot (S_5) recorded lowest nitrogen removal (0.90 kg ha^{-1}) which was on par with pre-emergence (pendimethalin @ 1.0 ltr ha^{-1}) *fb* post emergence *fb* post emergence (S_3) (0.99 kg ha^{-1}) and pre-emergence (pendimethalin @ 1.0 ltr ha^{-1}) *fb* post emergence *fb* earthing up (S2) (1.02 kg ha^{-1}). The highest was recorded in S_4 (2.52 kg ha^{-1}). At 60 DAS drip recorded the lowest nitrogen removal (1.76 kg ha^{-1}) which was followed by rain hose (2.33 kg ha^{-1}) and the highest was recorded in surface irrigation (2.43 kg ha^{-1}). Under weed management practices S_1 recorded the lowest nitrogen removal (0.95 kg ha^{-1}) which was on par with S_2 and S_4. This was followed by two hand weeding (1.60 kg ha^{-1}) and the highest was recorded in pre-emergence (pendimethalin @ 1.0 ltr ha^{-1}) *fb* post emergence *fb* post emergence (S_3) (6.19kg ha^{-1}).

Table 2: Effect of irrigation methods and weed management practices on nitrogen removal by weeds

Treatments	15 DAS	20 DAS	40 DAS	60 DAS
Surface irrigation (M_1)	1.28	1.50	1.77	2.43
Drip irrigation (M_2)	0.75	1.23	1.12	1.76
Rain hose irrigation (M_3)	0.87	1.05	1.33	2.33
S.Ed	0.04	0.05	0.06	0.17
CD(P=0.05)	0.10	0.14	0.16	0.46
Pre-emergence *fb* Hand weeding + Earthing up (S_1)	0.42	1.05	1.60	0.95
Pre-emergence *fb* Post emergence *fb* Earthing up (S_2)	0.40	0.96	1.02	0.96
Pre-emergence *fb* Post emergence *fb* Post emergence (S_3)	0.45	0.95	0.99	6.19
Post emergence *fb* Post emergence *fb* Earthing up (S_4)	1.77	1.06	2.52	1.17

Hand weeding *fb* Hand weeding + Earthing up (S_5)	1.79	2.28	0.90	1.60
S.Ed	0.05	0.06	0.06	0.21
CD(P=0.05)	0.11	0.13	0.12	0.43
MxS				
S.Ed	0.09	0.11	0.11	0.36
CD(P=0.05)	0.20	0.24	0.25	0.80
SxM				
S.Ed	0.09	0.11	0.10	0.36
CD(P=0.05)	0.19	0.22	0.21	0.74

Phosphorus

The phosphorus removal by weeds were recorded at 15, 20, 40 and 60 DAS (Table 3). There was a significant variation in phosphorus removal by weeds among different treatments during the crop season. At 15 DAS drip irrigation (M_2) recorded the least phosphorus removal (0.10 kg ha^{-1}) compared to other irrigation methods and this was followed by rain hose irrigation (M_3) (0.12 kg ha^{-1}) and the highest phosphorus was removed in surface irrigation (M_1) (0.17 kg ha^{-1}). While in weed management practices pre-emergence (pendimethalin @ 1.0 ltr ha^{-1}) *fb* post emergence (imazethapyr @ 75 g a.i. ha^{-1} + quizalofop-ethyl 50 g a.i. ha^{-1}) *fb* earthing up (S2) recorded the lowest phosphorus removal (0.05 kg ha^{-1}) compared to other weed management practices which was on par with pre-emergence *fb* hand weeding + earthing up (S_1) (0.06 kg ha^{-1}) and pre-emergence (pendimethalin @ 1.0 ltr ha^{-1}) *fb* post emergence *fb* post emergence (S_3) (0.06 kg ha^{-1}). The highest was recorded by two post emergence *fb* earthing up (S_4) (0.24 kg ha^{-1}) and two hand weeding + earthing up (S_5) (0.25 kg ha^{-1}). At 20 DAS rain hose recorded the lowest phosphorus removal (0.18 kg ha^{-1}) which was on par with drip irrigation (0.20 kg ha^{-1}) and the highest was recorded in surface irrigation (0.26 kg ha^{-1}). Under weed management practices pre-emergence (pendimethalin @ 1.0 ltr ha^{-1}) *fb* post emergence *fb* + earthing up (0.13 kg ha^{-1}) recorded lowest which was on par with S_3 and S_1. The highest was recorded in two hand weeding + earthing up (0.45 kg ha^{-1}). At 40 DAS drip irrigation (M_2) recorded the least phosphorus removal (0.22 kg ha^{-1}) compared to other irrigation methods and this was followed by rain hose irrigation (M_3) (0.26 kg ha^{-1}) and the highest phosphorus was removed in surface irrigation (M_1) (0.34 kg ha^{-1}). While in weed management practices weed free plot (S_5) recorded lowest phosphorus removal (0.16 kg ha^{-1}) which was followed by pre-emergence (pendimethalin @ 1.0 ltr ha^{-1}) *fb* post emergence *fb* post emergence (S_3) (0.20 kg ha^{-1}) and pre-emergence (pendimethalin @ 1.0 ltr ha^{-1}) *fb* post emergence + earthing up (0.20 kg ha^{-1}). The highest was recorded in S_4 (0.47 kg ha^{-1}). At 60 DAS, irrigation methods showed no significant variation in phosphorus removal by weeds. Under weed management practices S_1 recorded the lowest phosphorus removal (0.16 kg ha^{-1}) which was on par with S_2 (0.16 kg ha^{-1}) and S_4 (0.19 kg ha^{-1}). This was followed by two hand weeding (0.27 kg ha^{-1}) and the highest was recorded in pre-emergence (pendimethalin @ 1.0 ltr ha^{-1}) *fb* post emergence *fb* post emergence (S_3) (1.10 kg ha^{-1}).

Table 3: Effect of irrigation methods and weed management practices on phosphorus removal by weeds

Treatments	15 DAS	20 DAS	40 DAS	60 DAS
Surface irrigation (M_1)	0.17	0.26	0.34	0.41
Drip irrigation (M_2)	0.10	0.20	0.22	0.32
Rain hose irrigation (M_3)	0.12	0.18	0.26	0.39
S.Ed	0.00	0.01	0.01	0.03
CD(P=0.05)	0.01	0.03	0.03	NS
Pre-emergence *fb* Hand weeding + Earthing up (S_1)	0.06	0.15	0.32	0.16
Pre-emergence *fb* Post emergence *fb* Earthing up (S_2)	0.05	0.13	0.20	0.16
Pre-emergence *fb* Post emergence *fb* Post emergence (S_3)	0.06	0.13	0.20	1.10
Post emergence *fb* Post emergence *fb* Earthing up (S_4)	0.24	0.21	0.47	0.19
Hand weeding *fb* Hand weeding + Earthing up (S_5)	0.25	0.45	0.16	0.27
S.Ed	0.01	0.01	0.01	0.04
CD(P=0.05)	0.02	0.02	0.02	0.08
MxS				
S.Ed	0.01	0.02	0.02	0.06
CD(P=0.05)	0.03	0.05	0.05	0.14
SxM				
S.Ed	0.01	0.02	0.02	0.06
CD(P=0.05)	0.03	0.04	0.04	0.13

Potassium

The potassium removal by weeds were recorded at 15, 20, 40 and 60 DAS (Table 4). There was a significant variation in potassium removal by weeds among different treatments during the crop season. At 15 DAS drip irrigation (M_2) recorded the least potassium removal (1.46 kg ha^{-1}) compared to other irrigation methods and this was followed by rain hose irrigation (M_3) (1.61 kg ha^{-1}) and the highest potassium was removed in surface irrigation (M_1) (2.61 kg ha^{-1}). While in weed management practices pre-emergence (pendimethalin @ 1.0 ltr ha^{-1}) *fb* post emergence (imazethapyr @ 75 g a.i. ha^{-1} + quizalofop-ethyl 50 g a.i. ha^{-1}) *fb* earthing up (S2) recorded the lowest potassium removal (0.58 kg ha^{-1}) compared to other weed management practices which was on par with pre-emergence *fb* hand weeding + earthing up (S_1) (0.61 kg ha^{-1}) and pre-emergence (pendimethalin @ 1.0 ltr ha^{-1}) *fb* post emergence *fb* post emergence (S_3) (0.64 kg ha^{-1}). The highest was recorded by two post emergence *fb* earthing up (S_4) (3.78 kg ha^{-1}) and two hand weeding + earthing up (S_5) (3.86 kg ha^{-1}). At 20 DAS rain hose recorded the lowest potassium removal (2.06 kg ha^{-1}) which was followed by drip irrigation (2.33 kg ha^{-1}) and the highest was recorded in surface irrigation (3.11 kg ha^{-1}). Under weed management practices pre-emergence (pendimethalin @ 1.0 ltr ha^{-1}) *fb* post emergence *fb* post emergence (1.49 kg ha^{-1}) recorded lowest potassium removal which was on par with S_2 and S_1. The highest potassium removal was recorded in two hand weeding + earthing up (5.34 kg ha^{-1}). At 40 DAS drip irrigation (M_2) recorded the least potassium removal (2.03 kg ha^{-1}) compared to other irrigation methods and this was followed by rain hose irrigation (M_3) (2.42 kg ha^{-1}) and the highest potassium was removed in surface irrigation (M_1) (3.11 kg ha^{-1}). While in weed management practices, weed free plot (S_5) recorded lowest potassium removal (1.58 kg ha^{-1}) which was followed by pre-emergence (pendimethalin @ 1.0 ltr ha^{-1}) *fb* post emergence *fb* post emergence (S_3) (1.87 kg ha^{-1}) and pre-emergence (pendimethalin @ 1.0 ltr ha^{-1}) *fb* post emergence + earthing up (1.94 kg ha^{-1}). The highest was recorded in S_4 (4.50 kg ha^{-1}). At 60 DAS drip irrigation (M_2) recorded the least potassium removal (3.08 kg ha^{-1}) compared to other irrigation methods and this was followed by rain hose irrigation (M_3) (4.08 kg ha^{-1}) and the highest potassium was removed in surface irrigation (M_1) (4.18 kg ha^{-1}). Under weed management practices S_1 recorded the lowest potassium removal (1.51kg ha^{-1}) which was on par with S_2 (1.59 kg ha^{-1}) and S_4 (1.81 kg ha^{-1}). This was followed by two hand weeding (2.42 kg ha^{-1}) and the highest was recorded in pre-emergence (pendimethalin @ 1.0 ltr ha^{-1}) *fb* post emergence *fb* post emergence (S_3) (11.57 kg ha^{-1}).

Table 4: Effect of irrigation methods and weed management practices on potassium removal by weeds

Treatments	15 DAS	20 DAS	40 DAS	60 DAS
Surface irrigation (M_1)	2.61	3.11	3.25	4.18
Drip irrigation (M_2)	1.46	2.33	2.03	3.08
Rain hose irrigation (M_3)	1.61	2.06	2.42	4.08
S.Ed	0.05	0.12	0.11	0.30
CD(P=0.05)	0.13	0.32	0.30	0.84
Pre-emergence *fb* Hand weeding + Earthing up (S_1)	0.61	1.67	2.94	1.51
Pre-emergence *fb* Post emergence *fb* Earthing up (S_2)	0.58	1.50	1.94	1.59
Pre-emergence *fb* Post emergence *fb* Post emergence (S_3)	0.64	1.49	1.87	11.57
Post emergence *fb* Post emergence *fb* Earthing up (S_4)	3.78	2.48	4.50	1.81
Hand weeding *fb* Hand weeding + Earthing up (S_5)	3.86	5.34	1.58	2.42
S.Ed	0.09	0.14	0.11	0.36
CD(P=0.05)	0.18	0.29	0.23	0.75
MxS				
S.Ed	0.14	0.25	0.20	0.64
CD(P=0.05)	0.31	0.55	0.46	1.42
SxM				
S.Ed	0.15	0.24	0.19	0.63
CD(P=0.05)	0.31	0.50	0.40	1.30

At 15 DAS nutrient removal by weeds was reduced might be due to moisture availability was restricted to the crop canopy along with pre-emergence herbicide application provided less opportunity for weeds for its growth and dry matter accumulation, in turn reduced the removal of nutrients like nitrogen, phosphorus and potassium by weeds. Similar results were found by Mundra *et al.* (2002) [16] stating that application of pre-emergence herbicide saved the nutrients of 30.1% nitrogen and 26.4% phosphorus in maize; and Rana *et al.* (2000) [17] showed that uninterrupted weeds with crops removed 65.41, 9.6 and 66.21 kg/ha nitrogen (N), phosphorus (P) and potassium (K), respectively in transplanted rice. At 20 DAS weed nutrient depletion was reduced. This might be due to supply of required amount of water based on crop water demand rather than flooding enhanced the crop cover over surface and reduced opportunity for weed growth and thus reduced weed dry matter accumulation. And also application of post emergence herbicide inhibited the post emerged weeds, thus restricted the weed dry accumulation as well as nutrient removal by weeds. This was in line with the findings of Meena *et al.* (2017) [12] stated that application of post emergence herbicide recorded the minimum NPK content of weeds 2.52, 0.41 and 1.24 per cent, respectively. At 40 DAS through drip irrigation the nutrient removal by weeds was reduced due to minimized water availability to weeds for its emergence and growth along with hand weeding and application of post emergence herbicides. At 60 DAS nutrient removal by weeds was reduced due to reduced availability of moisture and crop cover imparts competition for nutrient removal by weeds which in turn reduced nutrients depletion by weeds. Effective weed control methods provide a favourable environment for increased uptake of nutrient by crops with proportionate decrease in the depletion of nutrients by weeds. This might be due to lower weed density and dry weight recorded in treatment plots during the cropping period.

Conclusion

Irrigation management is essential to develop a holistic system for weed management in crops. As water resources become costlier, drip irrigation technologies will become more widely utilized by growers worldwide. Although drip irrigation may be adopted due to water savings, the impact of drip irrigation on weed control is noteworthy. Nutrient removal by weeds was reduced in herbicide sprayed treatment plots than hand weeded plots in drip and rain hose irrigation. The ability to reduce soil wetting by drip irrigation will results in improved weed control over rain hose and surface irrigation systems. Similarly, the new technology of rain hose irrigation also significantly influenced the weed emergence and distributes moisture uniformly which promotes crop growth by reducing weed competition. Thus it can be concluded from the experimental results that either drip irrigation or rain hose irrigation with proper weed management practices would be advantageous for irrigating the groundnut to ensure minimum weed competition for nutrient resources to the crops and maximum moisture availability to crops with judicial water usage.

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