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Interaction effect of irrigation scheduling, mulching and integrated nutrient management on summer groundnut (*Arachis hypogaea* L.) yields under subtropical conditions of eastern Uttar Pradesh

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Abstract
The study aimed to evaluate the interaction effect of irrigation scheduling, mulching and integrated nutrient management on yields of summer groundnut under sub-tropical conditions. An experiment of summer groundnut involving three irrigation scheduling, two mulching and four integrated nutrient management treatments was undertaken for consecutive two years at Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, India in a split-plot design with three replications Treatments significantly influenced pod, kernel, haulm, and biological yield of groundnut. Irrigation scheduling at 60 CPE (cumulative pan evaporation) with paddy straw mulch and 75% recommended dose of nitrogen (RDN) + 25% N through farmyard manure (FYM)] + 60 kg S through gypsum recorded highest pod (3611 kg ha^{-1}), kernel (2254 kg ha^{-1}), haulm (5185 kg ha^{-1}), and biological yield (8743 kg ha^{-1}). Further this treatment combination was found better for increasing summer groundnut yields under subtropical conditions.

Keywords: Biological yield, Haulm yield, Kernel yield, Pod yield, Summer groundnut

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INTRODUCTION

India is one of the largest producers of oilseeds in the world accounting for 8% of the global oilseeds production with 14% world land area and notified as second largest producer of groundnut (Meena *et al.,* 2011). Groundnut is used as oil and food crop grown mainly in *kharif* and summer season especially in light textured soils. In India, groundnut is cultivated in an area of 4.56 million hectares (M ha) with 6.77 million tonnes (Mt) production at 1486 kg ha^{-1} productivity (MOA and FW, 2016).Uttar Pradesh with 0.10 M ha area, 0.07 Mt production at 670 kg ha^{-1} productivity is ranked 10^{th}most important among groundnut growing states in India(MOA and FW, 2016).The productivity of groundnut in Uttar Pradesh is low as compared to national average might be due to cultivation of groundnut crop mostly under moisture stress conditions and imbalanced fertilization with non-application of secondary nutrients viz., Ca and S. Optimum scheduling of irrigation increases pod yield due to proper moisture condition in the rhizosphere which affects the nodulation as well as availability of different nutrients (Das *et al.,*2013). Combination of irrigation with mulches has been found better for water uptake by the crop and to reduce the frequency of irrigation. Besides, increasing water uptake and reducing irrigation frequency, mulches also help in maintaining optimum moisture and thermal environment of soil. It also increases water use efficiency through reduction in evaporation and subsequently results in higher kernel yield (Chakraborty *et al.,*2008).The supply of nutrients to groundnut through integrated nutrient management (INM) along with gypsum is beneficial in boosting the crop performance as gypsum provides Ca and S, essential nutrients mainly responsible for enhancing pod yield and quality, while organic and inorganic sources of nutrient given through INM provide favourable nutritional environment (Karunakaran *et al.,* 2010) with positive effects on

soil physico-chemical properties. The information on above aspects, especially in summer groundnut is meagre in the eastern parts of Uttar Pradesh. Hence a study was undertaken to evaluate the effects of irrigation scheduling, mulching and INM on summer groundnut (*Arachis hypogaea* L.) yields in subtropical conditions of Uttar Pradesh.

MATERIALS AND METHODS

A field experiment was conducted at Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University (BHU), Varanasi (23^{o} 20' N latitude; 83^{o} 03' E longitude; at an altitude of 128.93 m above the mean sea-level) during summer seasons of 2015 and 2016. Varanasi experiences sub-tropical climate with hot dry summers and cold winters. Physico-chemical analysis showed that soil of the experimental site was sandy clay loam in texture having alkaline pH (7.86), low in available nitrogen (206.9 kg ha^{-1}) and available phosphorus (17.8 kg ha^{-1}) and medium in available potassium (233.1 kg ha^{-1}) and sulphur (15.6 kg ha^{-1}), respectively. The field was under rice-wheat cropping system (RWCS) for continuously five years (2011-2015) period before this experiment. The experiment had twenty-four treatment combinations viz. 6 combinations of three irrigation schedules (60, 80 and 100 mm cumulative pan evaporation (CPE) and two mulch treatments (paddy straw mulch and dust mulch) in main plots and four INM levels (100% N, 75% N+ 25% N (FYM) + 20 kg S through gypsum, 75% N+ 25% N (vermicompost) + 40 kg S through gypsum and 75% N+ 25% N (FYM) + 60 kg S (gypsum) in sub-plots and was laid-out in a split-plot design with three replications. Groundnut variety 'HG 37' was sown at a spacing of 30x10 cm on 25 and 10 March in 2015 and 2016, respectively. As per the treatments, paddy straw mulch (10 t ha^{-1}) was evenly spread only in the inter-row spaces at 15 days after sowing (DAS) and dust mulching after all irrigations was maintained by manipulating soil surface with the help of spade. The entire quantity of nutrients except gypsum was applied in rows as basal application. The whole quantity of gypsum was applied at peg initiation stage. To keep irrigation frequency constant, a pre-determined quantity of water was applied by using Parshall flume and CPE was worked out from the daily Epan data taken from institute observatory and accordingly crop was irrigated (6 cm depth) at 60, 80, and 100 CPE. The need-based crop management practices throughout the crop growing period were also followed to keep the crop in vigorous condition. Observations were recorded for yields (pod, kernel haulm, and biological) at harvest. When about 70% of haulms were dry, the crop was harvested from net plot area on 29 and 20 May in 2015 and 2016, respectively. Net plot yields (Pod, haulm, kernel, and biological yield) were recorded and converted into kg ha^{-1} by adopting standard computation procedure. The data recorded from the experiment were analyzed as per the procedure described by Gomez and Gomez (1984) for split-plot design. Critical difference (CD) was calculated at 5% probability level for comparing treatments mean.

RESULTS AND DISCUSSION

The interaction of irrigation scheduling, mulching, and INM significantly (P=0.05) influenced pod, kernel, haulm, and biological yield of groundnut (Table 1, 2, 3 and 4).The highest (3611 kg ha^{-1}) and lowest (2405 kg ha^{-1}) pod yield was recorded with 60 mm CPE with paddy straw mulch and 75% RDN + 25% N (FYM) + 60 kg S (gypsum) and100 mm CPE with dust mulch and100% RDN, respectively. The treatment combination of 60 mm CPE with paddy straw mulch and 75% RDN + 25% N (FYM) + 60 kg S (gypsum) recorded 4-50% higher pod yield over rest of the treatment combinations (Table 1).

Further, the kernel (2254 kg ha^{-1}), haulm (5185 kg ha^{-1}), and biological (8743 kg ha^{-1}) yield were significantly higher in 60 mm CPE with paddy straw mulch and 75% RDN + 25% N (FYM) + 60 kg S (gypsum) as compared to other treatment combinations. Furthermore, the combination of 60 mm CPE with paddy straw mulch and 75% RDN + 25% N (FYM) + 60 kg S (gypsum) increased kernel (2254 kg ha^{-1}), haulm (5185 kg ha^{-1}), and biological (8743 kg ha^{-1}) yield in the proportion of 4-

Table 1. Interaction effect of irrigation scheduling, mulching and integrated nutrient management on summer groundnut pod yield (kg ha^{-1}).

Treatment	Integrated nutrient management				
	100% RDN	75% RDN + 25% N (FYM) + 20 kg S (gypsum)	75% RDN + 25% N (Vermicompost) + 40 kg S (gypsum)	75% RDN + 25% N (FYM) + 60 kg S (gypsum)	Mean Groundnut pod yield
Paddy straw mulch x 60 mm CPE	3013	3227	3395	3611	3311
Paddy straw mulch x 80 mm CPE	2758	2952	3131	3322	3041
Paddy straw mulch x 100 mm CPE	2634	2820	2991	3223	2917
Dust mulch x 60 mm CPE	2893	3048	3259	3467	3167
Dust mulch x 80 mm CPE	2561	2750	2922	3025	2814
Dust mulch x 100 mm CPE	2405	2559	2775	2924	2666
Mean	2711	2892	3079	3262	
SEm±			32.1		
CD (P=0.05)			96.2		

Table 2. Interaction effect of irrigation scheduling, mulching and integrated nutrient management on summer groundnut kernel yield (kg ha^{-1}).

Treatment	Integrated nutrient management				
	100 % RDN	75% RDN + 25% N (FYM) + 20 kg S (gypsum)	75% RDN + 25% N (Vermicompost) + 40 Kg S (gypsum)	75% RDN + 25% N (FYM) + 60 kg S (gypsum)	Mean Groundnut kernel yield
Paddy straw mulch x 60 mm CPE	1881	2014	2120	2254	2067
Paddy straw mulch x 80 mm CPE	1723	1844	1956	2075	1899
Paddy straw mulch x 100 mm CPE	1646	1762	1869	1983	1815
Dust mulch x 60 mm CPE	1806	1904	2035	2165	1977
Dust mulch x 80 mm CPE	1598	1716	1823	1919	1764
Dust mulch x 100 mm CPE	1501	1598	1733	1825	1664
Mean	1692	1806	1923	2037	
SEm±			17.51		
CD (P=0.05)			52.54		

Table 3. Interaction effect of irrigation scheduling, mulching and integrated nutrient management on summer groundnut haulm yield (kg ha^{-1}).

Treatment	Integrated nutrient management				
	100 % RDN	75% RDN + 25% N (FYM) + 20 kg S (gypsum)	75% RDN + 25% N (Vermicompost) + 40 kg S (Gypsum)	75% RDN + 25% N (FYM) + 60 kg S (gypsum)	Mean groundnut haulm yield
Paddy straw mulch x 60 mm CPE	4550	4704	4951	5185	4847
Paddy straw mulch x 80 mm CPE	4108	4233	4252	4419	4253
Paddy straw mulch x 100 mm CPE	3867	3977	4183	4289	4079
Dust mulch x 60 mm CPE	3632	3664	4019	4193	3877
Dust mulch x 80 mm CPE	3428	3799	3852	4084	3791
Dust mulch x 100 mm CPE	3289	3303	3584	3708	3471
Mean	3812	3947	4140	4313	
SEm±			114.0		
CD (P=0.05)			342.2		

Table 4. Interaction effect of irrigation scheduling, mulching and integrated nutrient management on summer groundnut biological yield (kg ha^{-1}).

Treatments	Integrated nutrient management				
	100 % RDN	75% RDN + 25% N (FYM) + 20 kg S (gypsum)	75% NPK+ 25% N (vermicompost) + 40 kg S (gypsum)	75% RDN + 25% N (FYM) + 60 kg S (gypsum)	Mean ground-nut biological yield
Paddy straw mulch x 60 mm CPE	7518	7882	8295	8743	8109
Paddy straw mulch x 80 mm CPE	6971	7300	7477	7852	7400
Paddy straw mulch x 100 mm CPE	6501	6796	7175	7463	6984
Dust mulch x 60 mm CPE	6261	6781	7067	7497	6901
Dust mulch x 80 mm CPE	6036	6222	6792	7118	6542
Dust mulch x 100 mm CPE	5850	6052	6507	6783	6298
Mean	6523	6839	7219	7576	
SEm±			135		
CD (P=0.05)			387		

50, 13-57 and 5-49%, respectively over rest of the combinations (Table 2-4). The frequent irrigation, mulching with paddy straw and FYM based INM treatments might have helped in increasing the water holding capacity of soil following improvement in physico-chemical properties of soil which ultimately boosted the crop performance and increased yields of the crop. Karunakaran *et al.* (2010) have also reported higher pod and haulm yield of groundnut with application of organic manure in combination of recommended dose of nitrogen, while Patel *et al.*(2009) reported higher pod (3784 kg ha^{-1}) and haulm (6040 kg ha^{-1}) yield of groundnut with frequent irrigations (40 mm CPE) applied based on CPE. Our results are also in congruence with the findings of Maurya *et al.* (2017) on moisture extraction pattern and productivity of summer groundnut.

Conclusion

On the basis of the findings of this experiment it is concluded that scheduling irrigation at 60 mm CPE with paddy straw mulch (10 t ha^{-1}) and 75% RDN + 25% N (FYM) + 60 kg S (gypsum) was optimum for higher pod, kernel, haulm and biological yield.It is also inferred that substitution of 25% nitrogen requirement of the crop through FYM along with gypsum, paddy straw mulch, and frequent irrigation might have helped in improving physico-chemical properties and nutrient profile of the soil which ultimately boosted the crop performance.

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