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EFFECTS OF FERTILIZERS ON ROOT AND SHOOT BIOMASS OF *AMARANTHUS*

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ABSTRACT

Urea, potash and super phosphate were used for biomass (Fresh weight) production of amaranth i.e. Amaranthus hybridus Subsp. cruentus var. paniculatus (L.) Thell. Urea shows uniform increasing impact on biomass while potash and superphostate shows different responses which are promotory as well as inhibitory. Uniformly increased biomass was observed in urea treatment in root and shoot while superphosphate only in shoot. Inhibitory effect was observed in potash where biomass decreased with increasing concentration of treated plnts. Relative effectiveness was, urea > superphosphate > potash found as per total biomass.

KEY WORDS

Amaranthus hybridus subsp.cruentus var. paniculatus (L.) Thell., Fertilizers, Pot Culture urea, superphosphate and potash.

INTRODUCTION

Amaranth is a common name of the genus *Amaranthus* of the family Amaranthaceae. Most of the species are summer weeds and are called as pigweed. Many species are cultivated for leaf vegetables, grain and ornamental purpose. *Amaranthus hybridus* subsp.*cruentus* var. *paniculatus* (L.) Thell is important cultivated species of the genus *Amaranthus* which is locally known as 'ramdana' or 'rajgira'. There are 87 species of *Amaranthus* distributed worldwide. (Mujica and Jacobsen, 2003).

Amaranth (C_4 plant) plant species are distinguished by a significantly high dry matter yield potential in comparison with the C_3 plant. It is known for its significantly high yield as well as quality. Some of the species are becoming an increasingly important resource for healthy food (seeds nutritional value); the unprocessed biomass is used primarily as fodder in many countries but especially by Central America and India, who were the original cultivators (Viglasky *et al.*, 2009).

Plant nutrients are the chemical elements that are essential to the nourishment of plant health. Each plant nutrient performs the crucial role in plant growth and development. The primary plant nutrients are Nitrogen (N), Phosphorus (P) and Potassium (K). These essential elements are required by plants in higher quantities than secondary and micronutrients. Nitrogen is essential for building proteins, produces carbohydrates and is essential for plant cell division (growth). Phosphorus effects root growth, seed formation and plant maturity.

Urea (carbamide) is an organic compound. Urea has the highest nitrogen content of all solid nitrogenous fertilizers in common use. More than 90% of world industrial production of urea is destined for use as a nitrogen release fertilizer. Potash refers to potassium compounds and potassium bearing materials, the most common being potassium chloride (KCl). Potassium is important in disease resistance, fruit formation and effects plant enzymes. Superphosphate or single superphosphate (SSP) was the first commercial mineral fertilizer and it led to the development of the modern plant nutrient industry. It is an excellent source of three plant nutrients namely P, Ca and S. The availability of nutrients affects the plant growth. It is possible to generalize about the response of plants to limited amount of most nutrients. However, there are species and community specific responses and adaptations that enable plants to cope with specific nutrient limitations. Additional nutrients like urea, potash, superphosphate, NPK and farm-yard manure requirement depend on soil fertility status. These may influence the biomass productivity. The present study reveals the analysis of urea, potash and super phosphate fertilizers impact on biomass production in pot culture experiment.

MATERIALS AND METHODS

Seeds of *Amaranthus hybridus* subsp.*cruentus* var. *paniculatus* (L.) Thell. were shown after taxonomic confirmation of species by Botanical Survey of India, Jodhpur, Rajasthan. Pot culture experiments were carried out with seeds, which are small and lenticular in shape. The random amount of seeds was used in experiment. Plants were grown under natural environmental conditions in earthen pot of 28×28×16 cm. size. Each pot was filled with seven kilogram of garden soil of Department of Botany, University of Rajasthan, Jaipur (India). The soil was amended with different fertilizers, namely, urea, super phosphate and potash in ratio of 0.01 g/kg, 0.02 g/kg 0.03 g/kg and 0.05 g/kg. For each treatment three replicates were used. A set of pots without any additives served as control. Pots were irrigated manually using watering cans regularly i.e. every day. After every 15 days the data regarding biomass (fresh weight) were recorded up to three and half month (105 days) and statistically analyzed. Every 15 days interval was considered as a period. Vegetative growth and flowering and fruiting were observed during experiment.

RESULTS AND DISCUSSION

Amaranths are the important pseudo cereal and distributed worldwide. Many species are useful as green vegetable, food and fodder crops. The role of fertilizers namely urea, superphosphate and potash on plant biomass (fresh weight) in amaranths were analyzed in pot culture experiment. Fertilizer is substances which improve the growth and productivity of plant. Fertilizers may be biological or natural and chemical or artificial (usually contain nitrogen, phosphorus and potassium compounds) substance in origin.

Urea is a stable and organic fertilizer that can improve the soil quality and yield. Urea is the synthetic fertilizer having nitrogen (46%). In *Amaranthus caudatus* optimum grain yields obtained at plant densities of about 450,000 plants per hactare and fertilizer levels of 100N-138P-180K (Sumar-Kalinowsky *et al.,* 1992). Ghos and Chattopadhyay (1999) reported increasing effect of urea on mango fruits yield. Myers (1998) observed the effect of nitrogen fertilizer on *Amaranthus* species grain yield, growth and development increase up to 42% as compare to control. Highest yield and best quality in tobacco were obtained by applying 75 kg/ha nitrogen (Cai and Qian, 2003). In amaranthus increasing concentration of urea increase the biomass root and shoot. Presently in *A. hybridus* subsp. *cruentus* var. *paniculatus* gradually increased biomass yield obtained. The initial fresh weight (i.e. 0.09g) of the roots of control plants is least whereas in the soil amended with 0.05g /kg of urea was more than four times (i.e.0.41g) in the first period. In last period it increased up to 13.10g from 2.35g. (Table 1 and Pl.1).

Table-1: Effect of urea on root biomass (fresh weight) of *A. hybridus* subsp. *cruentus* var. *paniculatus*..

Conc.	Biomass (Fresh weight) in gm per plant						
	I	II	III	IV	V	VI	VII
0.00 g/kg	0.09	0.19	0.92	1.23	1.90	2.25	2.35
0.01 g/kg	0.18	0.35	0.75	1.40	1.98	2.96	3.05
0.02 g/kg	0.26	0.73	1.44	2.53	4.60	4.95	5.63
0.03 g/kg	0.37	0.61	1.19	4.05	6.77	8.04	8.90
0.05 g/kg	0.41	0.81	1.45	6.48	11.69	12.11	13.10

Analysis of variance

Source of variation	DF	SS	MSS	F-ratio
Conc. within 0.00g/kg	6	12.1332	2.0222	12.03**
Conc. within 0.01 gm/kg	6	20.6634	3.4439	20.54**
Conc. within 0.02 gm/kg	6	76.9221	12.8203	76.32**
Conc. within 0.03 gm/kg	6	215.0174	35.8362	213.35**
Conc. within 0.05 gm/kg	6	547.4674	91.2445	543.21**
Between concentrations	4	429.7864	107.4466	639.56**
Error	70	11.7573	0.1679	

**** Highly significant**

The shoot biomass (fresh weight) gradually increased in both control and treated plants. It is increased more than three times as compared to control. Fourth period revealed the highest growth in fresh weight. Concentration of 0.02, 0.03, and 0.05 g/kg urea showed similar data at second and third period. Best growth performance was found at fourth period (Table 2 and Pl.1). Immobilization of nitrogen by microorganisms followed by a net nitrogen mineralization, which was mostly favorable for the growth and development of plant (Zhang *et al*., 2002). Shoot growth in *Agave lechuguilla* dry matter productivity enhanced applications of N and P (Quero and Nobel, 1987 and Nobel *et al.,* 1988). Increase in biomass with concentration up to 0.05g/kg of soil in *Amaranthus palmeri* reported by Mohil and Jain (2012).

Table-2: Effect of urea on shoot biomass (fresh weight) of *A. hybridus* subsp. *cruentus* var. *paniculatus.*

Conc.	Biomass (Fresh weight) in gm per plant						
	I	II	III	IV	V	VI	VII
0.00 g/kg	1.62	2.32	4.46	9.20	14.05	16.02	16.80
0.01 g/kg	1.82	2.76	5.38	11.66	21.32	22.25	22.37
0.02 g/kg	2.01	4.03	8.44	19.57	37.58	39.17	40.33
0.03 g/kg	2.18	4.56	8.19	24.10	41.91	44.45	46.76
0.05 g/kg	2.31	4.68	8.13	27.68	43.22	47.71	48.35

Analysis of variance

Source of variation	DF	SS	MSS	F-ratio
Conc. within 0.00g/kg	6	844.5467	140.7578	1.82^{NS}
Conc. within 0.01 gm/kg	6	1592.7621	265.4603	3.43**
Conc. within 0.02 gm/kg	6	5313.9311	885.6551	11.44**
Conc. within 0.03 gm/kg	6	7087.9098	1181.3183	15.23**
Conc. within 0.05 gm/kg	6	7615.1304	1269.1884	16.41**
Between concentrations	4	4982.4819	1245.6201	16.10**
Error	70	5414.9327	77.356	

NS Non-significant; ** Highly significant

Superphosphate is a synthetic fertilizer having good percentage of phosphate and it becomes source of phosphorus for plants. In present study superphosphate shows variable effect. For the root fresh weight, initial concentration (0.01g) shows slight increase up to second period after second period results are inferior to control. Higher concentration of superphosphate in root, first period reveal enhancing effect i. e. 0.20g as compared to control (0.09g). Same trend found up to VIIth period. Best growth was observed for shoot at fifth period except 0.01g concentration which lower to control. Data regarding statistical analysis for both the plants, both for root and shoot found to the highly significant. (Table 3 & 4 and Pl. 2B). Zhu et al., (2001) investigated phosphorus and zinc interactions in two wheat cultivars (brookton versus krichauff) differing in Phosphorus uptake efficiency. Availability of Phosphorus is affected by plant biomass production, but Zn supply had little effect but in smooth pigweed (*Amaranthus hybridus*) increased concentration of phosphorus did not affect the biomass (Bielinski *et al.*, 2003). In *Mucuna pruriens* 40kg per hectare Phosphorus treatment resulted in significant increases in biomass, pod yield and pod quality as compared to control (Shoko et al., 2010). Said-Al Ahl and Hussien (2016) studied the effects of phosphorus fertilizer on dry matter of *Satureja montana* were significantly increased with the rise phosphorus fertilizers. Mohil and Jain (2012) also reported the enhancing effect on biomass of superphosphate in *Amaranthus palmeri*.

Table-3: Effect of superphosphate on root biomass (fresh weight) of *A. hybridus* subsp. *cruentus* var. *paniculatus.*

Conc.	Biomass (Fresh weight) in gm per plant						
	I	II	III	IV	V	VI	VII
0.00 g/kg	0.09	0.19	0.92	1.23	1.90	2.25	2.35
0.01 g/kg	0.15	0.28	0.57	0.85	0.99	1.24	1.51
0.02 g/kg	0.16	0.29	0.42	1.87	3.11	3.66	3.92
0.03 g/kg	0.17	0.35	0.62	2.25	5.04	5.81	6.12
0.05 g/kg	0.20	0.40	0.75	3.00	5.95	6.13	6.63

Analysis of variance

Source of variation	DF	SS	MSS	F-ratio
Conc. within 0.00g/kg	6	12.1332	2.0222	37.58**
Conc. within 0.01 gm/kg	6	31.8527	5.3087	98.67**
Conc. within 0.02 gm/kg	6	30.0084	5.0014	92.93**
Conc. within 0.03 gm/kg	6	10.0523	1.6753	31.14**
Conc. within 0.05 gm/kg	6	6.3489	1.0581	19.67**
Between concentrations	4	14.1259	3.5314	65.63**
Error	70	3.7661	0.0538	

**** Highly significant**

Table-4: Effect of superphosphate on shoot biomass (fresh weight) of *A. hybridus* subsp. *cruentus* var. *paniculatus.*

Conc.	Biomass (Fresh weight) in gm per plant						
	I	II	III	IV	V	VI	VII
0.00 g/kg	1.62	2.32	4.46	9.20	14.05	16.02	16.80
0.01 g/kg	1.62	3.45	6.40	8.26	10.21	11.83	13.17
0.02 g/kg	1.64	2.88	5.40	13.95	26.92	27.21	28.30
0.03 g/kg	1.75	2.97	5.34	22.25	42.44	44.81	48.97
0.05 g/kg	1.55	3.00	4.58	35.00	67.07	70.01	69.93

Analysis of variance

Source of variation	DF	SS	MSS	F-ratio
Conc. within 0.00g/kg	6	844.5467	140.7578	99.70**
Conc. within 0.01 gm/kg	6	708.4849	118.0808	83.63**
Conc. within 0.02 gm/kg	6	798.3711	133.0618	94.25**
Conc. within 0.03 gm/kg	6	691.4852	115.2475	81.63**
Conc. within 0.05 gm/kg	6	634.3108	105.7184	74.88**
Between concentrations	4	132.8341	22.1390	15.68**
Error	70	98.8248	1.4117	

**** Highly significant**

Potash is general term used for potassium fertilizer. Potassium is an important mineral and required for plant as well as human health. It must be adequate in the soil to maintain good growth. Availability of potassium can affect yield, quality, water utilizing efficiency and susceptibility to pest and disease damage. Gupta and Malhotra (1997) concluded that sufficient potassium is needed in biomass productivity and epicuticular wax deposition in *Euphorbia antisyphilitica*. Adequate potassium related maximization in biomass was recorded in *Euphorbia antisyphilitica* (Johari and Kumar, 1992). Kuiper *et al.,* (1989) using *Plantago major* var. *pleiosperma*, demonstrated that low levels of nitrogen, phosphorus and calcium resulted in reduced concentrations of zeatin and zeatin riboside (cytokinin) in shoots and roots. Reduced nitrogen levels were viewed as being the primary effect or of reduced growth.

Presently potash treatments showed negative responses for root, as well as shoot biomass. With increasing in concentrations of potash where fresh weight gradually decreased. Lower concentration of potash (0.01g/kg soil) was found to be more or less equal to control. Among periods, IVth period for root and Vth period for shoot gave the best results (except in control, period IIIrd for root and IVth for shoot).Periodically maximum increase in fresh weight were found 3.20 times for root and 4.20 times for shoot, more than initial fresh weight at IV th period (Table 5 & 6 and Pl. 1 & 2C) Statistical analysis revealed that root of *A. hybridus* subsp. *cruentus* var. *paniculatus,* control and 0.01 g/kg soil concentration and among concentration for shoot are not significant; remaining data show highly significance for both the plants.

Table-5: Effect of potash on root biomass (fresh weight) of *A. hybridus* subsp. *cruentus* var. *paniculatus.*

Conc.	Biomass (Fresh weight) in gm per plant						
	I	II	III	IV	V	VI	VII
0.00 g/kg	0.09	0.19	0.92	1.23	1.90	2.25	2.35
0.01 g/kg	0.31	0.36	0.39	1.95	2.11	3.01	4.11
0.02 g/kg	0.25	0.52	0.54	0.85	1.91	2.15	3.77
0.03 g/kg	0.19	0.39	0.47	1.25	1.19	1.98	2.26
0.05 g/kg	0.15	0.26	0.32	0.59	0.95	1.15	1.98

Analysis of variance

Source of variation	DF	SS	MSS	F-ratio
Conc. within 0.00g/kg	6	12.1332	2.0222	1.37 ^{NS}
Conc. within 0.01 gm/kg	6	9.7245	1.6207	1.10^{NS}
Conc. within 0.02 gm/kg	6	29.3651	4.8941	3.32**
Conc. within 0.03 gm/kg	6	71.1313	11.8552	8.05**
Conc. within 0.05 gm/kg	6	79.1111	13.1851	8.95**
Between concentrations	4	29.8956	7.4739	5.08**
Error	70	103.0135	1.4716	-

NS Non-significant; ** Highly significant

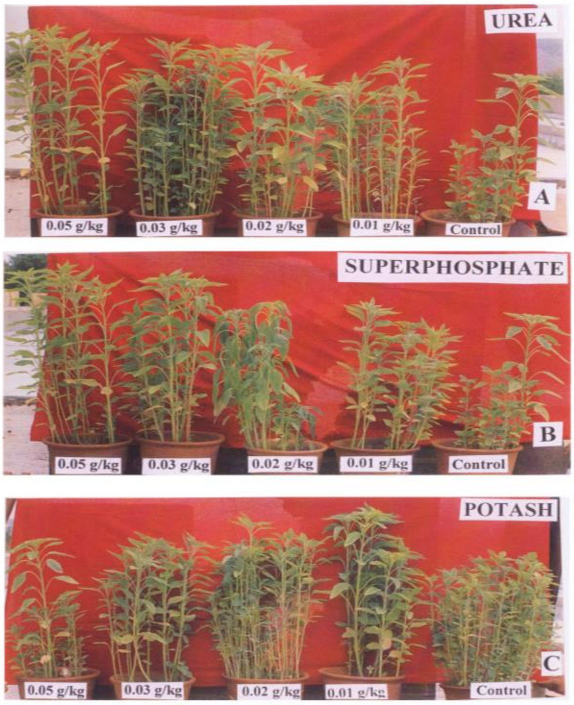
Table-6: Effect of potash on shoot biomass (fresh weight) of *A. hybridus* subsp. *cruentus* var. *paniculatus.*

Conc.	Biomass (Fresh weight) in gm per plant						
	I	II	III	IV	V	VI	VII
0.00 g/kg	1.62	2.32	4.46	9.20	14.05	16.02	16.80
0.01 g/kg	2.78	4.95	7.51	8.60	16.17	17.91	18.91
0.02 g/kg	1.54	2.86	5.47	7.85	14.75	16.12	17.81
0.03 g/kg	1.29	2.59	5.00	7.05	14.00	15.18	16.88
0.05 g/kg	0.45	0.82	1.25	6.30	13.11	13.29	14.01

Analysis of variance

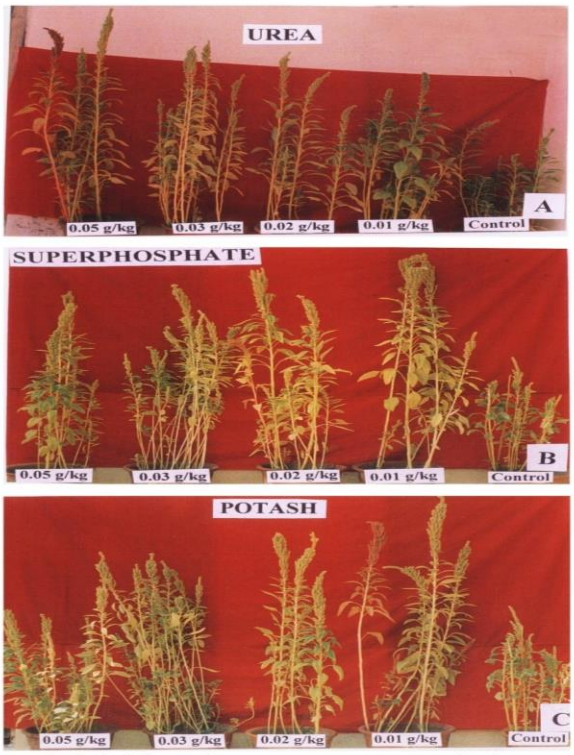
Source of variation	DF	SS	MSS	F-ratio
Conc. within 0.00g/kg	6	844.5467	140.7578	9.89**
Conc. within 0.01 gm/kg	6	333.4408	55.5734	3.90**
Conc. within 0.02 gm/kg	6	838.9346	139.8224	9.83**
Conc. within 0.03 gm/kg	6	892.6085	148.7680	10.46**
Conc. within 0.05 gm/kg	6	940.3378	156.7229	11.02**
Between concentrations	4	120.1077	30.0269	2.11^{NS}
Error	70	995.2962	14.2185	

NS Non-significant; ** Highly significant



A. hybridus **subsp.** ***cruentus*** **var.** ***paniculatus***

Plate: 1 A. Showing the effect of different concentration of urea on biomass at IIIrd period.
B: Showing the effect of different concentration of superphosphate on biomass at IIIrd period.
C: Showing the effect of different concentration of potash on biomass at IIIrd period.



A. hybridus **subsp.** ***cruentus*** **var.** ***paniculatus***

Note: Only vegetative growth observed

Plate: 2A: Showing the effect of different concentration of urea on biomass at VIth period.
B: Showing the effect of different concentration of superphosphate on biomass at VIth period.
C: Showing the effect of different concentration of potash on biomass at VIth period.

Note: Flowering and Fruiting observed

It has been found that inorganic fertilizers viz. urea, potash and super phosphate were used and among them urea show uniform increasing effect in root and shoot biomass while potash and superphostate show different responses which are promotory as well as inhibitory. No specific trend has been found using potash and super phosphate while urea shows this. In general, relative effectiveness of used organic and inorganic manure may sequenced as urea > superphosphate > potash were observed in the plants for root as well as shoot fresh weight. It is found that flowering and fruiting time were changed i.e. September-November to July and August. This may be due to fertilizers or regular irrigation.

CONCLUSION

Amaranthus (C_4 plant) plant species are distinguished by a significantly high yield potential in comparison with the C_3 plant. To increase the fresh weight urea can be used due to its uniformly increasing trend. Superphosphate also follows the same trend. Potash is not found suitable for the purpose.

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