Journal of Agricultural and Crop Research
Vol. 2(7), pp. 134-142, July 2014
ISSN: 2384-731X
Research Paper

Effect of seed soaking periods in varying levels of fertilizers on growth, yield and yield components of peanut

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Accepted 30th May, 2014

Abstract. A field study was conducted to evaluate the effect of soaking of seeds of peanut (*Arachis hypogea* L.) before sowing in freshly prepared solutions of two fertilizers namely Sangral and Quick nutria at different concentrations of 0, 1, 2 or 3 ml L^{-1} and at different periods of time (0, 12, 24 and 36 h). The results showed that all treatments had no effect on plant height. On the other hand, an application of Quick nutria fertilizer produced significantly longer roots (59.79), root fresh (31.55 g) and dry weights (21.48 g), leaf area index (LAI) (23.82) and yields of pods (13.60) and seeds (18.52%). These quantities were greater than those recorded from Sangral fertilizer. In addition, Quick nutria also improved water use efficiency (4.88 m^3 kg^{-1}). The seeds which were treated with fertilizers at a concentration of 3 ml L^{-1} produced the highest root length (22.43 cm), root fresh and dry weights (11.09 and 9.24 g), LAI (6.90), and pod and seed yields (3.44 and 2.28 t ha^{-1}). The latter also improved water use efficiency of the peanut plants (3.017 m^3 $kg^{-1)}$. Furthermore, soaking period of 36 h produced the highest root length (24.29 cm), root fresh and dry weight (12.03, 9.14 g), LAI (6.91), pod and seed yields (3.26, 2.06 t ha^{-1}), and improved water use efficiency (4.41 m^3 kg^{-1}). The highest interaction effects were obtained from fertilizer × concentration, fertilizer × soaking periods, concentration × soaking periods, and fertilizer × concentration × soaking periods for all of the studied variables except plant height. Further to that, the optimum seed yield (2.96 t ha^{-1}) was obtained from the seeds which were soaked in Quick nutria solution at 1 ml L^{-1} for 36 h. Soaking peanut seeds before sowing in freshly prepared fertilizer solutions at different concentrations is a simple and an economically viable option to improve the seedling establishment, plant growth and yield of peanut plant.

Keywords: Quick nutria, Sangral fertilizer, water use efficiency.

INTRODUCTION

Groundnut is an important oil-seed crop because its seed contains about 44 to 56% oil and 22 to 30% protein on dry basis. The crop is grown on 19.3 million hectares of land area in about 82 countries globally (Reddy et al., 2003). Groundnut is also one of the world's most important pulse crops and all parts of the crop are of importance. Its seeds are a primary source of protein and oil for human consumption while the haulm, and shells are important animal feed and it is considered as source of supplementary income during dry season (Ahmad et al., 2007; Naab et al., 2009). However, the crop has ability to thrive on newly reclaimed sandy soils, being a legume of high nutritive value (Desire et al., 2010). Studies have indicated that groundnut requires high levels of nutrients because of the soil where it is favoured for growth and development (Ha, 2003). These essential nutrient elements are never adequate in the soil systems because of their high transformations and the inherently low levels in the parent material. However, Veeramani and Subrahmaniyan (2011) indicated that farmers do not adequately replenish depleted nutrient elements in their groundnut farms because of poor knowledge on the importance of mineral fertilizers, low per capita and untested soil properties. Mineral fertilizers containing N and P nutrients have been reported by Thorave and Dhonde (2007) and Shinde et al. (2000) to give the highest plant height and total dry matter partitioning per plant at harvest and the yield attributes of summer groundnut.

Nitrogen (N) is a key element for plant growth, normally resulting in the largest yield in crop plants (Okito et al., 2004). The sources of N available to plant include native soil N, mineral N fertilizers and biological N_2-fixation (BNF) (Russelle and Birr, 2004). Small amounts of available soil or fertilizer N have often been reported to have a stimulatory effect on legume nodulation and BNF, the so-called "starter effect". This is mainly due to the stimulatory effect of N on growth and plant establishment during the periods between root emergence and the onset of active BNF (Giller and Cadisch, 1995). In situations where soil fertility status is promising, legumes in the field thrive without fixing atmospheric N. Under such conditions, legumes may derive all their N requirements from the soil N. However, in most soils of Iraq, the levels of plant available N are usually insufficient to satisfy a legume's N requirement. Groundnut can assimilate N as inorganic N (NH_4^+, NO_3^-) or through symbiotic N_2 fixation. Attempts to supplement N_2 fixation using inorganic fertilizers have not been successful in most soils of Iraq because the addition of fertilizer-N substitutes for, rather than supplementing, N_2 fixation (Selamat and Gardner, 1985). Nevertheless, it is generally accepted that symbiotically fixed N_2 is inadequate for realizing optimum seed yields. The latter suggests that an application of small amounts of ``starter'' fertilizer N is needed to establish seedlings and promote early denitrogen fixation (Selamat and Gardner, 1985). However, an application of large quantities of inorganic N inhibits the growth of rhizobia, nodulation and denitrogen fixation (Lie, 1974). Studies on other grain legumes have shown that for the plants which depended on symbiotic N_2, an application of small quantities of inorganic N can stimulate nodulation and increase N_2 fixation (Eaglesham et al., 1983). This leads to greater seed yields even at high air temperatures (Rawsthorne et al., 1985a). Prasad et al. (2001) reported that effectively nodulated plants with small quantities of inorganic N are potentially more adaptable to hot environments than those relying on large quantities of inorganic N. It is also believed that groundnut requires large quantities of phosphorus (P), calcium (Ca) and sulphur (S) for seed development and oil quantity. Because nutrients are removed and consequently lost as a result of cropping with crop harvests, there is a need to replace these losses. This could be done promptly through the application of inorganic fertilizers in order to maintain a positive nutrients' balance (Buah and Mwinkaara, 2009). The capacity of plants to access P under limiting conditions depends on some important adaptive traits, including organic acid excretion (Schachtman et al. 1998), alteration of pH of the rhizosphere (Hinsinger, 2001), and increased root surface area (Sas et al., 2001). Variations in root morphology and physiology were shown to be correlated with genotypic differences in the ability of the plant to utilize soil available P (Cynthia and Angela, 2004). Miao et al. (2007a) evaluated root characters of varieties under internal and external P conditions and observed differences among them in relation to root length, root surface, and P concentration in soybean plant parts. Shujie and Yunfa (2011) found an exponential relationship between P use efficiency (PUE) and P concentrations in shoots and roots of soybean. Babaji et al. (2010) at the semi-arid location found that an application of 120:60:60 kg NPK ha^{-1} produced higher maize cob yield than the not-fertilized maize. Several other researchers also revealed that combined application of NPK fertilizers have marked a significant effect on growth, yield and yield attributes of most of the crops than individual application of each nutrient (Pochauri et al., 1991). Kalaiyarasan et al. (2002) found that growth and yield of groundnut were significantly increased with S levels. Treatment for micronutrient deficiency includes application of their compounds to the soil or plant but these approaches of fertilizer applications are uneconomical and in certain cases disturb the nutrients' balance or might cause environmental pollution. The beneficial effects of seed treatment with micronutrients on grain yield and protein content of grain crops have been reported by Musakhanov (1964) and Pomogaeva and Butylkin (1977). Moreover, seed soaking with trace elements has been advocated to be more effective than soil treatment or foliar spray (Bamberg and Balode, 1961).

Pre-germination of peanut seeds by soaking in water before planting resulted in a minimized lag period between sowing and seedling establishment (Polthanee, 1991). The early seed emergence leads to an early use of soil moisture, and crop maturity prior to experiencing water stress. Challaraj et al. (2010) observed a significant increase in plant biomass and total chlorophyll content when seeds of peanut were soaked in rare earth elements (REE) solution at a concentration of 10 mg L^{-1} (Indian monazite soil sample rich in REE), for 4 to 8 h. Shafinazir et al. (2000) found that steeping of wheat seeds pre-sowing in aqueous solution of different micronutrients produced significantly the highest grain yield on account of significant improvement in the various yield components.

It is a fundamental principle that raising crop yield requires both genetic and agricultural improvement and the capacity of yield potential is enlarged by enhanced agronomic inputs. So, under sandy soil which is mostly deficient in one or more of the essential nutrients, it should be searched for the adequate nutrients supplement in balanced manner. Therefore, the objective of the present investigation were to evaluate the beneficial effect of seed soaking periods in varying levels of Sangral and Quick nutria fertilizers on the yield and yield components of peanut.

MATERIALS AND METHODS

The experiment was conducted in a farmer's field in AL-Qaam District, AL-Anbar Province, west of Iraq during April to September 2011 growing season. This was to evaluate the beneficial effect of seed soaking periods in varying levels of Sangral and Quick nutria fertilizers on the yield and yield components of peanut var. Egyptian. The soil of the study area was sandy loam whose organic matter was 0.7%, pH 8.3, Ec 4.5 dS m^{-1}, N 0.03%, available P 11.0 mg kg^{-1} and exchangeable K was 180 mg kg^{-1}. In addition, the extractable micronutrients recorded were Fe, Cu and Zn whose values were 5.53, 1.01 and 2.42 mg kg^{-1}, respectively.

Experimental design and experimentation

The experiment was laid out in a completely randomized block design (RCBD) with two fertilizers (Sangral high P and Quick nutria) and seed treated (soaking the seeds in three concentrations of fertilizer solutions 1.0, 2.0 and 3.0 ml L^{-1} before seeding, respectively). The seed priming treatments were carried out in three durations which were 12, 24 and 36 h and were compared with the un-soaked seeds as an absolute control all in three replications. Sangral fertilizer was composed of N-P_2O_5-K_2O-MgO-Solid and Quick nutria was composed of N-P_2O_5-K_2O-MgO-Liquid.

A constant dose of N at 40 kg N ha^{-1} in the form of urea, P at 80 kg P_2O_5 ha^{-1} (equivalent to 34.4 kg P ha^{-1}) in the form of triple superphosphate (TSP) and K at 40 kg K_2O ha^{-1} (equivalent to 33.2 kg K ha^{-1}) in the form of potassium sulphate were applied to each plot. The soaked seeds were sown in rows by hand, keeping 0.60 and 0.30 m inter and intra spacing, respectively. The plants were thinned to one plant per hill at 15 days after planting (DAP) and hand weeding was done once at 30 DAP. The crops in the experimental plots were managed according to the recommended conventional agronomical practices.

Data collection

Ten plants from each plot were taken for the measurement of plant height, root length, root fresh and dry weights and leaf area index. Leaf area was measured at 65 DAP and root samples were taken at physiological maturity for the measurements of pod yield and seed yield which were determined from the middle three rows harvested from each plot. The number of pods per plant was determined from 10 plants subsamples collected from randomly selected plants. The data on water use efficiency (WUE) of the crop was estimated and calculated as described by Giriappa (1983), thus:

$$\text{WUE} = \frac{Total\ yield\ (kg\ ha^{-1})}{ETa\ (m^3\ ha^{-1})}$$

Where: ETa = Actual evapotranspiration in mm per interval

$$\text{ETa} = \frac{(\theta\ \text{v2}\ -\ \theta\ \text{v1})\ \text{d}}{100}$$

Where: θ v2 = Soil moisture content after irrigation on volume basis (%)

θ v1 = Soil moisture content before irrigation on volume basis (%)

d = Depth of soil layer (mm)

Statistical analysis

The data were subjected to analysis of variance procedures and the least significance difference (LSD) at 5% level of probability was used to compare treatment means when F-test was significant.

RESULTS

Effect of fertilizers on growth, yield components and seed yield of peanut

Results indicated that that application of fertilizers had no significant effects on plant height and number of pods per plant. An application of Quick nutria fertilizer produced significantly increased root length, fresh and dry weights of root, and LAI by 59.79, 31.55, 21.48 and 23.82%, respectively than an application of Sangral fertilizer (Table 1). Yields in inference of pods and seeds also increased significantly by 13.60 and 18.52%. The use of Quick nutria fertilizer resulted in increment of water use efficiency of 4.88 m^3 kg^{-1} compared to Sangral fertilizer (5.38 m^3 kg^{-1}).

Effect of fertilizer concentrations on growth, yield components and yield of peanut

Results indicated that the treatments with different fertilizer concentrations had no significant effect on final plant height which on an average varied from 56.86 to 61.15 cm (Table 2). The average root length recorded under various fertilizer concentrations differed significantly but a fertilizer concentration of 3 ml L^{-1} produced significantly greater root length (22.43 cm) than the un-soaked (9.04 cm). However, the differences between fertilizer concentrations were insignificant. The effects of 3 ml L^{-1} produced significant increase in fresh (11.09 g) and dry (9.24 g) weights of roots against the absolute control which were 6.90 and 5.74 g, respectively. The data on leaf area index (LAI) revealed that all the fertilizer concentrations differed significantly from one

Table 1. Effect of Sangral and Quick nutria fertilizers on growth, yield components parameters and seed yield of peanut.

Fertilizers	Plant height (cm)	Root fresh wt (g)	Root dry wt (g)	Root length (cm)	LAI	Number of pods	Number of seeds	Yield (t/ha)	Water use efficiency (m^3 kg^{-1})
Sangral	54.92	13.28	8.24	7.17	5.08	20.77	2.72	1.64	5.38
Quick nutria	57.00	21.22	10.84	8.71	6.29	21.98	3.09	1.94	4.88
LSD (0.05)	N.S	3.12	1.02	0.95	0.43	N.S	0.18	0.07	0.03

Table 2. Effect of fertilizer concentrations on growth, yield components and seed yield of peanut.

Concentration (ml L^{-1})	Plant height (cm)	Root fresh wt (g)	Root dry wt (g)	Root length (cm)	LAI	Number of pods	Number of seeds	Yield (t/ha)	Water use efficiency (m^3 kg^{-1})
0	56.86	9.04	6.90	5.74	3.37	15.01	1.74	0.75	9.33
1	58.95	20.07	10.09	8.41	6.46	23.87	3.47	2.27	3.28
2	59.92	20.20	10.98	9.10	6.74	24.3	3.38	2.18	3.31
3	61.15	22.43	11.09	9.24	6.90	24.45	3.44	2.28	3.17
LSD (0.05)	N.S	4.14	2.82	1.99	0.93	3.12	0.51	1.25	2.13

Table 3. Effect of soaking periods of Sangral and Quick nutria solutions on growth, yield components and seed yield of peanut.

Soaking hours	Plant height (cm)	Root fresh wt (g)	Root dry wt (g)	Root length (cm)	LAI	Number of pods	Number of seeds	Yield (t/ha)	Water use efficiency (m^3 kg^{-1})
0	55.25	8.95	6.87	5.71	3.35	14.55	1.71	0.73	9.66
12	54.28	12.90	8.18	7.03	4.92	21.13	2.73	1.65	5.13
24	56.85	16.64	9.09	8.21	5.77	22.11	3.03	1.90	4.69
36	59.44	24.29	12.03	9.14	6.91	22.60	3.26	2.06	4.41
LSD(0.05)	N.S	4.14	1.19	1.28	1.04	3.88	0.97	0.75	2.74

another (Table 2). The highest LAI (6.90) was recorded for the seeds which were soaked at 3 ml L^{-1} against the minimum of the absolute control (3.37). Yield of pods or seeds (t ha^{-1}) was also significantly affected by the various concentrations of the fertilizers. The highest pod and seed yields of 3.44 t ha^{-1} and 2.28 t ha^{-1} were obtained from the seeds which were soaked in fertilizer concentration of 3 ml L^{-1} compared with the yields in absolute control which were 1.74 and 0.75 t ha^{-1}, respectively. In addition, water use efficiency was significantly affected by fertilizer concentrations because at 3 ml L^{-1} there was the highest water use efficiency (3.17 m^3 kg^{-1}) compared to absolute control (9.33 m^3 kg^{-1}).

Effect of soaking periods on growth, yield components and yield of peanut

Results indicated that seed soaking periods of 12, 24 and 36 h before seeding did not have a significant effect on plant height compared to non-soaked seeds (Table 3). There were significant differences among the soaking periods with regard to root length, and root fresh and dry weights (Table 3). Soaking seeds for 36 h produced the highest plant length (24.29 cm), fresh weight (12.03 g) and dry weight (9.14 g) over the absolute control. Results also showed a remarkable variation in LAI and the greatest LAI

Table 4. Effect of fertilizers and soaking periods on growth, yield components and seed yield of peanut.

Fertilizers	Soaking periods (h)	Plant height (cm)	Root fresh wt (g)	Root dry wt (g)	Root length (cm)	LAI	Number of pods	Number of seeds	Yield (t/ha)	Water use efficiency (m^3 kg^{-1})
Sangral	0	45.00	8.90	6.82	5.70	3.34	14.50	1.70	0.72	9.72
	12	53.45	9.75	7.50	6.28	4.28	20.30	2.43	1.43	5.56
	24	55.53	12.55	8.14	7.08	4.83	21.35	2.67	1.58	5.16
	36	58.25	18.63	9.45	8.53	6.57	22.15	3.34	2.15	4.29
Quick nutria	0	45.50	9.00	6.91	5.72	3.36	14.60	1.71	0.73	9.59
	12	55.10	16.05	8.86	7.79	5.55	21.88	3.04	1.88	4.71
	24	58.18	20.73	10.03	9.34	6.72	22.88	3.04	2.22	4.22l
	36	60.63	29.95	14.62	9.75	7.26	23.05	3.18	1.98	4.53
	LSD(0.05)	N.S	5.44	2.94	2.28	1.84	4.98	0.98	0.79	3.07

(6.91) was recorded after soaking the seeds for 36 h, and the lowest LAI (3.35) was recorded in the control treatment. Furthermore, soaking of seeds for 36 h produced the highest yields of pods (3.26 t ha^{-1}) and seeds (2.06 t ha^{-1}) compared to un-soaked seeds which had pod and seed yields of 1.71 and 0.73 t ha^{-1} respectively. Results also indicated that the water use efficiency of peanut increased with increasing soaking periods, and the highest water use efficiency (4.41 m^3 kg^{-1}) was recorded at 36 h and the lowest (9.66 m^3 kg^{-1}) for the un-soaked seeds.

Effect of fertilizers and soaking periods on growth, and yields of peanut

Results indicated that there was a significant fertilizers × soaking periods interaction effect on root length, root fresh and dry weights, LAI, number of pods per plant and pod yield. The afore-mentioned parameters were significantly higher when Quick nutria solution was used for 36 h while control treatment gave the lowest measurements (Table 4). Soaking the seeds in Quick nutria solution for 24 h gave the highest seed yield (2.22 t ha^{-1}) compared to the absolute control (0.72 t ha^{-1}). The best improvement in water use efficiency (4.22 m^3 kg^{-1}) was obtained when soaking the seeds in Quick nutria solution for 24 h.

Effect of fertilizers and their concentrations on growth, and yields of peanut

Results indicated that fertilizers x concentrations interaction was statically significant on plant height, root length, root fresh and dry weights, LAI, number of pods per plant and water use efficiency (Table 5). The highest measurements of these variables were obtained when seeds were soaked in Quick nutria solution at 3 ml L^{-1}, while the lowest results were obtained in control treatment. On other hand, soaking the seeds in Quick nutria solution at 1 ml L^{-1} gave the highest yield of pods and seeds of 3.84 and 2.54 t ha^{-1}, respectively.

Effect of fertilizer levels and soaking periods on growth, and yields of peanut

Results indicated that there was significant interaction between fertilizer concentrations and soaking periods on plant height, root length, root dry weight, and LAI at 3 ml L^{-1} soaking for 36 h while the absolute control treatment gave the lowest measurements of the same variables (Table 6). It was also observed that soaking the seeds in 1 ml L^{-1} for 36 h gave the highest root dry weight, and number of pods per plant, pod and seed yields and water use efficiency, whereas the control treatment also gave the lowest measurements of these variables.

Effect of fertilizers, concentrations and soaking periods on growth and yields of peanut

Results indicated that the interaction of fertilizers × concentrations × soaking periods were statically significant on root length, root fresh and dry weights (Table 7). The highest measurements were obtained when the seeds were soaked in Quick nutria solution at 1 ml L^{-1} for 36 h. The results recorded were the number of pods per plant (26.10), yields of pods (4.34 t ha^{-1}) and seeds (2.96 t ha^{-1}). The interaction of fertilizers ×

Table 5. Effect of fertilizers and concentrations on growth, yield components and seed yield of peanut

Fertilizers	Concentration (mL L^{-1})	Plant height (cm)	Root fresh wt (g)	Root dry wt (g)	Root length (cm)	LAI	Number of pods	Number of seeds	Yield (t/ha)	Water use efficiency (m^3 kg^{-1})
Sangral	0	46.70	9.00	6.86	5.73	3.36	14.95	1.73	0.74	9.43
	1	57.17	14.47	8.50	7.19	5.62	20.70	3.10	2.00	3.65
	2	59.40	15.47	8.96	8.11	5.90	23.63	3.17	2.04	3.55
	3	59.13	15.60	9.12	8.14	6.02	23.73	3.23	2.08	3.46
Quick nutria										
	0	47.03	9.08	6.94	5.76	3.38	15.08	1.75	0.76	9.22
	1	60.73	25.67	11,68	9.64	7.29	25.03	3.84	2.54	2.90
	2	60.43	24.93	13.00	10.08	7.59	24.97	3.58	2.31	3.07
	3	63.17	29.27	13.06	10.34	7.77	25.17	3.65	2.47	2.88
	LSD(0.05)	8.32	7.44	3.84	3.38	1.87	5.06	1.07	0.88	3.84

Table 6. Effect of fertilizer levels and soaking periods on growth, yield components and seed yield of peanut.

Concentration (mL L^{-1})	Soaking periods (h)	Plant height (cm)	Root fresh wt (g)	Root dry wt (g)	Root length (cm)	LAI	Number of pods	Number of seeds	Yield (t/ha)	Water use efficiency (m^3 kg^{-1})
0	0	45.25	8.95	6.87	5.71	3.35	14.55	1.71	0.73	9.66
	12	46.35	9.00	6.89	5.73	3.36	14.75	1.72	0.74	9.53
	24	47.20	9.05	6.92	5.75	3.37	15.15	1.75	0.76	9.21
	36	48.65	9.15	6.93	7.9	3.39	15.60	1.78	0.79	8.92
1	0	45.25	8.95	6.87	5.71	3.35	14.55	1.71	0.73	9.66
	12	55.70	13.50	8.20	6.87	5.20	22.75	2.91	1.82	3.92
	24	58.70	18.50	9.46	8.42	6.25	23.80	3.41	2.23	3.26
	36	62.45	28.50	12.61	9.96	7.39	25.05	4.09	2.78	2.65
2	0	45.25	8.95	6.87	5.71	3.35	14.55	1.71	0.73	9.66
	12	57.50	13.75	8.80	7.74	5.34	23.40	3.07	1.95	3.67
	24	59.80	19.00	9.96	9.27	6.73	24.65	3.45	2.25	3.21
	36	62.45	27.80	14.81	10.29	8.13	24.85	3.62	2.33	3.05
3	0	45.25	8.95	6.87	5.71	3.35	14.55	1.71	0.73	9.66
	12	57.55	15.30	8.84	7.80	5.73	23.60	3.24	2.12	3.42
	24	61.70	20.30	10.01	9.41	6.75	24.85	3.53	2.36	3.09
	36	64.20	31.70	14.42	10.53	8.21	24.90	3.57	2.36	3.01
	LSD(0.05)	12.32	7.89	3.44	2.18	1.07	4.23	0.87	0.58	2.04

Table 7. Effect of fertilizers, soaking periods and fertilizer concentrations on growth, yield components and yields of peanut

Fertilizer	Concentration ($mL\ L^{-1}$)	Soaking periods (h)	Plant height (cm)	Root fresh wt (g)	Root dry wt (g)	Root length (cm)	LAI	Number of pods	Number of seeds	Yield (t/ha)	Water use efficiency ($m^3\ kg^{-1}$)
Sangral	0	0	45.00	8.90	6.82	5.70	3.34	14.50	1.70	0.72	9.72
		12	46.20	9.00	6.84	5.72	3.35	14.70	1.71	0.73	9.59
		24	47.10	9.00	6.88	5.74	3.36	15.10	1.74	0.75	9.33
		36	48.50	9.10	6.89	5.77	3.38	15.50	1.77	0.77	9.09
	1	0	45.00	8.90	6.82	5.70	3.34	14.50	1.70	0.72	9.72
		12	54.70	10.0	7.52	5.80	4.40	21.50	2.54	1.59	4.41
		24	56.20	11.4	7.93	6.90	5.24	22.60	2.91	1.82	3.85
		36	60.60	22.0	10.04	8.86	7.23	24.00	3.84	2.59	2.70
	2	0	45.00	8.90	6.82	5.70	3.34	14.50	1.70	0.72	9.72
		12	56.80	10.0	7.81	6.81	4.64	22.50	2.67	1.67	4.19
		24	59.60	15.0	8.83	7.81	5.63	23.80	2.98	1.86	3.76
		36	61.80	21.4	10.23	9.72	7.42	24.60	3.86	2.60	2.69
	3	0	45.00	8.90	6.82	5.70	3.34	14.50	1.70	0.72	9.72
		12	56.10	10.0	7.83	6.79	4.74	22.80	2.78	1.74	4.02
		24	59.20	14.8	8.91	7.88	5.09	23.90	3.03	1.89	3.70
		36	62.10	22.0	10.63	9.76	8.24	24.50	3.89	2.62	2.67
Quick nutria	0	0	45.00	8.90	6.82	5.70	3.34	14.50	1.70	0.72	9.72
		12	46.50	9.00	6.93	5.74	3.37	14.80	1.73	0.74	9.46
		24	47.30	9.10	6.95	5.76	3.38	15.20	1.76	0.77	9.09
		36	48.80	9.20	6.97	5.80	3.40	15.70	1.78	0.80	8.75
	1	0	45.00	8.90	6.82	5.70	3.34	14.50	1.70	0.72	9.72
		12	56.70	17.0	8.87	7.93	6.00	24.00	3.27	2.04	3.43
		24	61.20	25.0	10.98	9.94	7.25	25.00	3.91	2.63	2.66
		36	64.30	35.0	15.18	11.05	8.63	26.10	4.34	2.96	2.60
	2	0	45.00	8.90	6.82	5.70	3.34	14.50	1.70	0.72	9.72
		12	58.20	17.60	9.79	8.66	6.11	24.30	3.46	2.23	3.13
		24	60.00	23.00	11.09	10.73	7.82	25.50	3.92	2.64	2.65
		36	63.10	34.20	18.12	10.86	8.84	25.10	3.37	2.05	3.41
	3	0	45.00	8.90	6.82	5.70	3.34	14.50	1.70	0.72	9.72
		12	59.00	20.60	9.85	8.81	6.73	24.40	3.69	2.49	2.81
		24	64.20	25.80	11.11	10.93	8.41	25.80	4.02	2.82	2.48
		36	66.30	41.40	18.21	11.29	8.17	25.30	3.24	2.09	3.35
	LSD(0.05)		N.S	7.13	4.55	2.91	1.67	5.44	1.22	0.77	0.67

concentrations × soaking periods showed that the highest water use efficiency (2.48 m^3 kg^{-1}) was recorded when the seeds were soaked in Quick nutria solution at 3 ml L^{-1} for 24 h compared to absolute control treatment which gave the lowest results of the same variable.

DISCUSSION

The availability of nutrients for the plant may determine growth, yield and yield components of peanut. Root proliferation and specific functional responses depend on the prevailing nutrient status of the plant (Lopez et al., 2003). In this experiment, there was a higher proportion of root biomass when using Quick nutria than Sangral fertilizer. This coincided with an increase in root parameters including root length, and, fresh and dry weights. These findings are in agreement with the reports from the studies conducted by Neumann and Martinoia (2002) on model plants to determine the effects of nutrient stress on root development which suggested that white lupin (*Lupin usalbus* L.) formed protein in roots and increased their absorptive surface. Shujie and Yunfa (2011) reported that an increase in the measured root parameters coupled with H^+ released by roots were the key mechanisms with high-P efficiency to cope with low P conditions when plant were grown in solution. However, in the present experiment, root length, root fresh and dry weights and LAI of peanut grown in 3 ml L^{-1} were larger than those of plants grown in untreated or non-soaked seeds. Obtained study conducted by Gohari and Niyaki (2010) found that 4.5 g L^{-1} iron (6 m^2) and 60 kg N ha^{-1} was the most suitable fertilizer management for peanuts which gave high yield. In a similar trend, soaking the seeds for 36 h gave the best results in this study. This indicates that peanut plants respond differently to fertilizer sources, concentrations and soaking periods. This signifies the importance of N for plant growth and increased yield responses (Okito et al., 2004). Similar findings have also been reported in other legumes (Achakzai and Kayani, 2004; Achakzai and Bangulzai, 2006).

Peanut plants whose seeds were soaked with Quick nutria solution were superior in terms of number of pods per plant, and the yields of pods and seeds compared to those soaked with Sangral fertilizer. Seeds soaking in fertilizer solutions increased these parameters attributed largely to the greater fertilizer-use efficiency than non-soaked seeds. Seed soaking produced large LAI which probably intercepted the photosynthetically active radiation (PAR) resulting in increased photosynthesis efficiency and export of more metabolites from the sources or leaves to the sinks or the pods and seeds. In addition, the increase in number of pods per plant reflects the increase in the yield of pods and seeds. Challaraj et al. (2010) observed a significant increase in plant biomass and total chlorophyll content when the seeds of peanut were soaked in rare earth elements (REE) solution. Shafinazir et al. (2000) found that pre-sowing wheat seeds steeping in aqueous solution of different micronutrients produced significantly the highest grain yield on account of significant improvement in the various yield components. Nasr-Alla et al. (1998) reported that increasing the rate of NP individually or in combination increased the crop growth and yield characters. Bala et al. (2011) reported that pod yield was positively influenced by a combination of NPK rates because of the benefit of a large growth period and a longer vegetative phase. The positive response of groundnut pod and seed yields to P application had been reported by Naab et al. (2009). However, the findings of this study are in contrary to those of Hossain et al. (2007) and Bala et al. (2011) who found insignificant influence of N and P fertilizers on seed yield in groundnut.

The findings of this study also show that the reliable and valuable interaction effects were obtained from fertilizer × concentrations, fertilizer × soaking periods, concentrations × soaking periods, or fertilizer × concentrations × soaking periods for all of the studied variables except plant height. These interactions are based on the suitability and high response of peanut to seeds soaking in the fertilizer solutions. These increases may be attributed to the balanced N and P components, and Mg, as well as to the reliable role of P for encouraging metabolic processes and consequently increasing dry matter. These results support those obtained by Nasr-Alla et al. (1998). Singh et al. (2008) also reported positive and significant association of water use efficiency (WUE) with total dry matter in groundnut while in Indian mustard it had positive association with seed yield per plant and dry matter per plant.

CONCLUSION

The findings of the present study have practical implications because pre-sowing seed treatment with fertilizer such as Sangral and Quick nutria solutions enhance growth, yield and yield components of crops. It was also realized that the effect of Quick nutria is superior to Sangral fertilizer on all measured traits of peanut plants. Furthermore, strong interaction was shown between fertilizers and their concentration in different seeds soaking periods ranging from 12 to 36 h. The practice of pre-sowing soaking of the seeds in Sangral and Quick nutria solutions is a simple economical approach to improve seedlings establishment, growth and yield of peanut plant.

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