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KH Kharabe
Agriculture Research Station, Achalpur, Maharashtra, India

YD Charjan
Agriculture Research Station, Achalpur, Maharashtra, India

RS Wankhade
Agriculture Research Station, Achalpur, Maharashtra, India

Corresponding Author:
KH Kharabe
Agriculture Research Station, Achalpur, Maharashtra, India

Effect of nutrient management on growth and yield of pigeonpea

KH Kharabe, YD Charjan and RS Wankhade

Abstract
Experiment was conducted at Agronomy Farm, College of Agriculture, Nagpur under Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, situated at 21° 10 North latitude and 79° 19 East longitudes with a subtropical climate. The topography of experimental plot was levelled and the soil was black in colour, fairly deep, well drained clayey in texture, low in nitrogen, low in available phosphorus, high in available potash and low available in sulphur and alkaline in reaction. The experiment was designed in randomised block design with three replications and twelve treatments i.e. 100% RDF (25:50:00 kg ha^{-1}), 125%RDF (31.5:62:5:00 kg ha^{-1}), 150% RDF (37.5:75:00 kg ha^{-1}), 100% RDF + 10 kg S ha^{-1}, 125% RDF + 10 kg S ha^{-1}, 150% RDF + 10 kg S ha^{-1}, 100% RDF + 20 kg S ha^{-1}, 125% RDF + 20 kg S ha^{-1}, 150% RDF + 20 kg S ha^{-1}, 100% RDF + 30 kg S ha^{-1}, 125% RDF + 30 kg S ha^{-1}, 150% RDF + 30 kg S ha^{-1}. Pigeonpea variety PKV-Tara was used as test crop.
All yield contributing characters such as no. of pods plant^{-1}, no. of seeds pod, seed yield kg ha^{-1}, straw yield kg ha^{-1}, and harvest index were significantly influenced by fertilizer application. Maximum value of growth and yield contributing character were recorded with application of 150% RDF + 30 kg S ha^{-1} and it was at par with 125% RDF + 30 kg S ha^{-1} with also 100% RDF + 30 kg S ha^{-1}. Highest values of seed yield 1880 kg ha^{-1}, straw yield 5552 kg ha^{-1}, harvest index 25.40 was recorded with 150% RDF + 30 kg S ha^{-1}. Nutrient uptake by crop was increased significantly with increase in levels of sulphur as well as recommended dose of fertilizer. Total uptake of nutrients significantly more with application of 150% RDF + 30 kg S ha^{-1}.

Keywords: Nutrient, management, yield, pigeonpea, experiment

Introduction

India ranks first in both area and production of pulses with 35% of world acreage and 29% world production. Our country accounts for pulse production around 25.23 million tons with 29.99 million ha (Anonymous, 2014) [2].

Pigeonpea is short lived perennial shrub that is traditionally cultivated as annual crop in developing countries. Among kharif grain legumes, it occupies first place. These crops have wide variations in the morphological characters, root system and nutrient requirements; thereby this crop possess differential capability to utilize plant nutrients from different soil layers, resulting in better use efficiency of the applied nutrient and residual fertility. It occupies about 15% of the total pulse area and accounts for 17% of the pulse production of the country. Pigeon pea is cultivated over an area of 4.4 million ha with 4.2 million tons. The national productivity is 960 kg ha^{-1}. In Maharashtra total area under pigeon pea is about 1.229 million ha and production 1.073 million tons which is one fourth of total pigeon pea production in our country. Pigeonpea used as spilt pulse “dal”. It is rich in iron, iodine and essential amino-acid like lysine, cysteine and arginine. In complete both grains and stalk of legumes contain good amount of protein and minerals, which are essential for growth, and development of human and animal body. It is also used for milch cattle. Its straw is also palatable and green leaves may be used as fodder. The selected variety PKV-Tara was developed by PDKV. It is suitable for rain fed agriculture because it is drought tolerant and resistant to insect pest and needs minimum input to produce reasonable yields. It is suitable for cultivation in Andhra Pradesh, Karnataka, Maharashtra, Madhya Pradesh and other states too.

Pigeonpea is a leguminous crop, but its yield potential depends on soil fertility of the soil which is being neglected. The reason behind limited productivity of pigeon pea is application of inputs is negligible. In Maharashtra, cultivation of traditional unrecognized variety of pigeon pea is old practice but use of improved variety of pigeon peas is generative approach.

Fertilizers, a key component of management influence the growth, development and yield. As full plant expression in pigeon pea can be achieved with proper and definite fertilizer schedule.

Growth and yield determination of pigeon pea are favorably influenced by a recommended dose of nitrogen, phosphorus and sulphur with respective contentment source. Sulphur is now known as fourth major nutrient in addition to nitrogen, phosphorus and potassium. Sulphur is involved in the chlorophyll formation and encourages vegetative growth. Sulphur involved various oxidizing metabolism in soil and plant nutrition also required for enzymatic action. It is also involved in synthesis of methionine, cysteine, cysteine vitamins like thiamine and biotin. Sulphur is mostly required by oilseed crops and secondly by legumes. Nitrogen is an essential element for structure of chloroplast and in the process of photosynthesis in leaves, has a direct role for production of material grain filling.

Its productivity is very low due to poor soil fertility especially phosphorus and sulphur. Phosphorus affects seed germination, cell division, flowering, fruiting, synthesis of fat, starch and in fact most biochemical activities. Sulphur and Phosphorus have systematic and antagonistic effect with each other on their varying levels of application as well as level of availability in the soil (Gowda *et al.*, 1985)

The deficiency of sulphur in soil and plant are being reported from several parts of the country and also in Maharashtra. Sulphur deficiency is increased due to intensive cropping, use of high yielding varieties and continuous use of sulphur free, high analysis fertilizers. Systemic factor such as fertilizer management is important for improving pigeonpea yield.

Methodology

The present experiment was conducted during *kharif* season of 2019-2020 in plot no. 09 at the Experimental Farm of Agronomy section, College of Agriculture, Nagpur, (Maharashtra), Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The soil was medium black in color, fairly deep, well drained and clayey in texture, poor in available nitrogen, medium in available phosphorus, high in available potash and poor available sulphur content in soil and alkaline in reaction. Nagpur is located at latitude at 20^{o} 10' north and longitude 79^{o} 19' east at the elevation of 321 m above mean sea level (MSL) and lies under sub-tropical zone with assured but variable rainfall in *Kharif* season, normally cool *rabi* and associated with hot and dry summer. The total rainfall during crop growth period from July, 2019 to February, 2020 was 1149.7 mm and there are 48 rainy days. The experiment was laid out in Randomised Block Design replicated thrice. The harvest index was calculated from each plot. It is calculated by grain yield divided by grain yield plus straw yield and multiplied by 100.

$$\text{Harvest index (\%)} = \frac{\text{Economical yield (kg ha}-1)}{\text{Biological yield (kg ha}-1)} \times 100$$

The chemical analysis of plant was done after harvest for determining the nutrient uptake by plant. The available nitrogen, phosphorus, potassium and sulphur from soil was estimated by alkaline permanganate (Subbiah and Asija, 1956) [13], olsen's (Jackson, 1973), flame photometer (Jackson, 1973) and turbido - metric method given by Chesnin and Yien (1951) [3].

Results and Discussion

Yield attributes significantly more no. of pods plant^{-1} was observed under the treatment receiving 150% RDF + 30 kg sulphur ha^{-1} produced maximum no. of pods plant^{-1} (141.1) and it was statistically at par with 125% RDF + 30 sulphur kg ha^{-1}(138.24) and 100% RDF + 30 kg sulphur ha^{-1} (136.66). Increasing levels of sulphur from 0 to 30 kg ha^{-1} with increased levels of RDF increased the no. of pods of plant ranging from 104.89 to 141.1 showing highest value i.e. 141.1 in treatment receiving 150% RDF + 30 kg sulphur ha^{-1}.The lowest mean no. of branches of plant was recorded in 100% RDF is 104.89. These results increased in total biomass production and their translocation in plant parts. Supply of sulphur in adequate and appropriate amount also helps in flower primordial initiation. These results were in conformity with findings of Akter *et al.* (2013) [1].

The treatment 150% RDF + 30 kg sulphur ha^{-1} produced maximum no. of seeds pod^{-1} (3.72) and it was statistically at par with 125% RDF + 30 sulphur kg ha^{-1} (3.69) and 100% RDF + 30 kg sulphur ha^{-1} (3.64). Increasing levels of sulphur from 0 to 30 kg ha^{-1} with increased levels of RDF increased the no. of seeds pod^{-1} ranging from 3.22 to 3.72 showing highest value i.e. 3.72 in treatment receiving 150% RDF + 30 kg sulphur ha^{-1}. Every increase in phosphorus as well as sulphur levels brought about significant increase in no. of seeds might be due to better assimilation of photosynthates similar results found by Kumar *et al.* (2014) [6].

Table 1: Number pods plant^{-1}, no. of seed pod^{-1}, seed yield plant^{-1} (g) and test weight (g) as influenced by various treatments.

Treatment	No. of pods plant^{-1}	No. of seeds pod^{-1}	Seed Yield plant^{-1} (g)	Test weight (g)
T_1 - 100% RDF (25:50:00 kg ha^{-1})	104.89	3.22	33.47	9.75
T_2 - 125% RDF (31.25:62.5:00 kg ha^{-1})	110.2	3.31	35.98	9.8
T_3 - 150% RDF (37.5:70:00 kg ha^{-1})	119.65	3.42	40.7	9.87
T_4 - 100% RDF + 10 kg S ha^{-1}	106.3	3.27	34.85	9.77
T_5 - 125% RDF + 10 kg S ha^{-1}	116.4	3.38	38.4	9.83
T_6 - 150% RDF + 10 kg S ha^{-1}	127.5	3.53	44.96	9.96
T_7 - 100% RDF + 20 kg S ha^{-1}	112.3	3.34	36.86	9.81
T_8 - 125% RDF + 20 kg S ha^{-1}	123.4	3.48	43.65	9.91
T_9 - 150% RDF + 20 kg S ha^{-1}	131.4	3.59	47.58	9.98
T_{10} - 100% RDF + 30 kg S ha^{-1}	135.66	3.64	49.62	10.01
T_{11} - 125% RDF + 30 kg S ha^{-1}	138.24	3.68	52.34	10.03
T_{12} - 150% RDF + 30 kg S ha^{-1}	141.1	3.72	53.52	10.05
S.E (m) ±	2.77	0.04	1.32	0.09
C.D at 5%	7.91	0.11	3.91	NS
G. M.	122.25	3.46	42.73	9.89

The treatment receiving 150% RDF + 30 kg sulphur ha^{-1} produced maximum seed yield $plant^{-1}$ (53.52) and it was statistically at par with 125% RDF + 30 sulphur kg ha^{-1} (52.34) and 100% RDF + 30 kg sulphur ha^{-1} (49.62). Increasing levels of sulphur from 0 to 30 kg ha^{-1} with increasing levels of RDF increased the seed yield $plant^{-1}$ ranging from 33.47 to 56.92 showing highest value i.e. 56.92 in treatment receiving 150% RDF + 30 kg sulphur ha^{-1}.The lowest seed yield $plant^{-1}$ was recorded in 100% RDF is (33.47). Significant increase in seed yield $plant^{-1}$ due to improved nitrogenage activity and nitrogen fixation which increased dry matter production that is translocated to seed production and with application of sulphur various processes such as cell division, flowering and fruiting, water relations that ultimately yielded increase in seed yield $plant^{-1}$. (Punse *et al.*, 2017)

The treatment receiving 150% RDF + 30 kg sulphur ha^{-1} produced maximum test weight (10.05 g). The increased in test weight of pigeon pea may be due to the availability of SO_4 during all growth stages of crop with application of elemental sulphur as reported by reported by Palsaniya and Ahlawat (2009) [9] in pigeon pea.

The treatment 150% RDF + 30 kg sulphur ha^{-1} produced maximum seed yield (1880 kg ha^{-1}) and it was statistically at par with 125% RDF + 30 sulphur kg ha^{-1} (1830 kg ha^{-1}) and 100% RDF + 30 kg sulphur ha^{-1} (1733 kg ha^{-1}). Increasing levels of sulphur from 0 to 30 kg ha^{-1} with increased levels of RDF increased the seed yield ranging from 1123 kg ha^{-1} to 1880 kg ha^{-1} showing highest value i.e. 1880 kg ha^{-1} in treatment receiving 150% RDF + 30 kg sulphur ha^{-1}. The improvement in seed yield with application of phosphorus fertilizers could be ascribed to its pivotal role in roots development, photosynthesis, energy transfer reaction, biological nitrogen fixation processes, again application of sulphur might be shown direct role of sulphur in root inoculation and enzymatic role in zinc and molybdenum in various metabolic processes in pigeon pea showing significance in increasing seed yield, same was observed by Singh *et al.* (2017) [12].

Table 2: Mean seed and straw yield (kg ha^{-1}), biological yield (kg ha^{-1}) and harvest index (%) as influenced by various treatments.

Treatment	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
T_1 - 100% RDF (25:50:00 kg ha^{-1})	1123	3781	4945	22.71
T_2 - 125% RDF (31.25:62.5:00 kg ha^{-1})	1209	3979	5172	23.36
T_3 - 150% RDF (37.5:70:00 kg ha^{-1})	1385	4433	5797	23.88
T_4 - 100% RDF + 10 kg S ha^{-1}	1197	3983	5210	22.36
T_5 - 125% RDF + 10 kg S ha^{-1}	1309	4263	5562	23.54
T_6 - 150% RDF + 10 kg S ha^{-1}	1529	4736	6227	24.54
T_7 - 100% RDF + 20 kg S ha^{-1}	1248	4086	5309	23.51
T_8 - 125% RDF + 20 kg S ha^{-1}	1456	4637	6043	24.09
T_9 - 150% RDF + 20 kg S ha^{-1}	1641	5028	6639	24.17
T_{10} - 100% RDF + 30 kg S ha^{-1}	1733	5227	6921	25.04
T_{11} - 125% RDF + 30 kg S ha^{-1}	1830	5489	7269	25.17
T_{12} - 150% RDF + 30 kg S ha^{-1}	1880	5552	7402	25.40
S.E (m) ±	62.18	136.2	183.5	_
C.D at 5%	177.24	367.74	524.41.27	_
G. M.	1461	4551	6041	23.98

The straw yield differed significantly among the treatments. The treatment receiving 150% RDF + 30 kg sulphur ha^{-1} produced maximum straw yield (5552 kg ha^{-1}) and it was statistically at par with 125% RDF + 30 sulphur kg ha^{-1} (5489 kg ha^{-1}) and 100% RDF + 30 kg sulphur ha^{-1} (5227 kg ha^{-1}). Improvement in straw yield might have resulted from favourable influence of sulphur on plant height, branching and leaf area index and efficient and greater partitioning of metabolites and adequate translocation of nutrients to developing reproductive structures (Singh *et al*., 1994).

The harvest index differed significantly among the treatments. The treatment receiving 150% RDF + 30 kg sulphur ha^{-1} recorded maximum harvest index 25.40% over 125% RDF + 30 sulphur kg ha^{-1} is 25.0% and 100% RDF + 30 kg sulphur ha^{-1} is 24.9%. The use chemical fertilizers improve harvest index due to greater availability of nitrogen, phosphorus and sulphur in early growth stages for fast developments of roots and translocation as well as assimilation of foods that might made harvest index to be significant, similar results met to the conformity of Kumar *et al.* (2014) [6].

Table 3: Mean nitrogen, phosphorus, potassium and sulphur uptake by plant of pigeonpea as influenced by various treatments

Treatment	Nitrogen uptake (kg ha^{-1})			
	Nitrogen	Phosphorus	Potassium	Sulphur
T_1 - 100% RDF (25:50:00 kg ha^{-1})	85.96	17.28	66.06	9.81
T_2 - 125% RDF (31.25:62.5:00 kg ha^{-1})	95.65	19.02	71.43	11.07
T_3 - 150% RDF (37.5:70:00 kg ha^{-1})	113.62	22.33	82.15	13.56
T_4 - 100% RDF + 10 kg S ha^{-1}	93.70	18.71	70.48	10.72
T_5 - 125% RDF + 10 kg S ha^{-1}	106.08	21.04	78.12	12.47
T_6 - 150% RDF + 10 kg S ha^{-1}	125.61	24.80	90.42	15.47
T_7 - 100% RDF + 20 kg S ha^{-1}	100.41	19.84	74.14	11.60
T_8 - 125% RDF + 20 kg S ha^{-1}	120.43	23.72	86.99	14.50
T_9 - 150% RDF + 20 kg S ha^{-1}	135.06	26.78	97.07	16.99
T_{10} - 100% RDF + 30 kg S ha^{-1}	143.63	28.50	102.40	18.04
T_{11} - 125% RDF + 30 kg S ha^{-1}	149.39	30.28	108.43	19.23

T_{12} - 150% RDF + 30 kg S ha^{-1}	156.24	31.16	110.80	19.99
S.E (m) ±	4.68	0.98	3.04	0.72
C.D at 5%	13.31	2.77	8.53	2.02
G. M.	119.06	23.61	86.54	14.45

Treatment 150% RDF + 30 kg sulphur ha^{-1} shown maximum nitrogen uptake (156.24 kg ha^{-1}), phosphorus uptake (31.16 kg ha^{-1}), potassium uptake (110.80 kg ha^{-1}) and sulphur uptake (19.99 kg ha^{-1}) it was statistically at par with 125% RDF + 30 sulphur kg ha^{-1} and 100% RDF + 30 kg sulphur ha^{-1}. Increasing levels of sulphur from 0 to 30 kg ha^{-1} with increasing levels of RDF increased the nitrogen, phosphorus, potassium and sulphur uptake by plant ranging from 65.72 to 169.46 kg ha^{-1}, 17.28 to 31.16 kg ha^{-1}, 66.06 to 110.80 kg ha^{-1} and 9.81 to 19.99 kg ha^{-1} showing highest value i.e. nitrogen, phosphorus, potassium and sulphur 169.46, 31.16, 110.80 and 19.99 kg ha^{-1} in treatment receiving 150% RDF + 30 kg sulphur ha^{-1}. All these higher levels produced significantly shown more nitrogen uptake by plant than other remaining treatments. Similar results confirmed by Kumawat *et al.* (2013) [7]

At harvest available nitrogen in soil was significantly influenced due to application of 150% RDF + 30 kg sulphur ha^{-1} significantly and recorded higher available nitrogen (231.65 kg ha^{-1}) over 125% RDF + 30 kg sulphur ha^{-1} and 100% RDF + 30 kg sulphur ha^{-1}.

Table 4: Available nutrient status after harvest as influenced by various treatments

Treatment	Available Nutrient (kg ha^{-1})			
	Nitrogen	Phosphorus	Potassium	Sulphur
T_1 - 100% RDF (25:50:00 kg ha^{-1})	203.38	14.20	390.12	13.24
T_2 - 125% RDF (31.25:62.5:00 kg ha^{-1})	207.55	15.35	395.04	14.19
T_3 - 150% RDF (37.5:70:00 kg ha^{-1})	217.30	17.86	405.60	16.07
T_4 - 100% RDF + 10 kg S ha^{-1}	205.90	14.77	391.18	13.85
T_5 - 125% RDF + 10 kg S ha^{-1}	212.30	16.35	399.21	16.81
T_6 - 150% RDF + 10 kg S ha^{-1}	222.42	18.92	412.56	17.32
T_7 - 100% RDF + 20 kg S ha^{-1}	209.31	15.87	397.70	14.93
T_8 - 125% RDF + 20 kg S ha^{-1}	219.14	18.28	408.10	18.28
T_9 - 150% RDF + 20 kg S ha^{-1}	226.42	20.18	417.02	19.13
T_{10} - 100% RDF + 30 kg S ha^{-1}	215.63	17.31	403.32	15.78
T_{11} - 125% RDF + 30 kg S ha^{-1}	225.30	19.34	414.32	18.21
T_{12} - 150% RDF + 30 kg S ha^{-1}	231.65	21.57	422.30	19.76
S.E (m) ±	1.85	0.41	1.83	0.35
C.D at 5%	5.27	1.17	4.96	1.01
G. M.	216.46	17.53	404.98	16.46

At harvest available nitrogen, phosphorus, potassium and sulphur in soil was significantly influenced due to application of 150% RDF + 30 kg sulphur ha^{-1} significantly and recorded higher available nitrogen (231.65 kg ha^{-1}) phosphorus (21.57 kg ha^{-1}), potassium (422.30 kg ha^{-1}) and sulphur (21.61 kg ha^{-1}) over 125% RDF + 30 kg sulphur ha^{-1} and 100% RDF + 30 kg sulphur ha^{-1}. Application of 100% RDF + 30 kg sulphur ha^{-1} found to be statistically effective and produced higher yield attributes as well as higher seed and straw yield kg ha^{-1}. Application of 150% RDF + 30 kg sulphur ha^{-1} shown maximum uptake of nutrients.

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