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Likhita Reddy S
Department of Agronomy, University of Agricultural Sciences, College of Agriculture, GKVK, Bengaluru, Karnataka, India

Kalyana Murthy KN
Professor, Department of Agronomy, GKVK, UAS, Bengaluru, Karnataka, India

Devika AR
Department of Agronomy, GKVK, UAS, Bengaluru, Karnataka, India

Parameshnaik C
Department of Agronomy, GKVK, UAS, Bengaluru, Karnataka, India

Anand SR
AICRN on Potential crops, GKVK, UAS, Bengaluru, Karnataka, India

Corresponding Author:
Likhita Reddy S
Department of Agronomy, University of Agricultural Sciences, College of Agriculture, GKVK, Bengaluru, Karnataka, India

Evaluation of impact of different levels of fertilizers on nutri rich grain amaranth (*Amaranthus hypochondriacus* L.) genotypes

Likhita Reddy S, Kalyana Murthy KN, Devika AR, Parameshnaik C and Anand SR

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Abstract
The University of Agricultural Sciences, GKVK, Bangalore staged a field experiment in Kharif 2021 titled "Evaluation of impact of different levels of fertilizers on nutri rich grain amaranth (*Amaranthus hypochondriacus* L.) genotypes." A factorial Randomised Complete Block design (RCBD) was used to set up the experiment, where factor A consisted of five genotypes and factor B consisted of three fertilizer doses that were reproduced three times with fifteen treatment combinations. The genotype G_2 (SKNA-808) is on par with VL-115 in terms of plant height (212.25 cm), leaf area per plant (1784.62 cm^2 $plant^{-1}$), stem girth (6.85 cm), number of fingers per inflorescence (52.39) and grain and stover yield (1839 kg ha^{-1} and 3313 kg ha^{-1}, respectively). The lowest was in SKGPA-61. Of the fertilizer levels, the application of 125% RDF resulted in significantly highest plant height (202.23 cm), leaf area per plant (1600.60 cm^2 $plant^{-1}$), stem girth (6.35 cm), number of fingers per inflorescence (47.37), finger length (31.56 cm), grain and stover yield (1802 kg ha^{-1} and 3327 kg ha^{-1}) that was comparable to that of 100% RDF. The application of 75% RDF produced numerically highest values of crude protein (15.36 g), calcium (397.60 mg), phosphorus (545.92 mg), and iron (14.88 mg) content per 100 gm. The interactions between different genotypes and fertilizer amounts were not statistically significant.

Keywords: Fertilizer, grain amaranth, genotypes

1. Introduction

Thirty thousand of the three million plant species have been proven to be edible in the wild and have been grown by humans at some point. Of those, 158 species are commonly consumed as food. Ten crops provided 75% of the world's food, while only three crops—rice, wheat, and maize—accounted for 60% of all food produced worldwide. The development of the green revolution, which increased crop productivity by using high yielding cultivars and fertilizers, was the catalyst for the trend of decreasing agro-biodiversity. However, the three main crops that achieved success were maize, wheat, and rice. Following the green revolution, India's food grain production has become self-sufficient since the country's growing middle class has raised the socioeconomic status of its citizens.

Researchers are interested in grain amaranth (*Amaranthus* spp.), also known as an orphan crop or "pseudocereal," because of its high nutritional value, particularly in the areas of crude protein (16.86%), calcium (330 mg/100 g), iron (17.5 mg/100 g), and phosphorus (557.33 mg/100 g). This ancient crop originated in Central and South America and was grown 5000–7000 years ago (Maurya and Arya, 2018) [13]. Patients with diabetes should ideally consume amaranth due to its low gluten and carbohydrate content (Zubillanga *et al.* 2019) [20]. According to Kushare *et al.* (2010) [11], amaranth is widely grown in Himachal Pradesh, Madhya Pradesh, Maharashtra, and a portion of Gujarat in India. Amaranth grain is a crop with several uses. is a member of the class of plants known to possess the carbon metabolism pathway C_4. Numerous physical characteristics, a broad range of genetic variability, health-promoting qualities, and applications in agronomy, nutrition, and industry define this category.

Even though amaranth genetics is rich in India, only a few number of cultivars are known to exist and are commercially farmed. For agricultural production to be sustained, stable genotypes are necessary (Kandel *et al.*, 2021) [9]. A cultivar can only reach its maximum potential when sound agronomic techniques are implemented. Fertilizer management is one of the many agronomic elements that are known to increase crop output. This is because crops respond better to the use of inorganic fertilizer, which is an expensive but crucial input for crop production. In contrast to other crops, grain amaranth requires a precise dosage of fertilizer for optimal development and production. Based on their growth behaviour, each genotype responds differently to fertilizer.

2. Materials and Methods

The field experiment was carried out at M block, a field unit of the AICRN on Potential Crops at the University of Agricultural Sciences in Bangalore. The soil at the experimental site was identified as kandic paleustalfs with a sandy loam texture, slightly acidic in reaction (pH 5.69), with an electrical conductivity of 0.24 dS m^{-1}, lowest in organic carbon (0.39%), and medium in available nitrogen (248.7 kg ha^{-1}), phosphorous (35.8 kg ha^{-1}), and potassium (272.4 kg ha^{-1}). The trial used a factorial Randomised Complete Block design (RCBD) that was replicated three times and included fifteen treatment combinations. Factor A consisted of five genotypes: G_1 (SKGPA-61), G_2 (SKNA-808), and G_3 (VL-115) are testing genotypes, while G_4 (Suvarna (check) and G_5 (KBGA-4) are national and local checks, respectively, and factor B consisted of three fertilizer doses: F_1 (75% RDF), F_2 (100% RDF), and F_3 (125% RDF). The crop received the prescribed fertilizer dose, which was 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 muriate of potash (MOP). The entire dose of phosphorous, potassium, and half of the dose of nitrogen was administered as a baseline dose, with the remainder being top dressed. The crop received need-based irrigation to avoid moisture stress on non-rainy days based on visible wilting signals. Measures to control insect pests were implemented during the crop season, such as spraying monocrotophos 20% EC @ 1.5 ml per litre at 50 DAS to control leaf-eating caterpillar. Biometric observations of several growth and yield characteristics were made at 30 and 60 DAS, as well as at harvest. To record the numerous morphological observations, five plants were randomly picked and tagged from each net plot. Green leaves were removed from the plants and put into the "L. I-3100 Leaf area meter" designed by LICOR, Ins., Lincoln, Nebraska, USA, to measure leaf area. The circumference of the stem was measured using thread along with scale and expressed in centimeter (cm).

The length of each finger was measured from the bottom, middle, and top of the panicle, and the average of three observations was calculated and expressed in centimetres. The number of fingers per inflorescence was calculated by counting the total number of fingers in each panicle of grain amaranth. After the grain was harvested from the net plot area, it was thoroughly cleaned, air dried for two days, and weighed in kilogrammes per plot. later worked out per hectare and expressed as kg per ha. In similar way stover yield was recorded. Crude protein was determined by Kjeldahl's digestion distillation method. The crude protein content was computed by multiplying the per cent nitrogen content with factor 6.25. Iron content was computed after making suitable dilution of di-acid extract, the samples were fed to the atomic absorption spectrophotometer using appropriate hallow cathode lamp. Calcium in the digested plant sample is estimated by titrating against standard Versenate solution using Patton Reeders indicator for calcium. The data collected from the experimental field was analyzed statistically by following the procedure as described by Gomez and Gomez (1984) [21].

3. Results and Discussion

3.1 Plant height, dry matter production per plant and Stem girth

The data in Table 1 indicates that there were substantial differences between the cultivars in terms of plant height at harvest. The genotype SKNA-808 had a larger plant height (212.25 cm) than the other genotypes examined, matching genotype VL-115. In contrast to the national check (Suvarna) and local check (KBGA-4), genotype SKGPA-61 registered a much lowest plant height (174.22 cm). This could be the result of genotype differences, which are expected given differences in their innate genetic potential and how they react to plant height. Myers (1998) [14] published similar findings, indicating that K 266 was the tallest cultivar, followed by Plainsman and D l36. According to Olaniyi *et al.* (2008) [17], there was a considerable increase in plant height of amaranth grain when the applied N rates were increased from 0 kg ha $^{-1}$ to 60 kg ha $^{-1}$. Plant height was significantly impacted by fertilizer amounts. The plant height of 202.23 cm, which was comparable to the application of 100% RDF, was considerably greater after applying 125% RDF than after applying other fertilizer levels. However, the plant's height (181.39 cm) was significantly reduced when applying 75% RDF. The primary function of macronutrients is to promote meristematic activity, which increases plant height and internode elongation as fertilizer dosage is raised. Abou Amer *et al.* (2011) [1] showed similar results with quinoa. According to Geren (2015) [5], quinoa plants grew substantially taller when the rate of nitrogen fertilizer was increased to 175 kg N ha^{-1}. Statistical analysis revealed that there was no statistically significant interaction between different genotypes and fertilizer quantities.

The dry matter yield per plant at harvest showed a substantial variation amongst the kinds, according to the results. On the other hand, genotype SKNA-808 (95.44 g $plant^{-1}$) was associated with the highest dry matter production per plant, which was comparable to genotype VL-115 (88.56 g $plant^{-1}$). However, genotype SKGPA-61 (57.00 g $plant^{-1}$) showed a noticeably decreased dry matter production value. The amount of dry matter in plants during harvest is significantly influenced by the type and quantity of fertilizer applied. However, the plants gathered significantly more dry matter (86.00 g $plant^{-1}$) when a highest level of fertilizer, such as 125 percent RDF, was applied. This was equivalent to the results of a 100 percent RDF treatment (79.73 g $plant^{-1}$). But when 75% RDF was used, there was a noticeably lowest build-up of dry matter. For the. dry matter output $plant^{-1}$ at harvest, the interaction effects between various genotypes and fertilizer amounts were found to be non-significant.

Table 1 illustrates the effects of various genotypes, fertilizer levels and their interactions on the stem girth of grain amaranth. Stem girth was statistically influenced by genotypes. However, highest stem girth was significantly recorded in genotype SKNA-808 (6.85 cm) it was on par with genotype VL-115 and the lowest stem girth was recorded in SKGPA-61 (5.01 cm). This was mainly because of variation in their genetic potential and response to crop management practices. SKNA-808 was found to be superior over the others because, it is having sturdy stem resistant to lodging than rest of genotypes. Bolpur Collection-2 ia a local variety that produced highest stem diameter in vegetable amaranth (Mandal *et al* 2013) [12]. Gutierrez *et al* (2002) [7] reported that *A. caudatus* recorded highest stem diameter over other cultivars. Significantly, greater fertilizer levels of 125 per. cent RDF (6.35 cm) were found to produce stem girth that was on par with. 100 per cent RDF (6.20 cm). However, 75 per cent RDF had noticeably lowest stem girth (5.75 cm). The results might be because, application of inorganic fertilizer containing phosphorous and nitrogen that are responsible. for increased cell multiplication, cell enlargement and luxuriant growth of stem which further leads to highest dry matter accumulation especially, carbohydrates which is responsible for stem thickness there by promoting the stem to be resistant to lodging. Similar results indicated that nitrogen increases the vegetative growth of amaranth as well as maximum stem diameter Dehariya *et al* (2019) [3]. Kushare *et al* (2010) [11] reported that maximum stem girth was recorded significantly under the application of 100 per cent RDF being at par with 75 per cent RDF. The interaction effects among genotypes and fertilizer levels for stem girth (cm) were found non-significant.

Table 1: Plant height, stem girth and dry matter production of grain amaranth at harvest as influenced by genotypes and fertilizer levels

Treatments	Plant height (cm)	Stem girth (cm)	Dry matter production (g $plant^{-1}$)
Genotypes (G)			
G_1- SKGPA-61	174.22	5.01	57.00
G_2- SKNA-808	212.25	6.85	95.44
G_3- VL-115	203.72	6.73	88.56
G_4- Suvarna	191.17	6.17	81.89
G_5- KBGA-4	186.64	5.73	67.78
F-test	*	*	*
S.Em±	3.40	0.13	3.11
CD @ 5%	9.85	0.39	9.01
Fertilizer levels (F)			
F_1:75% RDF	181.39	5.75	68.67
F_2:100% RDF	197.18	6.20	79.73
F_3:125% RDF	202.23	6.35	86.00
F-test	*	*	*
S.Em±	2.63	0.10	2.41
CD @ 5%	7.63	0.30	6.98
Interactions (G x F)			
F-test	NS	NS	NS
S.Em±	17.06	0.23	5.38
CD @ 5%	-	-	-

3.2 Leaf area per plant and Number of leaves per plant

Perusal of the data presented in Table 2 indicates that leaf area per plant was identified to be statistically. significant. However, highest leaf area $plant^{-1}$ was exhibited in genotype SKNA-808 (1784.62 cm^2 $plant^{-1}$) it was on par with genotype VL-115 (1684.13 cm^2 $plant^{-1}$). However, the lowest leaf area $plant^{-1}$ were recorded in SKGPA-61 (1136.24 cm^2 $plant^{-1}$) This might be as a result of the considerable differences in genotypes with respect to leaf area, 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 genotype. Similar outcomes were also found by Hossen (2017) [8]. Revanth (2020) [19] reported that in amaranth highest leaf area was recorded in suvarna variety compared to KBGA-4. Among fertilizer levels application of 125 per cent recommended dose of fertilizer witnessed highest leaf area (1600.60 cm^2 $plant^{-1}$) which was on par with 100 per cent RDF. Significantly, lowest leaf area per plant was recorded in treatment applied with 75 per cent RDF (1253.00 cm^2 $plant^{-1}$) results might be because, grain amaranth usually a broad leaved crop requires increased level of fertilizers containing highest concentration of nutrients especially nitrogen for their luxuriant growth and it was a major contributer in the formation of chlorophyll and there by increases photosynthetic activity resulted in greater leaf area. The results proved that with increased supply of nitrogen significantly influenced the leaf area the lowest was recorded from without nitrogen application Dehariya *et al* (2019) [3]. Interaction of genotypes and fertilizer levels were found non-significant

Table 2: Number of leaves, Leaf area per plant of grain amaranth at harvest as influenced by genotypes and fertilizer levels

Treatments	Leaf area (cm^2 $plant^{-1}$)	Number of leaves per plant
G_1- SKGPA-61	1136.24	15.27
G_2- SKNA-808	1784.62	31.47
G_3- VL-115	1684.13	29.51
G_4- Suvarna	1415.08	21.75
G_5- KBGA-4	1223.35	19.20
F-test	*	*
S.Em±	55.73	0.79
CD @ 5%	161.44	2.30
Fertilizer levels (F)		
F_1:75% RDF	1253.00	20.46
F_2:100% RDF	1492.45	24.01
F_3:125% RDF	1600.60	25.84
F-test	*	*
S.Em±	43.17	0.62
CD @ 5%	125.05	1.78
Interactions (G x F)		
F-test	NS	NS
S.Em±	96.53	1.38
CD @ 5%	-	-

3.3 Days to maturity, Number of fingers per inflorescence and Length of finger of grain amaranth as influenced by genotypes and fertilizer levels

A perusal of data presented in Table 3 reveals that the data regarding days to maturity as influenced by genotypes and fertilizer levels and their interaction effects were displayed in table 3. Among the genotypes, SKGPA-61 has taken longer number of days to maturity (97.40) significantly, fewer days for flowering and maturity were recorded in VL-115 (85.89). This was mainly due to variation in genomic characters. Though genotype SKGPA-61 has taken longer days to maturity, there was severe reduction in yield due to heavy rainfall at the time of harvest. Among fertilizer levels, 125 per cent recommended dose of fertilizer has taken more days to maturity (93.68) which was on par with 100 per cent RDF. However, 75 per cent RDF has taken lesser number of days to reach maturity. This could be mainly because, increased dose of inorganic fertilizers especially nitrogen leads to luxuriant vegetative growth which further slow down the days to reach flowering and maturity in crop. The interaction effects between various genotypes and fertilizer amounts were determined to be insignificant.

Table 3 contains information on the number of fingers per inflorescence as influenced by genotypes and fertilizer levels. Among different genotypes, SKNA-808 significantly recorded highest number of fingers per inflorescence (52.39) which was on par with genotype VL-115 (50.08) as compared to other genotypes. Significantly, lowest number of fingers per inflorescence (33.40) was recorded in SKGPA-61. This might be due to variation in their genetic makeup. SKNA-808 was identified as superior genotype with volumetric panicle bearing more number of fingers per inflorescence which ultimately contributes to yield. Among fertilizer levels, application of 125 per cent RDF significantly recorded more number of fingers per inflorescence (47.37) it was on par with application of 100 per cent RDF (45.62). Significantly lowest number of fingers per inflorescence (37.09) was recorded with application of 75 per cent RDF. This can be due to the fact that application of highest dose of fertilizer exhibited synergistic effect on reproductive growth of the crop by supplying nutrients like NPK in a more soluble form which are needed for the growth of plants, as well as to increase the fruit bearing branches. Above results were similar to findings of Kushare *et al* (2010) [11] highest number of fingers per spike were recorded under application of 100 per cent RDF being at par with 75 per cent RDF The interaction effect among different genotypes and fertilizer levels for number of fingers per inflorescence was found non-significant.

The data pertaining to length of finger.as influenced by genotypes and fertilizer levels was presented in table 3. Different genotypes exhibited significant variations on length of finger. Statistically, the genotype KBGA-4 recorded highest finger length. (35.61 cm) which was. on par with SKGPA-61 (33.50 cm). However, lowest finger length (22.14 cm) was found in genotype Suvarna. This could be due to variation in genetic characteristics among the genotypes. Genotype KBGA-4 bears enlarged panicle along with lengthy finger. Similar findings were obtained by Anand *et al* (2020) [2] in grain amaranth they communicated that panicle length were significantly highest in KBGA-4 as compared to SKGPA-74. Application of. 125 per cent RDF recorded highest length (31.56 cm) of finger which was on par with application of 100 percent RDF (29.98 cm). However, application of 75 per cent RDF. recorded significantly. lowest finger length (24.67 cm). This could be due to increased supply of macro nutrients in more synchronized way through application of highest dose of chemical fertilizer bring about significant improvement in overall growth of the crop by providing needed nutrient from initial stage. In turn photosynthetic efficiency and ability to translocate more photosynthates to reproductive parts was increased thus enhanced length of finger. The interaction effect among different genotypes and fertilizer levels for length of finger was found non-significant. The highest inflorescent length was achieved when inorganic fertilizer was applied at 100 kg N/ha because increased levels of inorganic fertilizer leads to more assimilation of N to sink thus enhanced finger length (Nyankanga *et al* 2012) [16].

Table 3: Days to maturity, Number of fingers per inflorescence and Length of finger of maize of grain amaranth as influenced by genotypes and fertilizer levels

Treatments	Days to maturity	Number of fingers per inflorescence	Length of finger (cm)	1000 grain weight (g)
Genotypes (G)				
G_1- SKGPA-61	97.40	33.40	33.50	1.00
G_2- SKNA-808	91.47	52.39	28.32	1.39
G_3- VL-115	85.89	50.08	24.13	1.37
G_4- Suvarna	93.00	46.11	22.14	1.26
G_5- KBGA-4	90.22	34.82	35.61	1.20
F-test	*	*	*	*
S.Em±	1.59	0.80	1.07	0.05
CD @5%	4.60	2.31	3.09	0.13
Fertilizer levels (F)				
F_1: 75% RDF	88.90	37.09	24.67	1.12
F_2:100% RDF	92.20	45.62	29.98	1.26
F_3:125% RDF	93.68	47.37	31.56	1.35
F-test	*	*	*	*
S.Em±	1.23	0.62	0.83	0.04
CD @5%	3.56	1.79	2.39	0.10
Interactions (G x F)				
F-test	NS	NS	NS	NS
S.Em±	2.75	1.38	1.85	0.08
CD @ 5%	-	-	-	-

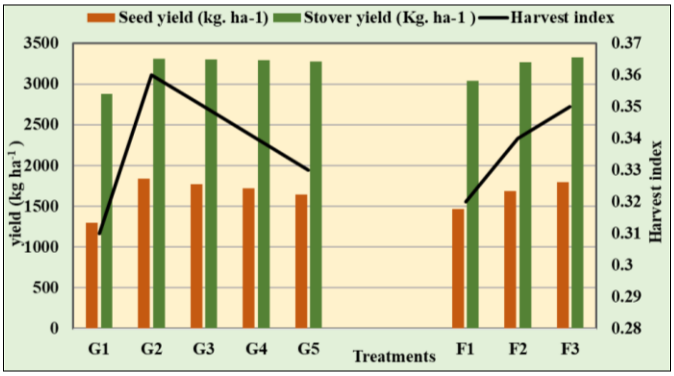
Different genotypes exhibited significant variations for 1000 grain weight. Statistically, genotype SKNA-808 (1.39 g) recorded highest value of 1000 grain weight which was on par with VL-115 (1.37 g). However, lowest 1000 grain weight was found in genotype SKGPA-61 (1.00 g). Above results were similar to findings of Gimplinger *et al* (2007) [6] Neuer genotype recorded highest 1000 grain weight than amar type the large seed size enabled the genotype to exhibit high 1000 grain weight. Varied fertilizer levels had a considerable impact on 1000 grain weight of grain amaranth. Whereas, 125 per cent RDF (1.35 g) application recorded highest 1000 grain weight of grain amaranth it was on par with application of 100 per cent RDF (1.26 g). while, application of 75 per cent RDF recorded lowest 1000-grain weight (1.12 g). Above results were similar to findings of Pospisil *et al* (2006) [18] who concluded that increased fertilizer dose upto 100 kg ha^{-1} led to significant increase in 1000 seed weight due to better availability of nutrients for plants in turn leads to better assimilation to reproductive parts which increased grain weight.

3.4 Grain yield, stover yield and harvest index of grain amaranth as influenced by genotypes and fertilizer levels

Different genotypes interactions with fertilizer levels were not found to be statistically significant. The data. pertaining to grain yield (kg ha^{-1}) of grain amaranth. as influenced by genotypes and varied fertilizer levels was presented. in table 4. Different genotypes significantly influenced the grain yield of grain amaranth. Significantly highest grain yield was recorded with genotype SKNA-808 (1839 kg ha^{-1}) which was on par with genotype VL-115. However, lowest grain yield per plant was recorded with genotype SKGPA-61 (1296 kg ha^{-1}). SKNA-808 was found to be superior genotype over the others due to its superior growth and yield parameters in addition, it exhibits resistance to lodging along with this, the genotype is bearing volumetric panicle, more number of fingers with filled grain which further adds to the yield. Above results were similar to findings of Anand *et al* (2020) [2] they quoted that SKGPA-71 recorded significantly highest grain yield to KBGA-4. *A. hypochondriacus* L. recorded highest seed yield than to *A.cruentus* (Pospisil *et al* 2006) [18]. Among different fertilizer levels, 125 per cent RDF application (1802 kg ha^{-1}) recorded highest grain yield which was on par with the 100 per cent application of RDF However, significantly lowest grain yield was found in treatment applied with 75 per cent RDF (1472 kg ha^{-1}). 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 interaction effects between genotypes and fertilizer levels were found non significant for grain yield of grain amaranth. Nitrogen fertilization of 120 kg ha^{-1} enhanced grain yield to 140%, compared to no fertilization (Erley *et al* 2003) [4]. Khurana *et al* (2016) [10] reported that the application of Nitrogen at the level up to 125 kg/ha can be recommended to get highest total green yield.

Different genotypes significantly influenced the grain amaranth stover yield (kg ha^{-1}). The stover yield was recorded significantly highest with genotype SKNA-808 (3313 kg ha^{-1}) which were on par with genotype VL-115 (3302 kg ha^{-1}) while the lowest stover yield. was recorded in SKGPA-61 (2879 kg ha^{-1}). Similar results were obtained by Anand *et al* (2020) [2] in grain amaranth. Among the genotypes, significantly highest straw yield were recorded in SKGPA-74 compared to KBGA-4 and KBGA-1. Data calculated for stover yield was numerically highest with application of 125 per cent RDF (3327 kg ha^{-1}) which was on par with 100 per cent RDF application. While a lowest 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 highest 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. similar results were obtained by Anand *et al* (2020) [2]

Different genotypes significantly influenced the harvest index of grain amaranth. According to the data, the SKNA-808 genotype (0.36) had a significantly highest harvest index. The lowest harvest index was recorded with SKGPA-61 (0.31). Cultivar K 343 had a lowest harvest index than K 432 in grain amaranth Erley *et al* (2003) [4]. Harvest index was not differed significantly due to varying fertility levels. However, numerically highest value for harvest. index was. obtained in treatment applied with 125 per cent recommended dose of fertilizer (0.35) the lowest value for harvest index was obtained with 75 per cent RDF application (0.32). This could be mainly due to application of sufficient quantities of fertilizers containing nutrients in available form responsible for better absorption and uptake by crop due to deep root system in turn, increased the growth parameters and yield attributes thus increased the harvest index. Similar results were also obtained by Nyankanga *et al* (2012) [16] showing that there was no change in biomass partitioning with application of the different rates of inorganic fertilizer.



3.5 Nutrient use efficiency of grain amaranth

The data pertaining to nutrient use efficiency of grain amaranth as influenced by genotypes and varied fertilizer levels was presented in table 5.

Among genotypes highest nitrogen, phosphorus and potassium use efficiency was recorded in SKNA-8008 (46.8, 31 and 31 Kg ha^{-1} respectively,). This is mainly because due to inherant ability of genotype due to its deep root system has a added advantage of its ability to uptake more nutrients thereby resulted in better yield.

Significantly highest nitrogen use efficiency was obtained with application of 125 per cent RDF (42.8 Kg ha^{-1}) and lowest nitrogen use efficiency (31.3 kg ha^{-1}) was observed with 75% RDF. The highest phosphorus use efficiency was obtained with application of 125 per cent RDF (28.8 Kg ha^{-1}) and lowest nitrogen use efficiency (21.9 kg ha^{-1}) was observed with 75% RDF. The highest potassium use efficiency was obtained with application of 125 per cent RDF (28.8 Kg ha^{-1}) and lowest nitrogen use efficiency (21.9 kg ha^{-1}) was observed with 75%

RDF.

The application of 125 per cent RDF resulted in highest uptake and utilization with respect to all major nutrients which in turn resulted in highest nutrient use efficiency. Ramachandra & Thimmaraju (1983) reported increase in P percentage in plant due to increasing levels of both N & P in grain amaranth. This may be attributed to increased availability of soil P owing to decomposition of organic matter added through FYM and vermicompost which might have contributed to the solubilisation of native and applied P_2O_5.

Table 5: Nutrient use efficiency of grain amaranth as influenced by genotypes and fertilizer levels

Treatments	Nutrient applied (kg ha^{-1})			Nutrient use efficiency (kg ha^{-1})		
	N	P_2O_5	K_2O	N use efficiency	P use efficiency	K use efficiency
Genotypes (G)						
G_1- SKGPA-61	75	50	50	32.6	22	22
G_2- SKNA-808	75	50	50	46.8	31	31
G_3- VL-115	75	50	50	36.2	28	28
G_4- Suvarna	60	40	40	35.9	26	26
G_5- KBGA-4	60	40	40	34.1	24	24
Fertilizer levels(F)						
F_1: 75% RDF	45	30	30	31.3	21.9	21.9
F_2:100% RDF	60	40	40	36.1	24.6	24.6
F_3:125% RDF	75	50	50	42.8	28.8	28.8
Interactions (G x F)						
F-test	-	-	-	NS	NS	NS
S.Em±	-	-	-	2.59	0.86	0.86
CD @ 5%	-	-	-	-	-	-

3.6 Analysis of nutrient content of grain amaranth

The crude protein, Ca, P and Fe content in the grain amaranth seeds were found to be non-significant. However, among the genotypes, SKNA-808 recorded numerically highest values of crude protein (16.44 g), calcium (400.67 mg), phosphorus (546.50 mg) and iron (14.98 mg) content per 100 gm.

Among varied fertilizer levels, application of 125 per cent of RDF numerically highest values of crude protein (15.36 g), calcium (397.60 mg), phosphorus (545.92 mg) and iron (14.88 mg) content per 100 gm.

The interaction of genotypes and fertilizer levels did not differ significantly the nutritional value of grain amaranth seed.

Neeraja and Patel (2015) noticed the highest protein content in grains due to the highest vegetative growth and yield attributing characters, which might have helped in the increased uptake of nitrogen. highest protein content in seed might be due to root enlargement, better microbial activities resulting more availability and uptake of nitrogen (Naveen and Mevada, 2012) [15].

Table 6: Nutritional value of Grain Amaranth seed (per 100 gm) as influenced by levels of fertilizers and various genotypes.

Treatments	Crude protein (g)	Calcium (mg)	Phosphorus (mg)	Fe (mg)
Genotypes (G)				
G_1- SKGPA-61	11.92	392.33	542.77	14.57
G_2- SKNA-808	16.44	400.67	546.50	14.98
G_3- VL-115	15.68	396.33	545.43	14.96
G_4- Suvarna	14.00	395.00	545.10	14.85
G_5- KBGA-4	11.60	394.33	543.47	14.80
F-test	NS	NS	NS	NS
S.Em±	0.29	8.20	11.29	0.31
CD @ 5%	0.84	23.76	32.72	0.89
Fertilizer levels (F)				
F_1: 75% RDF	12.25	394.00	543.52	14.79
F_2:100% RDF	14.17	395.60	544.52	14.83
F_3:125% RDF	15.36	397.60	545.92	14.88
F-test	NS	NS	NS	NS
S.Em±	0.22	6.35	8.75	0.24
CD @ 5%	0.65	18.40	25.34	0.69
Interactions (G x F)				
F-test	NS	NS	NS	NS
S.Em±	0.50	14.20	115	0.53
CD @ 5%	-	-	-	-

3.7 Economics of grain amaranth as influenced by genotypes and fertilizer levels

Table 7 show the effect of genotypes and fertilizer levels on grain amaranth economics. Among genotypes maximum gross returns (Rs. 91967 ha^{-1}), net returns (Rs. 60808 ha^{-1}) and benefit cost ratio (2.95) were obtained in SKNA-808 genotype which was superior over other genotypes. lowest gross returns, net returns and benefit cost ratio were noticed in SKGPA-61. The above results were similar to findings of Revanth (2020) [19]. Among varied fertilizer levels, numerically highest gross returns (Rs. 90150 ha^{-1}), net returns (Rs. 56894 ha^{-1}). and benefit cost ratio (2.71) were recorded with application of 125 per cent RDF. Whereas, lowest value for gross returns, net returns and B:C ratio was recorded with application of 75 per. cent RDF.

Whereas, cost of cultivation (COC) in. 125 per cent RDF was highest because of more cost on additional dose of fertilizer. Gross returns, net returns and B:C ratio of grain amaranth were not influenced significantly due to interaction between genotypes and fertilizer levels (Table 5). Among all the treatment combinations, SKNA-808 with application of 125. per cent RDF recorded significantly highest gross returns, net returns and B:C ratio (Rs. 99650 ha^{-1}, Rs. 66394 ha^{-1} and 2.99, respectively) which was superior over others. Significantly lowest gross returns, net returns and B:C ratio were recorded in genotype SKGPA-61 with 75 per cent RDF among all treatment combinations.

Table 7: Economics of grain amaranth as influenced by genotypes and fertilizer levels

Treatments	Cost of cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C ratio
Genotypes (G)				
G_1- SKGPA-61	31158	64800	33642	2.07
G_2- SKNA-808	31158	91967	60808	2.95
G_3- VL-115	31158	88483	57325	2.83
G_4- Suvarna	31158	86000	54842	2.76
G_5- KBGA-4	31158	82367	51208	2.64
Fertilizer levels (F)				
F_1: 75% RDF	28565	73610	45045	2.57
F_2:100% RDF	31654	84410	52756	2.66
F_3:125% RDF	33256	90150	56894	2.71
Interactions (G x F)				
G_1F_1	28565	57150	28585	2.00
G_1F_2	31654	66900	35246	2.11
G_1F_3	33256	70350	37094	2.12
G_2F_1	28565	82800	54235	2.89
G_2F_2	31654	93450	61796	2.95
G_2F_3	33256	99650	66394	2.99
G_3F_1	28565	77500	48935	2.71
G_3F_2	31654	90850	59196	2.87
G_3F_3	33256	97100	63844	2.92
G_4F_1	28565	77100	48535	2.70
G_4F_2	31654	87150	55496	2.75
G_4F_3	33256	93750	60494	2.82
G_5F_1	28565	73500	44935	2.57
G_5F_2	31654	83700	52046	2.64
G_5F_3	33256	89900	56644	2.70

4. Conclusion
Based on the findings, it can be inferred that the G_2 (SKNA-808) was found to be the most promising genotype among those tested, followed by G_3 (VL-115) because, it responded better to applied fertilizers and provided highest grain yield. There was no statistically significant difference between fertilizer levels at 125 per cent RDF and 100 per cent RDF. As a result, farmers can be advised to use 100 per cent RDF in order to reduce cultivation costs and promote soil health. There is a need to evaluate genotypes that are resistant to shattering and can perform better under adverse conditions such as salinity stress, drought and water logging.

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