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Effect of phosphorus, manganese and growth regulator (NAA) on yield and uptake of nutrients by cowpea (*Vigna unguiculata*)

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ABSTRACT

The field experiments were conducted during *kharif* seasons of 2008 and 2009 at the research farm of RBS College, Bichpuri, Agra to study effect of phosphorus, manganese and growth regulator (NAA) on yield and uptake of nutrients by cowpea [*Vigna unguiculata* (L.) Walp]. Result of the experiment revealed that an application of phosphorus @ 60 kg/ha recorded significantly higher plant height (42.70, 44.30 cm), green foliage (178.50,181.50 kg/ha), dry matter yield (19.64, 20.52 q/ha), content N(1.12, 1.13 %) P (0.18, 0.19 %) K (1.34, 1.35 %) and Mn (1.19, 1.20 ppm) over the control. Similarly manganese level @ 10 kg/ha also recorded significant effect in increasing all these yields and chemicals composition parameters while NAA also @ (100 ppm NAA) levels of growth regulator was obtained higher growth yield and uptake nutrient by cowpea.

Kew words: Cowpea, Content, Green foliage, Manganese, NAA, Phosphorus, Uptake

Phosphorus is essential element required for plant growth and root development. It is found in every living cell of the plant and animals. It is known to be associated with several vital functions in the plant body such as utilization of sugar and starch, photosynthesis, nucleus formation and cell division. Fat and albumin formation cell organization and transfer of the heredity. The availability of phosphorus form soil to plants depends on the equilibrium adjustment around the root zone.

Manganese one of the essential micronutrients is involved in plants respiration process such as oxidation of carbohydrates to carbon dioxide and water. Manganese also participates in the metabolism of nitrogen. It activates the enzymes, which are directly involved in the synthesis of chlorophyll.

It has been reported that the major effect of saline- sodic environment in root-media reduces the hormone supply form roots to the leaves, consequently resulting into growth inhibition. A number of hormones such as indole acetic acid- IAA, gibberellins- GA and naphthalene acetic acid- NAA (Darra *et al.* 1973) have been found to be useful in minimizing the effects of poor quality water on crop through different ways. The pre-sowing seed soaking in the specified hormones has been found to increase the yield and nutrient uptake under saline environment by Balki and Padole (1982).

Cowpea (*Vigna unguiculata* (L.) Walp) is one of the important fodders in *kharif* seasons in Agra region. It is only of preferable nature fodder for cultivation in adverse climate/ soil conditions of this region. Cowpea contains about 24% protein and is a rich source of calcium and iron. It can also be used as green manure. It acts as cover crop on the soil and protect if form erosion. Besides, cowpea being legume help in building up soil fertility is well known and has been recognized. The benefit has been attributed to the fixation of atmospheric nitrogen through the agencies of bacteria contained in the nodules on the roof of plants.

MATERIALS AND METHODS

The field experiments were conducted at the research farm of R B S College, Bichpuri, Agra during *kharif* seasons of 2008 and 2009. The soils of the experiment field low in available N, medium in P_2O_5, medium in available K_2O and low in available Mn. The treatment combinations composed of four levels of phosphorus (0,20,40 and 60 kg/ha), three levels of manganese (0, 5 and 10 kg/ha) and three levels of growth regulator as NAA (0, 50 and 100 ppm) with three replications in split plot design. Whole amount of potassium was applied as muriate of potash at the time of sowing. The recommended dose of nitrogen, potassium was supplied

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through urea and muriate of potash, respectively. The phosphorus was supplied through single superphosphate.

RESULTS AND DISCUSSION

Growth attributes

The maximum plant height was recorded under highest levels of phosphorus of 2008 and 2009. It is quite clear that there was not significant difference between P2 (40 kg/ha) and P3 (60 kg/ha) levels of mean values of two years the phosphorus levels P1, P2 and P3 resulted 4.14, 10.69 and 14.30% enhancement in plant height over control, respectively. This increase might be due to well-developed root system, which might have helped in increased nitrogen fixation with other nutrients. Similar to these findings Singh *et al.* (2008).

The highest levels of manganese Mn2 (10 kg/ha) proved significantly better over other manganese levels with respect to plant height of cowpea fodder during both the kharif seasons of 2008 and 2009. On the basis of mean data of two years, the manganese levels Mn1 and Mn2 resulted 4.14 and 10.15% enhancement in plant height of cowpea over control (Mn0), respectively.

The maximum plant height was noted under T3 (100 ppm NAA) levels of growth regulator during both the years of experimentation. On the basis of mean data of two years, the growth regulator NAA levels T2 and T3 resulted 6.20 and 12.51% enhancement in plant height of cowpea as compared to control, respectively. In general, the superiority of the growth regulator (NAA) could be arranged as T3>T2>T1 in case of plant height of cowpea. The useful effect of seed soaking treatments with growth regulator on plant height is due to stimulation of elongation of stem and coleoptiles (Thimann 1937). Similar observations were also reported by Kumar (1997), Gupta *et al.* (2006) and Kumawat *et al.* (2010).

YIELD ATTRIBUTES

Green foliage dry matter yield of cowpea

The green foliage and dry matter yield of cowpea significantly affected by phosphorus levels during both the years of experimentation. On the basis of mean data of two years, the phosphorus levels P1, P2 and P3 resulted 10.11, 28.19 and 30.71 percent enhancement in green foliage yield over control, respectively. Although, maximum green foliage and dry matter yield was noted under highest level P3 (60 kg/ha) of phosphorus but it was not significantly better over P2 level (40 kg/ha) of phosphorus. In general, the highest level of manganese (10.0 kg/ha) gave better response in case of green foliage and dry matter yield of cowpea fodder. Like the above, growth regulator (NAA) significantly enhanced the green foliage and dry matter yield of cowpea. The T3 treatment (100 ppm NAA) proved superior in case of green foliage and dry matter yield of cowpea.

NUTRIENT CONTENT

Nitrogen content

It could be inferred form Table 1 that nitrogen content of

Table 1 Effect of different levels of phosphorus, manganese and NAA on growth and yield attributes of cowpea

Treatment	Plant Height (cm)		Green foliage yield (q/ha)		Dry matter yield (q/ha)		N content (%)		P content (%)		K content (%)		Mn content (ppm)	
	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
Phosphorus level														
P_0	42.70	44.30	178.50	181.50	19.64	20.52	1.12	1.13	0.18	0.19	1.34	1.35	1.19	1.20
P_1	44.80	45.80	197.00	199.40	23.73	25.87	1.15	1.17	0.20	0.22	1.37	1.38	1.22	1.23
P_2	48.00	48.30	229.36	232.14	28.48	29.02	1.18	1.20	0.25	0.24	1.40	1.41	1.26	1.28
P_3	49.50	49.94	234.18	236.38	28.94	29.86	1.20	1.23	0.27	0.28	1.42	1.43	1.30	1.34
SEm±	0.541	0.629	2.13	2.02	0.721	0.801	0.0059	0.0048	0.0034	0.0038	0.0048	0.0062	0.017	0.024
CD ($P = 0.05$)	1.55	1.80	6.11	5.80	2.07	2.30	0.017	0.014	0.010	0.011	0.014	0.018	0.05	0.07
Manganese Level														
Mn_0	44.25	45.05	179.10	181.70	19.69	21.71	1.13	1.15	0.16	0.18	1.32	1.34	1.20	1.20
Mn_1	46.10	46.90	209.53	210.83	22.98	24.72	1.16	1.18	0.19	0.21	1.35	1.38	1.25	1.28
Mn_2	49.00	49.36	236.80	240.14	26.47	28.71	1.20	1.21	0.23	0.24	1.39	1.42	1.32	1.34
SEm±	0.574	0.418	1.67	1.86	0.655	0.714	0.0045	0.0042	0.0073	0.0059	0.0076	0.0069	0.011	0.014
CD ($P = 0.05$)	1.65	1.20	4.84	5.33	1.88	2.05	0.013	0.012	0.021	0.017	0.022	0.020	0.03	0.04
NAA level														
T_1	42.65	42.85	193.92	196.68	20.68	22.72	1.14	1.15	0.19	0.19	1.34	1.36	1.18	1.19
T_2	45.30	45.50	220.75	223.05	23.60	25.72	1.17	1.19	0.22	0.22	1.37	1.40	1.22	1.24
T_3	47.90	48.30	226.88	227.82	27.85	28.65	1.20	1.22	0.25	0.26	1.41	1.43	1.26	1.27
SEm±	0.480	0.540	1.59	1.43	0.627	0.746	0.0038	0.0035	0.0066	0.0076	0.0062	0.0059	0.011	0.006
CD ($P = 0.05$)	1.38	1.55	4.55	4.10	1.80	2.14	0.011	0.010	0.019	0.022	0.018	0.17	0.03	0.02

cowpea increased significantly with each increasing doses of phosphorus over control during both the years of experimentation. A critical evaluation of data reflects that the nitrogen content enhanced significantly levels of phosphorus as compared to each preceding lower levels of phosphorus during throughout the experimentation.

The maximum nitrogen content was recorded under highest level of phosphorus P3 (60 kg/ha) during both the seasons of *kharif* 2008 and 2009. Phosphorus being an energy source also plays an important role in protein synthesis. The increase in nitrogen content with phosphorus application was reported by Pathan (2010).

The manganese levels significantly affected the nitrogen content of cowpea during both the years of experimentation. It is noted that each level of manganese proved better in enhancing the nitrogen content of cowpea over control throughout the experimentation. The highest levels of manganese Mn2 (10 kg/ha) gave significantly better performance over rest of the treatments in case of nitrogen content of cowpea during *kharif* 2008 and 2009. Similar results were also reported by Singh (1994) and Tripathi *et al.* (2006).

The nitrogen content of cowpea accelerated significantly by increasing dose of growth regulator (NAA) in comparison to without seed soaking treatment during both the years of experimentation. In general, T3 (100 ppm NAA) treatment found superior over rest of the treatments in case of nitrogen composition of cowpea during both the years of study. This is due to the fact that the pre-sowing seed soaking in the hormones/ growth regulator have been found to increase the nutrient uptake under saline environment by Balki and Gremici *et al.* (2000).

Phosphorus content

Phosphorus content of cowpea increased significantly with increasing doses of phosphorus over control during both the years of experimentation. A critical evaluation of data reflects that the phosphorus content enhanced significantly levels of phosphorus as compared to each preceding lower levels of phosphorus throughout the experimentation. The maximum phosphorus content was recorded under highest level of phosphorus P3 (60 kg/ha) during both the seasons of *kharif* 2008 and 2009. Phosphorus application improves the root system through accelerating various metabolic processes such as cell division, cell development and cell enlargement ultimately increase the uptake of nutrients by plants. Similar results were reported by Pathan (2010).

The manganese levels significantly affected the phosphorus content of cowpea during both the years of experimentation. It is noted that each level of manganese proved better in enhancing the phosphorus content of cowpea over control throughout the experimentation. The highest levels of manganese Mn2 (10 kg/ha) gave significantly better performance over rest of the treatments in case of phosphorus content of cowpea during *kharif* 2008 and 2009.

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Potassium content

It is evident form Table 2 that potassium content of cowpea enhanced significantly with each increasing levels of phosphorus over control during both the years of experimentation. A critical evaluation of data reflects that the potassium content enhanced significantly levels of phosphorus as compared to each preceding lower levels of phosphorus during the experimentation. The maximum potassium content was recorded under highest level of phosphorus P3 (60 kg/ha) during both the seasons of *kharif* 2008 and 2009. Phosphorus being an energy source also plays an important role in protein synthesis. The increase in potassium content with phosphorus application was reported by Pathan (2010).

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Manganese content

Manganese content of cowpea increased significantly with each increasing levels of phosphorus over control during both the years of experimentation. The data also reflects that the manganese content enhanced significantly with increasing levels of phosphorus as compared to each preceding lower levels of phosphorus during throughout the experimentation. The maximum manganese content was recorded under highest level of phosphorus P3 (60 kg/ha) during both the seasons of

Table 2 Effect of different levels of phosphorus, manganese and NAA on N,P,K and Mn uptake in cowpea

Treatment	N uptake (kg/ha)		P uptake (kg/ha)		K uptake (kg/ha)		Mn uptake (kg/ha)	
	2008	2009	2008	2009	2008	2009	2008	2009
Phosphorus level								
P_0	21.99	23.19	3.54	3.90	26.32	27.70	2.34	2.46
P_1	27.29	30.27	4.75	5.69	32.51	35.70	2.90	3.18
P_2	33.61	34.82	6.55	7.26	39.87	40.92	3.59	3.71
P_3	34.73	36.73	7.81	8.36	41.09	42.70	3.76	4.00
SEm±	0.882	0.965	0.376	0.359	0.467	0.655	0.052	0.076
CD (P=0.05)	2.53	2.77	1.08	1.03	1.34	1.88	0.15	0.22
Manganese level								
Mn_0	22.25	24.97	3.15	3.91	25.99	29.09	2.36	2.60
Mn_1	26.66	29.17	4.37	5.19	31.02	34.11	2.87	3.16
Mn_2	31.76	34.74	6.09	6.89	37.32	40.48	3.49	3.85
SEm±	0.480	0.502	0.369	0.436	0.439	0.551	0.132	0.153
CD (P=0.05)	1.38	1.44	1.06	1.25	1.26	1.58	0.38	0.44
NAA level								
T_1	23.58	26.13	3.93	4.32	37.71	30.90	2.44	2.70
T_2	27.61	30.61	5.19	5.66	32.33	36.01	2.88	3.19
T_3	33.42	34.95	6.96	7.45	39.27	40.97	3.51	3.64
SEm±	0.491	0.487	0.425	0.509	0.530	0.592	0.087	0.105
CD (P=0.05)	1.41	1.40	1.22	1.46	1.52	1.70	0.25	0.30

kharif 2008 and 2009. Phosphorus being an energy source also plays an important role in protein synthesis. The increase in manganese content with phosphorus application.

The manganese levels significantly affected the manganese content of cowpea during both the years of experimentation. It is noted that each level of manganese proved better in enhancing the manganese content of cowpea over control during the experimentation. The highest levels of manganese Mn2 (10 kg/ha) gave significantly better performance over rest of the treatments in case of manganese content of cowpea during *kharif* 2008 and 2009. Similar results were also reported by Sharma and Singh (1999) and Akbari *et al.* (2003).

The manganese content of cowpea accelerated significantly by increasing dose of growth regulator (NAA) in comparison to without seed soaking treatment during both the years of experimentation. In general, T3 (100 ppm NAA) treatment found superior over rest of the treatments in case of manganese composition of cowpea during both the years of study.

NUTRIENT UPTAKE

Nitrogen uptake

The phosphorus levels P2 (40 kg/ha) and P3 (60 kg/ha) do not differ significantly during both the seasons of *kharif* 2008 and 2009. This increase in uptake might be due to increased dry matter yield as well as nitrogen content. Similar to these are findings of Singh *et al.* (2008) and Pathan (2010).

Manganese application uptake significantly affected the nitrogen uptake by cowpea fodder crop during the investigation. On the other hand, the nitrogen uptake enhanced significantly with increasing levels of manganese over each preceding lower levels of manganese during both the *kharif* seasons. Comparatively maximum nitrogen uptake was recorded under Mn2 (10 kg/ha) level of manganese during *kharif* 2008 and 2009. The indispensable role of Mn in nitrogen metabolism particularly in the biochemical process involving nitrate reduction and protein synthesis of numerous enzymes systems might account for higher nitrogen content of plants supplemented with manganese application. Hence, increase in uptake of nitrogen may be due to increase in nitrogen content and dry matter yield with manganese fertilization. Our findings are in agreement with those of Nayak *et al*. (2006) and Chandel (2010).

The nitrogen utilization by cowpea increased significantly with each treatment of seed soaking with growth regulator (NAA) as compared with without soaking (T1) treatment during both the years of research experimentation. It is also noted that T3 (100 ppn NAA) treatment showed more beneficial during both the years of 2008 and 2009.The increase in nitrogen uptake with seed soaking treatments may be due to enhanced nitrogen content and dry weight with the use of growth regulator for seed soaking treatments in this experiment. These results are in accordance with those of Darra and Saxena (1974).

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Potassium uptake

The potassium uptake by cowpea increased significantly with increasing doses of phosphorus as compared to control during both the years of experimentation. However, the maximum potassium utilization by cowpea was recorded under highest level (60 kg/ha) of phosphorus but it was not increased significantly as compared to P2 (40 kg/ha) level of phosphorus during both the seasons of *kharif* 2008 and 2009. This increase in uptake might be due to increased dry matter yield as well as potassium content. Similar to these are findings of Kumar *et al.* (2010).

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Manganese uptake

The manganese uptake by cowpea increased significantly with increasing doses of phosphorus as compared to control during both the years of experimentation. The P3 (60 kg/ha) level gave better response over other phosphorus levels in case of manganese utilization by cowpea fodder crop during *kharif* season of 2008 and 2009. This increase in uptake might be due to increased dry matter yield as well as manganese content.

Manganese application significantly affected the manganese uptake by cowpea fodder crop during the investigation. On the other hand, the manganese uptake enhanced significantly with increasing levels of manganese over each preceding lower levels of manganese during both the *kharif* seasons. Comparatively maximum manganese uptake was recorded under Mn2 (10 kg/ha) level of manganese during *kharif* 2008 and 2009. The indispensable role of Mn in nutrient metabolism particularly in the biochemical process involving nitrate reduction and protein synthesis of numerous enzymes systems might account for higher manganese content of plants supplemented with manganese application. Hence, increase in uptake of manganese may be due to increase in manganese content and dry matter yield with manganese fertilization. Our findings are in agreement with those of Singh (1996) and Mishra *et al.* (2006).

The manganese utilization by cowpea increased significantly with each treatment of seed soaking with growth regulator (NAA) as compared with without soaking (T1) treatment during both the years of research experimentation. It is also noted that T3 (100 ppn NAA) treatment showed more fruitful during both the years of 2008 and 2009. The increase in manganese uptake with seed soaking treatments may be due to enhanced manganese content and dry weight with the use of growth regulator for seed soaking treatments in this experiment. These results are in accordance with those of Balki and Padole (1982).

ANALYSIS OF EXPERIMENTAL SOIL AFTER CROP HARVEST

The representative soil samples from the plots were

Table 3 Analysis of experimental soil after crop harvest (mean data of two years)

Treatment	pH	OC (%)	Available plant nutrient			
			N (kg/ha)	P (kg/ha)	K (kg/ha)	Mn (ppm)
Phosphorus level						
P_0	8.1	0.38	218.5	18.3	146.0	3.7
P_1	8.1	0.38	218.8	18.8	145.6	3.8
P_2	8.2	0.38	220.0	19.3	145.2	3.7
P_3	8.0	0.39	221.4	19.7	144.6	3.8
Average	8.1	0.38	219.7	19.1	145.4	3.8
Manganese level						
Mn_0	8.1	0.38	216.3	18.1	145.7	3.5
Mn_1	8.0	0.38	217.1	18.6	145.3	4.0
Mn_2	8.1	0.38	219.0	18.8	144.5	4.3
Average	8.1	0.38	217.5	18.5	145.2	3.9
NAA level						
T_1	8.1	0.38	216.0	18.4	146.0	3.7
T_2	8.1	0.38	216.7	18.8	145.3	3.7
T_3	8.0	0.39	218.2	18.8	144.3	3.6
Average	8.1	0.38	217.0	18.7	145.2	3.7

collected after crop harvest during both the years of experimentation and analysed form pH, organic carbon (OC), available nitrogen, phosphorus, potassium and manganese. The treatment wise mean data of two years have been presented in Table 3 and same have been discussed in the following paragraphs.

Effect on soil pH

The data pertaining to mean value of two years of soil presented in Table 3 show that soil was slightly increased with P2 level but it was decreased to some extent with highest level of phosphorus (P3) in comparison to control. Similar, it was noted lower with manganese (Mn1) and growth regulator (NAA) had no remarkable effect on soil pH. Similarly Singh (1987) did not observe any effect of phosphorus and micronutrient fertilizer application on the pH values of the experimental soil after harvesting of berseem crop.

Effect on organic carbon (%)

The mean values of organic carbon are given in Table 3 that the soil organic carbon was slightly increased (0.39%) with P3 level of phosphorus and T3 level of growth regulator as NAA as compared to initial value (0.38%). In general, phosphorus, manganese and growth regulator (NAA) did not show effect on soil organic carbon.

Effect on available N, P, K and Mn

The mean values of available plant nutrients are given in Table 3 and clearly show that available N and P of soil was slightly higher than initial values under almost all the treatments. Further, the available potassium slightly decreased with phosphorus, manganese and growth regulator (NAA) as compared to initial values, whereas the mean values of manganese was recorded with manganese application.

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