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Inorganic Fertilizers and Cultivar Effects on Growth, Yield, Economics and Nutrient Dynamics of Grain Amaranth (*Amaranthus hypochondriacus* L.)

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Abstract

A field experiment entitled Inorganic fertilizers and cultivar effects on growth and nutrient dynamics of grain amaranth (*Amaranthus hypochondriacus* L.) was conducted at University of Agricultural Sciences, GKVK, Bengaluru during *kharif* 2021-22. The soil of the experimental field was sandy loam texture lower in organic carbon and medium in available nitrogen, phosphorous and potassium. The experiment was laid out in a Factorial Randomized Complete Block design (FRCBD) with five cultivars as factor A and three levels of in organic fertilizers as factor B replicated thrice with 15 treatment combinations. Results revealed that cultivar G_2 (SKNA-808) has recorded significantly higher plant growth (207.25 cm), leaf area index (1.19), nutrient uptake *i.e.,* nitrogen (99.64 kg ha^{-1}), phosphorous (41.23 kg ha^{-1}) and potassium (45.36 kg ha^{-1}) and grain yield (1839 kg ha^{-1}). Among the fertilizer levels, application of 125 per cent RDF has recorded significantly higher plant growth (198.23 cm), leaf area index (1.13), nutrient uptake *i.e.,* nitrogen (93.47 kg ha^{-1}), phosphorous (36.38 kg ha^{-1}) and potassium (42.81 kg ha^{-1}) and grain yield (1802 kg ha^{-1}). Higher available soil nitrogen, phosphorous and potassium (188.34 kg ha^{-1}, 43.05 kg ha^{-1} and 284.34 kg ha^{-1}) was observed in G_1 (SKGPA-61).

Keywords : Growth and yield of grain amaranth, Cultivars, Inorganic fertilizer, Nutrient uptake

Currently, global population is expected to rise up to 9.5 billion by 2050. To feed increasing population there is a need to achieve food and nutritional security. It is possible with diversified cropping pattern and revival of indigenous and nuti-rich potential crops such as grain amaranth, quinoa, chenopodium, buck wheat etc. Grain amaranth (*Amaranthus hypochondriacus*) termed as 'pseudocereal' characterized as a plastic plant due to its high adaptability to abiotic stress. Being a nutrient-rich potential crop, it is suitable for semi-arid and seasonal wet areas with poor soils. Orphan crop *i.e.,* grain amaranth nutrient composition includes calcium (27.5 - 206 mg/100g), zinc (0.8 - 5.2 mg/100g), lysine (2.4 - 8.6 mg/100g) and crude protein (9.1 - 21.5 mg/100g) Coelho *et al*., 2018. The bio-active compounds in these grains are phenols, phytosterols, phytoedysteroids and betalains. The growing demand for high-quality, nutrient-dense gluten-free products has led to an increase in the use of grain amaranth in gluten-free food formulations.

In India, grain amaranth is frequently referred to as Ram Dana or Rajgirah (King seed). It is widely spread and available in the form of 70 species (as cultivated plants or cosmopolitan weeds) that are found over all tropical and subtropical parts of the world, including Argentina, Sierra Leone, Nigeria, Zambia, Kenya and Egypt, it originated in Central and South America. It is grown across the Himalayan region, Southern India, certain areas of Gujarat, Maharashtra, Orissa and eastern Uttar Pradesh, as well as in plains and mountains. The Grain amaranth is grown on 40,000-10,000 acres, yet precise data on productivity and area is lacking. The crop covers over 10,000 hectares in the Banaskantha district of Gujarat alone. In the Chamarajnagara district of Karnataka, BR hills tribal groups cultivate a crop that is not well-known to farmers. Therefore, there is a need to raise awareness of this crop's benefits.

In order for expanding organs to absorb and transport, nitrogen (N) is crucial. One of the primary building blocks of organic molecules, including proteins, nucleic acids and amino acids is N. N appears to preserve the survival of the leaf surface; as the durability of the leaf surface rises, so do the length and rate of photosynthesis, which enables the plant to create more dry matter. Phosphorous promotes better root development, flowering and fruit production in addition to aiding in the synthesis of nucleic acids like DNA and RNA. Potassium is vital for translocation and control of stomata's opening and shutting. Lack of K causes a decrease in the absorption of photosynthetic carbon, which eventually slows plant development and lowers output.

MATERIAL AND METHODS

The field experiment was conducted at 'M' block, field unit of AICRN on Potential Crops, University of Agricultural Sciences, Bangalore. The experiment was laid out in a Factorial Randomized Complete Block Design (RCBD) replicated thrice with 15 treatment combinations during *kharif* 2021-22. Factor A consisted of five cultivars among them G_1 (SKGPA-61), G_2 (SKNA -808), G_3 (VL -115) are testing cultivars whereas, G_4 (Suvarna) and G_5 (KBGA-4) are National and Local check, respectively and factor B consisted of three fertilizer doses F_1 (75% RDF), F_2 (100% RDF) and F_3 (125% RDF). Crop was supplied with recommended dose of fertilizer *i.e.,* 60 kg of N, 40 kg of P_2O_5 and 40 kg of K_2O ha^{-1} in the form of urea, 20:20:0:13 and murate of potash (MOP), respectively. Entire dose of phosphorous, potassium and half dose of nitrogen was applied as basal dose and remaining was top dressed. Five plants selected from the net plot area which were used for recording the growth observations were harvested separately and utilized for recording of yield observations.

The representative soil samples (0-15 cm depth) from five spots of each plot before sowing and after the harvesting of amaranth crop was collected, composed and air dried. The samples were powdered using a wooden mortar and pestle later passed through 2 mm sieve to the soil samples were stored in polythene lined cotton bags for further analysis. These soil samples were used for the estimation of soil chemical properties.

The pH value was recorded using pH meter (Jackson, 1973) and expressed in 0-14 scale. The electrical conductivity of the supernatant solution was measured with using Electrical Conductivity Bridge and expressed in dS m^{-1}. Organic carbon content of soil samples was determined by Walkley and Black - wet digestion method. Alkaline potassium permanganate method was used to determine the available nitrogen in the soil as described by Subbaiah and Asija (1956). Available phosphorus in soil was determined by brays method (chloro-stannous reduced molybdo-phosphoric blue colour method) in HCl system (Jackson, 1973) as soil was having acidic pH. Neutral normal ammonium acetate at 1:5 :: soil:extractant ratio was used to extract available potassium in soil and its concentration in the extract was determined by flame photometry as described by Jackson (1973). Plant samples were collected from each treatment at harvest. The samples were oven dried at 60^0C and grinded into fine powder by using mixer and preserved in polythene bags for further analysis of Nitrogen, Phosphorous and Potassium content.

RESULTS AND DISCUSSION

Growth Parameters

The data relevant to plant height of grain amaranth at different growth stages as influenced inorganic fertilizer levels on growth parameters of various promising cultivars are depicted in Table 1. The data clearly shows that plant height steadily increases with increase in age of the plant irrespective of treatments imposed. The extent of increase was higher between 30 to 60 DAS and lesser during later stages at age of the plant irrespective of treatments imposed. The extent of increase was higher between 30 to 60 DAS and lesser during later stages.

Table 1 shows the plant height and number of functional leaves per plant were impacted by cultivar and fertilizer. Levels at 30, 60 days after sowing (DAS) and at 90 DAS. Varieties differed significantly with respect to plant height and number of functional leaves per plant at all growth phases. Genotype SKNA-808 recorded higher plant height (25.10 cm, 153.76 cm and 207.25 cm at 30, 60 DAS and at 90 DAS, respectively) and number of functional leaves per plant (14.59, 31.47 and 38.02 plant^{-1}, respectively).

However, genotype SKGPA-61 recorded significantly lower plant height (17.61, 124.97 and 171.22 cm at 30, 60 DAS and harvest, respectively) and number of functional leaves per plant (9.18, 15.27 and 25.62

TABLE 1

Plant height and number of functional leaves per plant of Amaranth as influenced by cultivars and levels of fertilizers

Treatments	Plant height (cm)			Number of functional leaves per plant^{-1}		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
Cultivar (G)						
G_1- SKGPA-61	17.61	124.97	171.22	9.18	15.27	25.62
G_2- SKNA-808	25.10	153.76	207.25	14.59	31.47	38.02
G_3- VL-115	23.40	143.60	198.72	13.69	29.51	36.54
G_4- Suvarna	20.35	136.88	185.32	11.68	21.75	32.74
G_5- KBGA-4	18.90	132.32	178.22	10.16	19.20	29.11
F-test	*	*	*	*	*	*
S.Em$\pm$	0.65	3.70	3.62	0.40	0.79	1.11
CD @ 5%	1.88	10.71	10.82	1.16	2.30	3.21
Fertilizer levels (F)						
F_1:75% RDF	19.25	127.88	169.54	10.24	20.46	26.67
F_2:100% RDF	21.47	139.79	191.20	12.23	24.01	34.04
F_3:125% RDF	22.51	147.26	198.23	13.10	25.84	36.51
F-test	*	*	*	*	*	*
S.Em$\pm$	0.50	2.87	2.72	0.31	0.62	0.86
CD @ 5%	1.44	8.30	8.14	0.90	1.78	2.48
Interactions (G x F)						
F-test	NS	NS	NS	NS	NS	NS
S.Em$\pm$	1.12	6.41	7.48	0.70	1.38	1.92
CD @ 5%	-	-	-	-	-	-

plant^{-1} at 30, 60 DAS and harvest, respectively) compared to national check (Suvarna) and local check (KBGA-4).

At all growth stages, fertilizer levels had a substantial impact on plant height and number of functional leaves per plant. Application of 125 per cent RDF resulted in significantly higher plant height than other fertilizer levels (22.51, 147.26 and 198.23 cm at 30, 60 DAS, and at 90 DAS, respectively) and number of functional leaves per plant (13.10, 25.84 and 36.51 plant^{-1} at 30, 60 DAS and at 90 DAS, respectively). However, application of 75 per cent RDF, resulted in noticeably decreased plant height (19.25, 127.88 and 169.54 cm at 30, 60 DAS and at 90 DAS, respectively) and number of functional leaves per plant (10.24, 20.46 and 26.67 plant^{-1} at 30, 60 DAS and harvest, respectively). At various stages of crop growth, it was determined that the interactions between various cultivar and fertilizer amounts were not statistically significant.

The genotype SKNA-808 showed a noticeably increased plant height. This might be because various cultivar responds differently to plant height, due to variations in their inherent genomic potential which is to be expected. Since, a plant growth and development result from the coordinated interaction of its inherited traits and environmental factors. Elbehri *et al.* (1993) and Malligawad (1994) in grain amaranth. Application of higher doses of fertilizers stimulated the plants for greater uptake, assimilation and translocation of elements which reflected in better growth Anand *et al.* (2020).

At every stages of plant growth, leaf area per plant was identified to be statistically significant. Higher leaf area plant^{-1} was exhibited in genotype SKNA-808 at 30, 60 DAS and at 90 DAS (197.46, 2088.49 and 2284.62 cm^2 plant^{-1}, respectively), it was on par with genotype VL-115 (185.23, 2031.72 and 2184.13 cm^2 plant^{-1}, respectively). However, the lower leaf area plant^{-1} were recorded in SKGPA-61 (126.21, 1496.98 and 1536.24 cm^2 plant^{-1}, respectively) at 30, 60 DAS and at 90 DAS. This might be as a result of the considerable differences in cultivar with respect to leaf area, SKNA-808 was found to be superior genotype over the others. This was mainly because the genotype is tall statured and broad leaved which is responsible for intercepting more sunlight, resulted in increased activity of photosynthesis in turn responsible for holding highest leaf area than rest of cultivar. Similar outcomes were also found by Hossen (2017) and Revanth (2020) in amaranth.

Among fertilizer levels application of 125 per cent recommended dose of fertilizer witnessed higher leaf area (183.58, 1991.12 and 2050.60 cm^2 plant^{-1}, respectively) which was on par with 100 per cent RDF (173.42, 1889.30 and 1992.45 cm^2 plant^{-1}, respectively) at 30, 60 DAS and 90 DAS. Significantly, lower leaf area per plant was recorded in treatment applied with 75 per cent RDF (141.88, 1539.21 and 1653.00 cm^2 plant^{-1}, respectively). The results might be because, grain amaranth usually a broad-leaved crop requires increased level of fertilizers containing higher concentration of nutrients especially nitrogen for their luxuriant growth and it was a major contributor in the formation of chlorophyll and there by increases photosynthetic activity resulted in greater leaf area and leaf count per plant. Similar outcomes were also indicated by Dehariya *et al.* (2019); Hossen (2017) and Kushare *et al.* (2010).

Interactions of Cultivar and Fertilizer Levels were found Non-significant at every Phase of Growth. In case of days to 50 per cent flowering is influenced by cultivar and fertilizer levels and their interaction effects were displayed in Table 2. Among the cultivar, SKGPA-61 has taken longer number of days to 50 per cent flowering (52.62 days) significantly, fewer days for flowering was recorded in VL-115 (44.30). This was mainly due to variation in genomic characters. Among fertilizer levels, 125 per cent recommended dose of fertilizer has taken more days to 50 per cent flowering and maturity (48.84 days) which was on par with 100 per cent RDF (47.46 days). However, 75 per cent RDF (45.36 Days) has taken lesser number of days to reach 50 per cent flowering. In case of days to maturity shows nonsignificant.

TABLE 2

Leaf area, days to 50 per cent flowering and days to maturity of Amaranth as influenced by cultivars and levels of fertilizers

Treatments	Leaf area (cm^2 plant^{-1})			Days to 50% flowering	Days to maturity
	30 DAS	60 DAS	90 DAS		
Cultivar (G)					
G_1- SKGPA-61	126.21	1496.98	1536.24	52.62	115.0
G_2- SKNA-808	197.46	2088.49	2284.62	46.89	118.53
G_3- VL-115	185.23	2031.72	2184.13	44.30	116.85
G_4- Suvarna	169.87	1824.34	1915.08	47.11	118.48
G_5- KBGA-4	152.70	1590.74	1623.35	45.18	120.83
F-test	*	*	*	*	NS
S.Em±	5.75	49.12	55.73	0.97	1.10
CD @ 5%				2.80	-
Fertilizer levels (F)					
F_1:75% RDF	141.88	1539.21	1653.00	45.36	119.58
F_2:100% RDF	173.42	1889.30	1992.45	47.46	120.43
F_3:125% RDF	183.58	1991.12	2050.60	48.84	121.43
F-test	*	*	*	*	NS
S.Em±	4.46	38.05	43.17	0.75	0.94
CD @ 5%	12.91	110.22	125.05	2.16	-
Interactions (G x F)					
F-test	NS	NS	NS	NS	NS
S.Em±	9.97	85.08	96.53	1.67	1.75
CD @ 5%	-	-	-	-	-

This could be mainly because, increased dose of inorganic fertilizers especially nitrogen leads to luxuriant vegetative growth which further slowdown the days to reach flowering and maturity in crop. The interaction effects between various cultivar and fertilizer amounts were determined to be insignificant.

Yield attributes and Yield: The data pertaining to grain yield (kg ha^{-1}) of grain amaranth as influenced by cultivars and varied fertilizer levels was presented.in Table 3. Different cultivars significantly influenced the number of inflorescence and grain yield of grain amaranth. Significantly higher number of inflorescence and grain yield was recorded with genotype SKNA-808 (55.72 plant^{-1} and 1839 kg ha^{-1}, respectively) which was on par with genotype VL-115 (54.58 plant^{-1} and1770 kg ha^{-1}, respectively). It was mainly because SKNA-808 exhibits resistance to lodging along with this, the genotype is bearing volumetric panicle, a greater number of fingers with filled grain which further adds to the yield. The above results were similar to the findings of Elbehri *et al.* (1993) and Gimplinger *et al.* (2007). However, lower grain yield per plant was recorded with genotype SKGPA-61 (1296 kg ha^{-1}).

Among different fertilizer levels, 125 per cent RDF application (56.54 plant^{-1} and 1802 kg ha^{-1},

TABLE 3

Yield attribute, grain and stover yield of Grain amaranth as influenced by cultivar and fertilizer levels

Treatments	No. of Inflorescence plant^{-1}	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest Index
Cultivar (G)				
G_1- SKGPA-61	48.75	1296	2879	0.45
G_2- SKNA-808	55.72	1839	3313	0.56
G_3- VL-115	54.58	1770	3302	0.54
G_4- Suvarna	51.85	1720	3294	0.52
G_5- KBGA-4	50.93	1647	3274	0.50
F-test	*	*	*	NS
S.Em±	0.42	55	66	0.001
CD @ 5%	1.25	159	193	-
Fertilizer levels (F)				
F_1:75% RDF	48.32	1472	3039	0.48
F_2:100% RDF	53.40	1688	3271	0.52
F_3:125% RDF	56.54	1802	3327	0.54
F-test	*	*	*	NS
S.Em±	1.11	43	51	0.001
CD @ 5%	4.37	123	149	-
Interactions (G x F)				
F-test	NS	NS	NS	NS
S.Em±	0.73	95	115	0.02
CD @ 5%	-	-	-	-

(a) SKNA-808 (G_2)

(b) SKGPA-61 (G_1)

Plate1: Performance of genotype (a) SKNA-808 (G_2) and (b) SKGPA-61 (G_1) nutrient uptake by Grain amaranth

respectively) recorded higher number of inflorescence and grain yield which was on par with the 100 per cent application of RDF (53.40 plant^{-1} and 1688 kg ha^{-1}, respectively). However, significantly lower number of inflorescence and grain yield was found in treatment applied with 75 per cent RDF (48.32 plant^{-1} and 1472 kg ha^{-1}, respectively). This could be due to sufficient nutrient availability especially upon application of fertilizers might have resulted in better growth and development of crop there by increasing photosynthetic efficiency and production of photosynthates. In turn increased the translocation of assimilates effectively from source to sink. The above results were similar to findings of Khurana *et al.* (2016), Hossen (2017) and Geren (2015).

The stover yield was recorded significantly higher with genotype SKNA-808 (3313 kg ha^{-1}) which were on par with genotype VL-115 (3302 kg ha^{-1}) while the lower stover yield. was recorded in SKGPA-61 (2879 kg ha^{-1}). The above results were similar to findings of Elbehri *et al.* (1993), Gimplinger *et al.* (2007) and Revanth (2020).

Data calculated for Stover yield was numerically higher with application of 125 per cent RDF (3327 kg ha^{-1}) which was on par with 100 per cent RDF application (3271 kg ha^{-1}), While a lower value was obtained with application of 75 per cent RDF (3039 kg ha^{-1}). This could be mainly because, grain amaranth being a pseudo cereal has virtuous growth features like thick leaves, sturdy stems and bulky panicle requires higher dose of fertilizers to maintain physiological activities. This can be fulfilled by supplying high dose of fertilizers during growth period of crop, resulted in better uptake, translocation of nutrients eventually resulted towards increase in stover yield. The above results were similar to findings of Kushare *et al* (2010) and Rathore *et al.* (2004). In case of harvest index data didn't shows significant.

Nutrient Uptake by.Grain Amaranth

Cultivar and fertilizer levels significantly influenced nutrient uptake (kg ha^{-1}) *i.e.,* nitrogen, phosphorous and potassium by the grain amaranth is displayed in Table 4.

Nutrient Dynamics of Grain Amaranth

Nitrogen uptake (kg ha^{-1}): Nitrogen uptake by grain amaranth crops varied significantly due to genotype as indicated in Table 4. Nitrogen uptakes was statistically higher in the SKNA-808 genotype, (99.64 kg ha^{-1}) and significantly lower in the SKGPA-61 genotype (67.02 kg ha^{-1}).

Among varied fertilizer levels statistically higher uptake of Nitrogen was obtained with application of 125 per cent RDF (93.47 kg ha^{-1}) which was significantly superior to application of 75 per cent RDF (72.72 kg ha^{-1}). Addition of mineral nitrogen increased nitrogen uptake with increasing the rate of mineral nitrogen fertilizer up to the highest rate, *i.e.,* 100kg N/fed in the report given by Abou-Amer *et al*. (2011). Geren (2015) reported that amaranth and quinoa were significantly affected by nitrogen supply, increased supply of nitrogen in amaranth and quinoa up to 120 kg ha^{-1} enhanced the N uptake (223.2 and 161.3 kg ha^{-1}, respectively) as compared to control (1986 and 140.1, respectively).

There was no significant variation in nitrogen uptake observed when different cultivar and fertilizer levels were combined. G_2F_3 (SKNA-808 with 125 % RDF) had a higher nitrogen uptake (109.74 kg ha^{-1}) than G_1F_1, which had a lower nitrogen uptake (58.33 kg ha^{-1}) (SKGPA-61 with 75 % RDF).

Phosphorous uptake (kg ha^{-1}): Different cultivars had shown significant impact on phosphorous uptake by grain amaranth. Results shown that significantly higher uptake of phosphorous was obtained in SKNA-808 genotype (41.23 kg ha^{-1}) whereas, lower value of phosphorous uptake was recorded with genotype SKGPA-61 (24.34 kg ha^{-1}).

Uptake of phosphorous by the grain amaranth differed significantly depending on fertilizer levels. Significantly more uptake was observed with application of 125 per cent RDF (36.38 kg ha^{-1}) which was significantly superior to application of 75 per cent RDF (29.57 kg ha^{-1}).

There was no significant difference observed for phosphorous uptake by the interaction of cultivar

TABLE 4

Nutrient up take at harvest by Grain amaranth as influenced by cultivar and fertilizer levels

Treatments	Nitrogen uptake (kg ha^{-1})	Phosphorus (kg ha^{-1})	Potassium (kg ha^{-1})
Cultivar (G)			
G_1- SKGPA-61	67.02	24.34	33.44
G_2- SKNA-808	99.64	41.23	45.36
G_3- VL-115	94.60	39.14	43.76
G_4- Suvarna	83.39	32.50	37.55
G_5- KBGA-4	75.24	28.82	35.85
F-test	*	*	*
S.Em±	1.73	0.90	0.90
CD @5%	5.02	2.62	2.61
Fertilizer levels (F)			
F_1:75% RDF	72.72	29.57	34.03
F_2:100% RDF	85.75	33.67	40.74
F_3:125% RDF	93.47	36.38	42.81
F-test	*	*	*
S.Em±	1.34	0.70	0.70
CD @5%	3.89	2.03	2.09
Interactions (G x F)			
F-test	NS	NS	NS
S.Em±	3.00	1.57	1.56
CD @5%	-	-	-

and fertilizer levels. Numerically higher value of phosphorous uptake (43.21 kg ha^{-1}) was noticed in G_2F_3 (SKNA-808 with 125 % RDF) treatment combination. Whereas, lower uptake (21.07 kg ha^{-1}) was noticed in G_1F_1 (SKGPA-61 with 75 % RDF).

Potassium uptake (kg ha^{-1}): The uptake of potassium by grain amaranth varied significantly depending on genotype. Potassium uptake was statistically higher with genotype SKNA-808 (45.36 kg ha^{-1}), whereas SKGPA-61 had significantly lower potassium uptake (33.44 kg ha^{-1}).

Among varied fertilizer levels higher uptake of potassium by grain amaranth was recorded significantly with application of 125 per cent RDF (42.81 kg ha^{-1}) which was significantly superior to application of 75 per cent RDF (34.03 kg ha^{-1}). Ananda and Dhanapal (2006) revealed that application of 80:80:40 kg NPK ha^{-1} found greater nitrogen and phosphorus uptake (114.7 and 15.3 kg ha^{-1}, respectively) than 40:40:20 kg NPK ha^{-1} (89.5 and 12.8 kg ha^{-1}, respectively,).

No significant difference was observed for potassium uptake when cultivar and fertilizer levels are combined. Numerically higher potassium uptake (50.54 kg ha^{-1}) was observed in G_2F_3 (SKNA-808 with 125 % RDF) whereas, lower uptake (30.57 kg ha^{-1}), was observed in G_1F_1 (SKGPA-61 with 75 % RDF).

It can also be due to fact that nutrients play an important role in building up of tissues and maintaining plant physiological functions throughout crop growth. Pseudo cereals especially grain amaranth requires higher dose of fertilizer for its metabolic activities. Application of increased amount of fertilizer significantly influenced nutrient (N, P and K.) uptake. Similar findings were spelt by Modhvadia *et al.* (2007), Ganesh (2011) and Erley *et al.* (2003).

Soil Chemical Properties After Harvest of the Grain Amaranth as Influenced by Cultivar and Levels of Fertilizers

Chemical properties of soil *viz.,* soil pH, electrical conductivity (EC) and organic carbon (OC) of soil at harvest of grain amaranth were influenced by cultivar and fertilizer levels it is presented in Table 2.

Soil pH: Soil pH did not show significant difference due to cultivar. Numerically higher pH was observed with SKNA-808 genotype (5.70), whereas lower pH was observed with SKGPA-61 (5.62). The results (Table 2) revealed that there was non-significant influence on soil pH with application of NPK fertilizers in the soil. However, numerically higher pH value was found for F_3 (125 % RDF) (5.68). The lower soil pH was obtained F_1 (75 % RDF) (5.65). The interaction effect between different cultivar and fertilizer levels was found non-significant in view of soil pH.

Electrical conductivity (ds m^{-1}): Electrical conductivity of soil doesn‘t showed any significant difference due to cultivar. Numerically higher EC (0.31 ds m^{-1}) was noticed in G_2 (SKNA-808), whereas lower EC (0.26 ds m^{-1}) was analyzed in G1 (SKGPA-61). According to the data represented in Table 3 revealed that, the EC (Electrical conductivity) differed in the soil at harvest due to fertilizer levels was statistically found non-significant. Numerically higher soil electrical conductivity was analyzed in F_3 (125 % RDF) (0.30 ds m^{-1}), whereas lower soil EC (0.27 ds m^{-1}) was noted in F_1 (75 % RDF).

The interactive effects of different cultivar and fertilizer levels on electrical conductivity of soil analyzed at harvest were found to be non-significant (Table 4).

Organic carbon (%) : Organic carbon (OC) of soil after harvest of grain amaranth doesn’t showed any significant difference due to cultivar. Numerically higher soil organic carbon (0.43 %) was observed in G_2 (SKNA-808) and lower soil OC was recorded (0.39 %) in G_1 (SKGPA-61). Data presented in Table 5 revealed that difference in soil organic carbon at harvest due to fertilizer levels was statistically found non-significant. Numerically higher soil OC was noted in F_3 (125 % RDF) (0.42 %), whereas, F_1 (75 % RDF) recorded lower value for soil organic carbon (0.40 %).

Table 5

Soil pH, EC and soil OC as influenced by different cultivar and fertilizer levels in Grain amaranth

Treatments	pH	EC (ds m^{-1})	OC (%)
Cultivar (G)			
G_1- SKGPA-61	5.62	0.26	0.39
G_2- SKNA-808	5.70	0.31	0.43
G_3- VL-115	5.68	0.30	0.42
G_4- Suvarna	5.67	0.29	0.41
G_5- KBGA-4	5.66	0.27	0.40
F-test	NS	NS	NS
S.Em$\pm$	0.12	0.01	0.01
CD @5%	-	-	-
Fertilizer levels (F)			
F_1:75% RDF	5.65	0.27	0.40
F_2:100% RDF	5.67	0.29	0.41
F_3:125% RDF	5.68	0.30	0.42
F-test	NS	NS	NS
S.Em$\pm$	0.09	0.00	0.01
CD @5%	-	-	-
Interactions (G x F)			
F-test	NS	NS	NS
S.Em$\pm$	0.21	0.01	0.01
CD @5%	-	-	-

Available Soil Nutrient Status after Harvest of Grain Amaranth as Influenced by Cultivar and Fertilizer Levels

Available nitrogen (kg ha^{-1}): Nitrogen availability had significant difference due to cultivar. Numerically, higher available soil nitrogen (188.34 kg ha^{-1}**)** was observed in G_1 (SKGPA-61) while, lower value for available soil nitrogen (174.99 kg ha^{-1}) was observed in G_2 (SKNA-808). Nitrogen availability after harvest of grain amaranth has depicted clear difference due to varied fertilizer levels. Significantly higher nitrogen availability (185.64kg. ha^{-1}) was observed in F_3 (125 % RDF) whereas, lower nitrogen availability (176.53 kg ha^{-1}) was noted in F_1 (75 % RDF). As grain amaranth requires higher amount of fertilizers, addition of fertilizer lead to greater N availability which was needed by soil microorganisms for multiplication and further conversion of organic nitrogen (N) to mineral form was carried out thus increasing the pool of available nitrogen in soil. Similar evidences were also reported by Erley *et al.* (2003); Ananda & Dhanapal (2006) and Hossen (2017).

After grain amaranth has harvested, available nitrogen of soil did not show any significant difference due to the interaction of cultivar and fertilizer levels. However, statistically higher value for nitrogen availability (193.43 kg. ha^{-1}) was observed with G_1F_3 (SKGPA-61 with 125 % RDF) whereas, lower nitrogen availability (172.27 kg. ha^{-1}) was observed with G_2F_1 (SKNA-808 with 75 % RDF).

Available phosphorus (kg ha^{-1}): Phosphorous availability after grain amaranth harvest had showed a significant difference due to different fertilizer levels. Significantly higher phosphorous availability was observed with application of 125 per cent RDF (40.73 kg ha^{-1}) whereas, the lower phosphorous availability was observed with 75 per cent RDF application (37.48 kg ha^{-1}). The increased value for available phosphorus might be due to fact that grain amaranth was basically P lover addition of higher doses of phosphorous lead to strong roots with better proliferation into soil further enriched the microbial growth thus responsible for conversion of insoluble form of P to available P. These findings were also consistent with those of Ananda and Dhanapal (2006).

After grain amaranth harvest phosphorous availability had shown non-significant difference due to interaction of cultivar and fertilizer levels. However, G_1F_3 (SKGPA-61 with 125 % RDF) had a numerically higher phosphorous availability (45.82 kg ha^{-1}) while G_2F_1 had a lower phosphorous availability (33.20 kg ha^{-1}) (SKNA-808 with 75 % RDF).

Available Potassium (kg ha^{-1}) : Available potassium after harvest of grain amaranth has shown significant difference due to cultivar and fertilizer levels. Whereas, statistically higher potassium availability (284.34 kg ha^{-1}). was observed in G_1 (SKGPA-61), whereas lower value for potassium availability (252.38kg ha^{-1}) was observed in G_2 (SKNA-808).

After grain amaranth harvest available potassium in soil had shown significant difference due to different fertilizer levels. Significantly higher potassium availability was observed in 125 per cent RDF (275.41 kg ha^{-1}) whereas, lower value for available potassium observed with 75 per cent RDF (256.77 kg ha^{-1}). This can also due to higher supplementation of nutrients through a medium such as inorganic fertilizers. They act as a primer for organic matter mineralization by increased activity of soil microorganisms. These results were also consistent with the findings of Dehariya *et al.* (2019) and Gélinas & Seguin (2008).

TABLE 6

Available soil nutrient status after harvest of Grain amaranth as influenced by cultivar and fertilizer levels

Treatments	Available nutrients (kg ha^{-1})		
	N	P_2O_5	K_2O
Cultivar (G)			
G_1- SKGPA-61	188.34	43.05	284.34
G_2- SKNA-808	174.99	35.00	252.38
G_3- VL-115	177.39	36.03	260.52
G_4- Suvarna	180.92	38.80	265.09
G_5- KBGA-4	184.65	42.61	271.39
F-test	*	*	*
S.Em±	3.19	0.80	6.17
CD @5%	9.23	2.30	17.89
Fertilizer levels (F)			
F_1:75% RDF	176.53	37.48	256.77j
F_2:100% RDF	181.60	39.09	268.06
F_3:125% RDF	185.64	40.73	275.41
F-test	*	*	*
S.Em±	2.47	0.62	4.78
CD @5%	7.15	1.78	13.85
Interactions (G x F)			
F-test	NS	NS	NS
S.Em±	5.52	1.38	10.69
CD @5%	-	-	-

After grain amaranth harvest potassium availability had shown non-significant difference due to interaction of cultivar and fertilizer levels. However, G_1F_3 (SKGPA-61 with 125 % RDF) had numerically higher potassium availability (287.02 kg ha^{-1}) while G_2F_1 had lower availability (237.70 kg ha^{-1}) (SKNA-808 with 75 % RDF).

Economics of Grain Amaranth as Influenced by Cultivars and Fertilizer Levels

The effect of cultivars and fertilizer levels on grain amaranth economics (Fig. 1). Among cultivars maximum net returns (Rs.60808 ha^{-1}) and benefit cost ratio (2.95) were obtained in SKNA-808 genotype

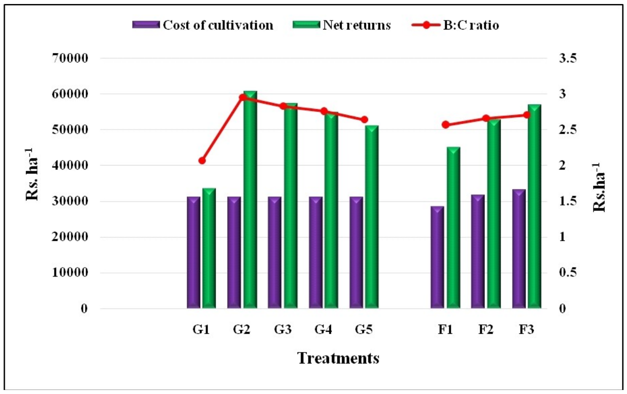

Fig. 1 : Economics of grain amaranth as influenced by cultivars and fertilizer levels

which was superior over other cultivars. Lower net returns and benefit cost ratio were noticed in SKGPA-61. The above results were similar to findings of Malligawad (1994) and Revanth (2020).

Pseudo cereals like grain amaranth varies its response with cultivars and levels of fertilizers cultivar SKNA-808 recorded higher growth and yield attributes. As grain amaranth is voracious feeder of nutrients cultivar SKNA-808 recorded highest nutrient uptake due to its inherent capabilities such as deep root system and sturdy nature of stem which in turn reflect better uptake and assimilation. The available nutrients in soil were significantly higher under cultivar SKGPA-61 as compared to other cultivars because the cultivar its not able to uphold and concentrate nutrients in its plant parts thereby soil arena contains higher amount of nutrients. Nutrient uptake by grain amaranth and available nutrient status in soil after harvest of the crop was significantly increased when higher dose of inorganic fertilizer was applied compared to other fertilizer levels. It can be recommended that grain amaranth can be cultivated economically employing superior genotype such as SKNA-808 along with application of 125 per cent RDF in order to fetch higher net returns.

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