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Tillage Practices, Nutrient Levels and Foliar Sprays Effect on Nutrient Content of Redgram [*Cajanus cajan* L.] at Different Growth Stages

Gurrala Suresh[1*], A.V. Nagavani[1], V. Sumathi[1], T. Giridhara Krishna[2] and P. Sudhakar[3]
[1]Department of Agronomy,
Acharya NG Ranga Agricultural University, (Andhra Pradesh), India.
[2]Department of Soil Science and Agricultural Chemistry,
Acharya NG Ranga Agricultural University, (Andhra Pradesh), India.
[3]Department of Crop Physiology,
Acharya NG Ranga Agricultural University, (Andhra Pradesh), India.

(Corresponding author: Gurrala Suresh)*
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ABSTRACT: A field experiment was conducted during the *kharif* seasons of 2019-20 and 2020-21 to study the influence of tillage practices, nutrient levels and foliar sprays on nutrient content of redgram [*Cajanus cajan* (L.)] on sandy loam soil which was low in available nitrogen, medium in available phosphorus and available potassium. The experiment was conducted in a split-split plot design, consisting of three tillage practices in main plots, three nutrient doses in sub-plots and three foliar sprays in sub-sub plots. Higher nutrient content of redgram was recorded with vertical tillage with subsoiler upto 60 cm deep at 1 m interval with application of 125 % RDF along with foliar application of KNO_3 1 % twice with 15 days interval from 50 per cent flowering stage.

Keywords: Tillage practices, nutrient levels, foliar sprays, nutrient content and redgram.

INTRODUCTION

Pulses form an important group of food crops for nutritional security, sustainable crop production and soil health. Redgram is commonly known as tur or arhar and it is the second important pulse crop in the country after gram. The ability of redgram to produce higher economic yield under soil moisture deficit makes it an important crop in rainfed and dryland agriculture. India ranks first in redgram production globally with 3.88 million tonnes cultivated under 4.82 million hectares with productivity of 804 kg ha^{-1} (Anonymous, 2020). In Andhra Pradesh, redgram is grown under rainfed conditions to an extent of 2.23 lakh hectares with an annual production of 1.16 lakh tonnes and productivity of 486 kg ha^{-1} (Directorate of Economics & Statistics, Govt. of A.P., 2020). Redgram has the special morphological characters with respect to deep rooting and drought tolerance that have made this crop adaptable for growing in wide range of unfavourable conditions with uncertain rainfall and varied soil depth. Thus, among the various agronomic practices, tillage has more influence on yield than any other production factor. Tillage pans have high bulk densities, few macropores for roots to grow through mechanical impedance great enough to markedly reduce root growth rate which subsequently reduce nutrients and water uptake by the crop. Subsoil root development can often be increased if the tillage pan is fractured by a subsoiler (Thakur and Kumar, 1999). Subsoil tillage is one of the most effective ways to break up a plough pan, loosening the soil and deepening the topsoil without inverting it, increasing soil permeability. It can also play an important role in promoting water storage in the soil, adjusting the proportion of solid, liquid, and gas of soil, improving the structure and characteristics of topsoil, and improving the ecological environment for root development and root activities that enhance the anti-stress capacity of plants (Cai *et al.*, 2014; Priya, 2017; Ramana *et al*., 2015). Redgram is relatively a long duration crop, basal application of fertilizers alone may be inadequate to meet the nutrient needs of the crop, especially at latter stages of growth. Synchronised flowering in redgram alter the source-sink relationship due to rapid translocation of nutrients from leaves to the developing pods. Additional nutrition through foliar feeding play a vital role in redgram production by stimulating root development, nodulation, energy transformation, metabolic processes and pod setting. It is also recognized that supplementary foliar nutrients usually penetrate the leaf cuticle or stomata and enters the cells facilitating easy, rapid utilization and supplying nutrient instantly during crop growth can improve the mineral status of plants which boost the vegetative growth and reduce flower drop, enhances the supply of photosynthates from source to sink during reproductive stage and pod formation in turn increase the crop yield (Sarkar & Malick, 2009; Thakur *et al*., 2017). The lower yield of redgram is mainly attributed to inadequate and imbalance application of nutrients. The prominent effect of foliar application of nutrients from flowering stage was on reduction in flower shed and flower drop percentage. Hence, the present study was carried out to study the effect of tillage practices, nutrient levels and foliar application on nutrient content of redgram crop.

MATERIALS AND METHODS

A field experiment was conducted at S.V. Agricultural College, Tirupati campus of Acharya N.G. Ranga Agricultural University, Andhra Pradesh during two consecutive *kharif* seasons of 2019-20 and 2020-21 to study the influence of tillage practices, nutrient levels and foliar application on nutrient content of redgram crop. The soil of the experimental field was sandy loam in texture, low in available N, medium in available P and available K. Redgram variety LRG-52 was used for experimentation. The experiment was laid in split-split design with three tillage practices (T_1:Conventional tillage with tractor drawn cultivator, T_2:Ploughing with duck foot cultivator upto a depth of 30 cm and T_3:Vertical tillage with subsoiler upto 60 cm deep at 1.0 m interval) in main plots, three nutrient levels (N_1:75 % RDF, N_2:100 % RDF (20:50:00 kg ha^{-1}) and N_3:125 % RDF) in subplots and three foliar sprays (F_1: Control - No spray, F_2: Borax 0.1 % and F_3: KNO_3 1 %) in sub-sub plots. Three nutrient levels were applied to sub plots as per the prescribed treatments assigned. Entire quantities of N, P_2O_5 and K_2O were applied by placement method at the time of sowing and first foliar spray of borax 0.1% and KNO_3 1 % was done from 50 per cent flowering stage and second spray at 15 days after the first spray.

The plant samples collected at 30, 60, 90, 120 DAS and at harvesting stage of redgram were shade dried and subsequently dried in a hot air oven at 65^0C to a constant weight. The plant samples were ground in willey mill and stored in labelled brown paper bags for analysis. The samples were analysed for nitrogen, phosphorus and potassium content by following standard methods. The nitrogen content in dried plant samples was determined by Micro Kjeldahl distillation method after destroying organic matter by H_2SO_4 and H_2O_2 (Piper, 1966). Plant samples were digested with a tri-acid mixture consisting of (HNO_3: H_2SO_4: $HClO_4$ in 9:4:1). The digest was made upto 100 ml phosphorus content in the triacid digest was determined by developing yellow colour with Barton's reagent. The intensity of yellow colour was determined by using UV visible spectrophotometer at 420 nm (Piper, 1966). Potassium content in the tri-acid extract of plant samples was determined using flame photometer as per the method described by Piper (1966).

RESULTS AND DISCUSSION

Plant nutrient content *viz.,* nitrogen, phosphorus and potassium was estimated in redgram at 30, 60, 90, 120 DAS and at harvest. Content of nutrients differed significantly due to tillage, nutrient management practices, foliar sprays and interactions had no significant influence on content of nutrient in redgram at all the growth stages during both the years of study as well as in pooled mean.

Plant Nitrogen Content. The nitrogen content in plant at all the growth stages of redgram varied conspicuously due to different tillage, nutrient management practices but foliar sprays could exerted significant effect only at harvesting stage, while their interaction was found to be non-significant (Table 1 and 1a).

Nitrogen content at 30 DAS. Various tillage and nutrient management practices could not exert significant influence on plant nitrogen content and their interaction was not statistically traceable during both the years of investigation and in pooled mean. However, nitrogen content in plant was maximum with vertical tillage with subsoiler upto 60 cm depth at 1 m interval (T_3) followed by ploughing with duck foot cultivator upto a depth of 30 cm (T_2) and it was minimum with conventional tillage with tractor drawn cultivator (T_1). Among nutrient management practices studied, 125 % RDF (N_3) resulted in higher nitrogen content followed by 100 % RDF (N_2) and 75 % RDF (N_1).

Nitrogen content at 60, 90 and 120 DAS. The nitrogen content in plant varied conspicuously due to different tillage and nutrient management practices, while their interaction effect was found to be non-significant during both the years of study as well as in pooled mean. The nitrogen content in plant was recorded maximum with vertical tillage with subsoiler upto 60 cm deep at 1 m interval (T_3) which was significantly superior to ploughing with duck foot cultivator upto a depth of 30 cm (T_2) and conventional tillage with tractor drawn cultivator (T_1). The nitrogen content in plant was recorded minimum with conventional tillage with tractor drawn cultivator (T_1). As regards nutrient management practices studied, application of 125 % RDF (N_3) registered higher nitrogen content in plant which was significantly superior to 100 % RDF (N_2) and 75 % RDF (N_1). The difference between latter two treatments was significant.

Nitrogen content at harvest. Different tillage, nutrient management practices and foliar sprays significantly influenced the nitrogen content in plant, while their interaction effect was not statistically traceable during both the years of study as well as in pooled mean. Vertical tillage with subsoiler upto 60 cm deep at 1 m interval (T_3) produced significantly higher nitrogen content in plant which was at par with ploughing with duck foot cultivator upto a depth of 30 cm (T_2) and significantly superior to conventional tillage with tractor drawn cultivator (T_1). Among different nutrient management practices tried, maximum nitrogen content in plant was registered with application of 125 % RDF (N_3) which was significantly superior to 100 % RDF (N_2) and 75 % RDF (N_1).

Table 1: Nitrogen content (%) of redgram as influenced by tillage and nutrient management practices at 30, 60 and 90 DAS.

Treatments	30 DAS		Pooled	60 DAS		Pooled	90 DAS		Pooled
	2019-20	2020-21		2019-20	2020-21		2019-20	2020-21	
Main plots : Tillage practices (T)									
T_1- Conventional tillage with tractor drawn cultivator	1.19	1.13	1.16	1.35	1.25	1.30	1.39	1.26	1.33
T_2- Ploughing with duck foot cultivator upto a depth of 30 cm	1.23	1.17	1.20	1.39	1.33	1.36	1.43	1.34	1.39
T_3- Vertical Tillage with subsoiler upto 60 cm deep at 1.0 m interval	1.27	1.20	1.24	1.44	1.38	1.41	1.48	1.37	1.43
SEm ±	0.022	0.020	0.021	0.013	0.013	0.013	0.013	0.013	0.013
CD (P = 0.05)	NS	NS	NS	0.05	0.05	0.05	0.05	0.05	0.05
Sub plots : Nutrient management practices (N)									
N_1- 75 % RDF	1.19	1.13	1.16	1.31	1.23	1.27	1.35	1.23	1.29
N_2- 100 % RDF	1.23	1.17	1.20	1.39	1.32	1.36	1.44	1.33	1.39
N_3- 125 % RDF	1.27	1.21	1.24	1.47	1.41	1.44	1.52	1.42	1.47
SEm ±	0.04	0.036	0.038	0.018	0.018	0.018	0.019	0.018	0.019
CD (P = 0.05)	NS	NS	NS	0.06	0.06	0.060	0.06	0.06	0.06
Sub sub plots : Foliar sprays (F)									
F_1- Control (No spray)	1.22	1.16	1.19	1.39	1.32	1.36	1.43	1.32	1.38
F_2- Borax 0.1 %	1.23	1.17	1.20	1.39	1.32	1.36	1.43	1.33	1.38
F_3- KNO_3 1 %	1.23	1.17	1.20	1.39	1.32	1.36	1.44	1.33	1.39
SEm ±	0.019	0.018	0.019	0.022	0.02	0.021	0.023	0.021	0.022
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction									
T × N									
SEm ±	0.065	0.062	0.064	0.032	0.031	0.032	0.033	0.031	0.032
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
T × F									
SEm ±	0.033	0.032	0.033	0.038	0.037	0.038	0.039	0.037	0.038
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
N × F									
SEm ±	0.033	0.032	0.033	0.038	0.037	0.038	0.039	0.037	0.038
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
T × N × F									
SEm ±	0.056	0.054	0.055	0.066	0.064	0.065	0.068	0.065	0.067
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 1a: Nitrogen content (%) of redgram as influenced by tillage and nutrient management practices at 120 DAS and at harvest.

Treatments	120 DAS		Pooled	At harvest		Pooled
	2019-20	2020-21		2019-20	2020-21	
Main plots : Tillage practices (T)						
T_1- Conventional tillage with tractor drawn cultivator	1.41	1.30	1.36	1.35	1.28	1.32
T_2- Ploughing with duck foot cultivator upto a depth of 30 cm	1.51	1.39	1.45	1.47	1.39	1.43
T_3- Vertical Tillage with subsoiler upto 60 cm deep at 1.0 m interval	1.56	1.43	1.50	1.54	1.46	1.50
SEm ±	0.017	0.015	0.016	0.033	0.032	0.033
CD (P = 0.05)	0.07	0.06	0.07	0.13	0.12	0.13
Sub plots : Nutrient management practices (N)						
N_1- 75 % RDF	1.39	1.28	1.34	1.35	1.29	1.32
N_2- 100 % RDF	1.50	1.38	1.44	1.46	1.38	1.42
N_3- 125 % RDF	1.59	1.46	1.53	1.54	1.47	1.51
SEm ±	0.03	0.028	0.029	0.023	0.022	0.023
CD (P = 0.05)	0.09	0.09	0.090	0.07	0.07	0.07
Sub sub plots : Foliar sprays (F)						
F_1- Control (No spray)	1.48	1.36	1.42	1.38	1.31	1.35
F_2- Borax 0.1 %	1.49	1.37	1.43	1.45	1.37	1.41
F_3- KNO_3 1 %	1.50	1.38	1.44	1.53	1.45	1.49
SEm ±	0.023	0.021	0.022	0.026	0.025	0.026
CD (P = 0.05)	NS	NS	NS	0.07	0.07	0.07
Interaction						
T × N						
SEm ±	0.052	0.048	0.050	0.039	0.037	0.038
CD (P = 0.05)	NS	NS	NS	NS	NS	NS
T × F						
SEm ±	0.040	0.037	0.039	0.045	0.043	0.044
CD (P = 0.05)	NS	NS	NS	NS	NS	NS
N × F						
SEm ±	0.040	0.037	0.039	0.045	0.043	0.044
CD (P = 0.05)	NS	NS	NS	NS	NS	NS
T × N × F						
SEm ±	0.069	0.064	0.067	0.078	0.074	0.076
CD (P = 0.05)	NS	NS	NS	NS	NS	NS

Difference between the latter two nutrient management practices was statistically comparable with each other and lower nitrogen content in plant was registered with application of 75 % RDF (N_1). Foliar application of KNO_3 1 % (F_3) with 15 days interval from 50 per cent flowering stage recorded higher nitrogen content in plant at harvest followed by foliar application of borax 0.1 % (F_2) and control (No spray) (F_1) with significant disparity between any two of the three foliar sprays during first year. In the second year, foliar application of KNO_3 1 % (F_3) recorded the higher nitrogen content in plant which was comparable with foliar application of borax 0.1 % (F_2) and significantly superior to control (No spray) (F_1).

Phosphorus Content. The Phosphorus content in plant at all the growth stages of redgram varied conspicuously due to different tillage, nutrient management practices but foliar sprays, as well as their interaction was found to be non-significant during both the years of study inclusive of pooled mean (Table 2 and 2a).

Phosphorus content at 30 DAS. The phosphorus content in plant was not significantly influenced by different tillage, nutrient management practices and their interaction during both the instances of investigation inclusive of pooled mean. However, phosphorus content in plant was maximum with vertical tillage with subsoiler upto 60 cm depth at 1 m interval (T_3) followed by ploughing with duck foot cultivator upto a depth of 30 cm (T_2). Conventional tillage with tractor drawn cultivator (T_1) recorded the minimum phosphorus content in plants. Phosphorus content in plant was recorded higher with 125 % RDF (N_3) followed by 100 % RDF (N_2) and 75 % RDF (N_1) recorded the lower phosphorus content in redgram plants.

Phosphorus content at 60, 90 and 120 DAS. Different tillage and nutrient management practices significantly influence the phosphorus content in plant, while their interaction effect was not statistically traceable during both the years of study as well as in pooled mean. The highest phosphorus content in plant was due to vertical tillage with subsoiler upto 60 cm deep at 1 m interval (T_3), followed by ploughing with duck foot cultivator upto a depth of 30 cm (T_2) and conventional tillage with tractor drawn cultivator (T_1) with significant disparity between any two of the three tillage practices in the order of descent. Successive increase in fertilizer dose from 75 % RDF to 125 % RDF progressively increased the phosphorus content in plant. The highest phosphorus content in plant was with the highest dose of 125 % RDF (N_3) followed by 100 % RDF (N_2) and significantly superior to 75 % RDF (N_1) in the order of descent with significant disparity with each other.

Table 2: Phosphorus content (%) of redgram as influenced by tillage and nutrient management practices at 30, 60 and 90 DAS.

Treatments	30 DAS			60 DAS			90 DAS		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
Main plots : Tillage practices (T)									
T_1- Conventional tillage with tractor drawn cultivator	0.159	0.145	0.152	0.165	0.149	0.157	0.179	0.188	0.184
T_2- Ploughing with duck foot cultivator upto a depth of 30 cm	0.199	0.182	0.191	0.210	0.189	0.200	0.225	0.237	0.231
T_3- Vertical Tillage with subsoiler upto 60 cm deep at 1.0 m interval	0.244	0.223	0.234	0.263	0.242	0.253	0.280	0.296	0.288
SEm ±	0.0006	0.0050	0.0028	0.0084	0.0080	0.0082	0.0070	0.0103	0.0087
CD (P = 0.05)	NS	NS	NS	0.033	0.031	0.032	0.027	0.041	0.034
Sub plots : Nutrient management practices (N)									
N_1- 75 % RDF	0.185	0.169	0.177	0.192	0.174	0.183	0.192	0.192	0.192
N_2- 100 % RDF	0.202	0.185	0.194	0.218	0.198	0.208	0.231	0.245	0.238
N_3- 125 % RDF	0.215	0.197	0.206	0.228	0.207	0.218	0.260	0.283	0.272
SEm ±	0.0005	0.001	0.0008	0.0030	0.0028	0.0029	0.0044	0.0218	0.0131
CD (P = 0.05)	NS	NS	NS	0.009	0.009	0.009	0.014	0.067	0.041
Sub sub plots : Foliar sprays (F)									
F_1- Control (No spray)	0.199	0.182	0.191	0.211	0.192	0.202	0.227	0.240	0.234
F_2- Borax 0.1 %	0.201	0.183	0.192	0.211	0.191	0.201	0.227	0.239	0.233
F_3- KNO_3 1 %	0.202	0.184	0.193	0.216	0.197	0.207	0.229	0.241	0.235
SEm ±	0.0004	0.0003	0.0004	0.0024	0.0022	0.0023	0.0023	0.0024	0.0024
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction									
T × N									
SEm ±	0.0040	0.0040	0.0040	0.0050	0.0050	0.0050	0.0080	0.0380	0.0230
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
T × F									
SEm ±	0.0030	0.0030	0.0030	0.0040	0.0040	0.0040	0.0040	0.0040	0.0040
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
N × F									
SEm ±	0.0003	0.0003	0.0003	0.0040	0.0040	0.0040	0.0040	0.0040	0.0040
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
T × N × F									
SEm ±	0.0004	0.0004	0.0004	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 2a: Phosphorus content (%) of redgram as influenced by tillage and nutrient management practices at 120 DAS and at harvest.

Treatments	120 DAS		Pooled	At harvest		Pooled
	2019-20	2020-21		2019-20	2020-21	
Main plots : Tillage practices (T)						
T_1- Conventional tillage with tractor drawn cultivator	0.172	0.159	0.166	0.157	0.146	0.152
T_2- Ploughing with duck foot cultivator upto a depth of 30 cm	0.218	0.200	0.209	0.202	0.188	0.195
T_3- Vertical Tillage with subsoiler upto 60 cm deep at 1.0 m interval	0.272	0.250	0.261	0.257	0.239	0.248
SEm ±	0.0109	0.0101	0.0105	0.0096	0.0089	0.0093
CD (P = 0.05)	0.043	0.039	0.041	0.038	0.035	0.037
Sub plots : Nutrient management practices (N)						
N_1- 75 % RDF	0.186	0.171	0.179	0.168	0.157	0.163
N_2- 100 % RDF	0.221	0.204	0.213	0.198	0.184	0.191
N_3- 125 % RDF	0.255	0.235	0.245	0.249	0.232	0.241
SEm ±	0.0127	0.0117	0.0122	0.0189	0.0176	0.0183
CD (P = 0.05)	0.039	0.036	0.038	0.058	0.054	0.056
Sub sub plots : Foliar sprays (F)						
F_1- Control (No spray)	0.221	0.203	0.212	0.206	0.191	0.199
F_2- Borax 0.1 %	0.220	0.202	0.211	0.204	0.190	0.197
F_3- KNO_3 1 %	0.222	0.204	0.213	0.206	0.191	0.199
SEm ±	0.0022	0.0020	0.0021	0.0021	0.0020	0.0021
CD (P = 0.05)	NS	NS	NS	NS	NS	NS
Interaction						
T x N						
SEm ±	0.022	0.0200	0.0210	0.0330	0.0300	0.0315
CD (P = 0.05)	NS	NS	NS	NS	NS	NS
T × F						
SEm ±	0.0035	0.0040	0.0038	0.0040	0.0030	0.0035
CD (P = 0.05)	NS	NS	NS	NS	NS	NS
N × F						
SEm ±	0.0035	0.0040	0.0038	0.0040	0.0030	0.0035
CD (P = 0.05)	NS	NS	NS	NS	NS	NS
T × N × F						
SEm ±	0.0060	0.0060	0.0060	0.0060	0.0060	0.0060
CD (P = 0.05)	NS	NS	NS	NS	NS	NS

Phosphorus content at harvest. The phosphorus content in redgram plants varied conspicuously due to tillage, nutrient management practices, foliar sprays and their interaction was found to be non-significant during both the years of investigation and in pooled mean. The highest phosphorus content in plant was due to vertical tillage with subsoiler upto 60 cm deep at 1 m interval (T_3) followed by ploughing with duck foot cultivator upto a depth of 30 cm (T_2) and conventional tillage with tractor drawn cultivator (T_1) with significant disparity between any two of the three tillage practices in the order of descent. The phosphorus content in plant was higher with application of 125 % RDF (N_3) which was however on par with 100 % RDF (N_2) and significantly superior to 75 % RDF (N_1). The latter two treatments were comparable during both the years of investigation. Foliar application of KNO_3 1 % (F_3) twice with 15 days interval from 50 per cent flowering stage was registered higher phosphorus content in plant followed by borax 0.1 % (F_2) and control (No spray) (F_1) with no significant disparity among the treatments.

Potassium Content. The potassium content in plant at all the growth stages of redgram varied conspicuously due to different tillage, nutrient management practices and foliar sprays exerted significant effect only at harvesting stage, while their interaction was found to be non-significant during both the years of study as well as in pooled mean (Table 3 and 3a).

Potassium content at 30 DAS. The potassium content was not varied by different tillage and nutrient management practices imposed in redgram, while their interaction effect was not statistically traceable during both the years of investigation and in pooled mean. Tillage and nutrient management practices could not exert significant influence on potassium content in plant. However, potassium content in plant was maximum with vertical tillage with subsoiler upto 60 cm depth at 1 m interval (T_3) followed by ploughing with duck foot cultivator upto a depth of 30 cm (T_2). Conventional tillage with tractor drawn cultivator (T_1) recorded the minimum potassium content. Higher potassium content in plant was observed with 125 % RDF (N_3) followed by 100 % RDF (N_2) and 75 % RDF (N_1) with no significant disparity among the nutrient management practices.

Potassium content at 60, 90 and 120 DAS. The potassium content was invariable altered by different tillage and nutrient management practices imposed in redgram, while their interaction effect was not statistically traceable during both the years of investigation and in pooled mean. The potassium content in plant was higher with vertical tillage with subsoiler upto 60 cm depth at 1 m interval (T_3), which was however comparable with ploughing with duck foot cultivator upto a depth of 30 cm (T_2) and significantly superior to conventional tillage with tractor drawn cultivator (T_1). The difference between ploughing with duck foot cultivator upto a depth of 30 cm (T_2) and conventional tillage with tractor drawn cultivator (T_1) was comparable. Higher potassium content in plant was noticed with application 125 % RDF (N_3), which was however comparable with 100 % RDF (N_2) and significantly superior to 75 % RDF (N_1). Lower potassium content in plant was recorded with 75 % RDF (N_1). Difference between latter two nutrient management practices was non-significant.

Potassium content at harvest. The potassium content in redgram plants varied conspicuously due to tillage, nutrient management practices and foliar sprays, while their interaction effect was non-significant during both the years of investigation and in pooled mean. The potassium content in plant was higher with vertical tillage with subsoiler upto 60 cm depth at 1 m interval (T_3) which was however comparable with ploughing with duck foot cultivator upto a depth of 30 cm (T_2) and significantly superior to conventional tillage with tractor drawn cultivator (T_1). Higher potassium content in plant was noticed with application 125 % RDF (N_3), which was however comparable with 100 % RDF (N_2) and significantly superior to 75 % RDF (N_1). Lower potassium content in plant was recorded with 75 % RDF (N_1). Difference between latter two nutrient management practices was non-significant. Foliar application of KNO_3 1 % (F_3) with 15 days interval from 50 per cent flowering stage recorded higher potassium content in plant at harvest, which was significantly superior to foliar application of borax 0.1 % (F_2) and control (No spray) (F_1). The latter two treatments were comparable.

Among tillage practices studied during both the years of experiment maximum nutrient content of nitrogen, phosphorus and potassium at all the growth stages of redgram was recorded with vertical tillage with subsoiler upto 60 cm depth at 1 m interval (T_3) due to more availability of nutrients and moisture in vertical tillage treatments that favoured more mineralisation and translocation of nutrients especially phosphorous and potassium which helped in higher uptake of nutrients compared to deep ploughing with duck foot cultivator and conventional with tractor drawn cultivator. Similar results stating that significant effect of vertical tillage on nutrient uptake by plants were reported by Mathukia and Khanpara (2007); Cai *et al*., (2014); Priya (2017). Also due to higher nitrogen uptake might be due to adequate availability of moisture and nitrogen, phosphorus and potassium nutrients throughout the growth favoured more mineralisation and translocation of nutrients (Pal & Phogat, 2005; Ramana *et al*., 2015). Lower nutrient content was due to less availability of nutrients, moisture and less root exploitation for the plants.

Among nutrient management practices studied during both the years of study, higher nitrogen, phosphorus and potassium content at 30, 60, 90, 120 DAS and at harvest was obtained with 125 % RDF application, which was might be due to higher availability of nitrogen, phosphorus and potassium. These results are in agreement with the findings of Elayaraja and Singarvel (2009); Pacharne *et al*., (2015); Nagamani *et al*., (2020). Minimum amount of nitrogen, phosphorus and potassium content was measured with 75 % RDF treatment where less fertilizers were applied which was significantly lower than with rest of the nutrient management practices tried, due to less availability of nutrients for the plants during both the years of study (Nagamani, 2015; Priya, 2017).

Table 3: Potassium content (%) of redgram as influenced by tillage and nutrient management practices at 30, 60 and 90 DAS.

Treatments	30 DAS		Pooled	60 DAS		Pooled	90 DAS		Pooled
	2019-20	2020-21		2019-20	2020-21		2019-20	2020-21	
Main plots : Tillage practices (T)									
T_1- Conventional tillage with tractor drawn cultivator	1.19	1.16	1.18	1.22	1.12	1.17	1.35	1.27	1.31
T_2- Ploughing with duck foot cultivator upto a depth of 30 cm	1.25	1.20	1.23	1.26	1.16	1.21	1.42	1.34	1.38
T_3- Vertical Tillage with subsoiler upto 60 cm deep at 1.0 m interval	1.29	1.24	1.27	1.30	1.20	1.25	1.50	1.41	1.46
SEm ±	0.013	0.016	0.015	0.016	0.015	0.016	0.021	0.019	0.020
CD (P = 0.05)	NS	NS	NS	0.06	0.06	0.06	0.08	0.08	0.08
Sub plots : Nutrient management practices (N)									
N_1- 75 % RDF	1.21	1.12	1.17	1.18	1.08	1.13	1.34	1.26	1.30
N_2- 100 % RDF	1.25	1.19	1.22	1.25	1.14	1.20	1.41	1.33	1.37
N_3- 125 % RDF	1.26	1.28	1.27	1.35	1.24	1.30	1.53	1.43	1.48
SEm ±	0.036	0.039	0.038	0.041	0.038	0.040	0.05	0.045	0.048
CD (P = 0.05)	NS	NS	NS	0.13	0.12	0.12	0.15	0.14	0.15
Sub sub plots : Foliar sprays (F)									
F_1- Control (No spray)	1.26	1.14	1.20	1.20	1.10	1.15	1.36	1.28	1.32
F_2- Borax 0.1 %	1.23	1.19	1.21	1.26	1.15	1.21	1.42	1.34	1.38
F_3- KNO_3 1 %	1.24	1.25	1.25	1.32	1.21	1.27	1.49	1.40	1.45
SEm ±	0.028	0.034	0.031	0.036	0.033	0.035	0.040	0.038	0.04
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction									
T × N									
SEm ±	0.063	0.068	0.066	0.072	0.066	0.069	0.083	0.078	0.081
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
T × F									
SEm ±	0.057	0.060	0.059	0.063	0.058	0.061	0.069	0.065	0.067
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
N × F									
SEm ±	0.057	0.060	0.059	0.063	0.058	0.061	0.069	0.065	0.067
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
T × N × F									
SEm ±	0.101	0.103	0.102	0.109	0.100	0.105	0.120	0.113	0.117
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 3a: Potassium content (%) of redgram as influenced by tillage and nutrient management practices at 120 DAS and at harvest.

Treatments	120 DAS		Pooled	At harvest		Pooled
	2019-20	2020-21		2019-20	2020-21	
Main plots : Tillage practices (T)						
T_1- Conventional tillage with tractor drawn cultivator	1.25	1.16	1.21	1.22	1.15	1.19
T_2- Ploughing with duck foot cultivator upto a depth of 30 cm	1.32	1.23	1.28	1.29	1.24	1.27
T_3- Vertical Tillage with subsoiler upto 60 cm deep at 1.0 m interval	1.40	1.30	1.35	1.37	1.29	1.33
SEm ±	0.028	0.026	0.027	0.027	0.026	0.027
CD (P = 0.05)	0.11	0.10	0.11	0.11	0.10	0.11
Sub plots : Nutrient management practices (N)						
N_1- 75 % RDF	1.25	1.16	1.21	1.22	1.16	1.19
N_2- 100 % RDF	1.31	1.22	1.27	1.29	1.22	1.26
N_3- 125 % RDF	1.41	1.31	1.36	1.38	1.30	1.34
SEm ±	0.04	0.037	0.039	0.04	0.024	0.032
CD (P = 0.05)	0.12	0.11	0.12	0.12	0.07	0.10
Sub sub plots : Foliar sprays (F)						
F_1- Control (No spray)	1.26	1.18	1.22	1.24	1.17	1.21
F_2- Borax 0.1 %	1.32	1.23	1.28	1.29	1.22	1.26
F_3- KNO_3 1 %	1.38	1.29	1.34	1.36	1.30	1.33
SEm ±	0.037	0.035	0.036	0.018	0.022	0.020
CD (P = 0.05)	NS	NS	NS	0.07	0.06	0.07
Interaction						
T × N						
SEm ±	0.069	0.064	0.067	0.067	0.042	0.055
CD (P = 0.05)	NS	NS	NS	NS	NS	NS
T × F						
SEm ±	0.065	0.060	0.063	0.063	0.039	0.051
CD (P = 0.05)	NS	NS	NS	NS	NS	NS
N × F						
SEm ±	0.065	0.060	0.063	0.063	0.039	0.051
CD (P = 0.05)	NS	NS	NS	NS	NS	NS
T × N × F						
SEm ±	0.112	0.104	0.108	0.110	0.067	0.089
CD (P = 0.05)	NS	NS	NS	NS	NS	NS

Higher nitrogen, phosphorus and potassium content was registered with foliar application of KNO_3 1 % (F_3) twice with 15 days interval from 50 per cent flowering stage due to improved nutritional environment in the rhizosphere and plant system, potassium nitrate may help the plant to pump sucrose through roots that attracts soil microbes consequently that promoted better nutrient uptake by the roots. These results are in accordance with Sarkar and Pal, (2006); Sarkar and Malik (2009); Raj and Mallick (2017); Krishna and Kaleeswari (2018); Laishram *et al.,* (2020).

CONCLUSION

From the present investigation, it can be concluded that vertical tillage with subsoiler upto 60 cm deep at 1 m interval with application of 125 % RDF and with foliar application of KNO_3 1 % twice with 15 days interval from 50 per cent flowering stage resulted in higher nutrient content under the prevailing condition.

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