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Nutrient uptake of different contingent crops under delayed sowings in changed climate in rainfed agriculture

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Abstract

A field experiment was conducted during *kharif* 2018 at Dryland Agriculture Project, All India Coordinated Research Project (AICRP) on Dryland Agriculture, University of Agricultural Sciences, GKVK, Bengaluru, Karnataka. The experiment comprised of two factors laid out in Factorial Randomized Complete Block Design (FRCBD) with three replications. Treatments consist of three sowing windows *viz.*, August 2nd fortnight, September 1st fortnight and September 2nd fortnight and five crops *viz.* foxtail millet, finger millet, field bean, french bean and quinoa. Delayed dates of sowing caused drop in growth parameters which may be due to unfavorable weather conditions to the plants as well as high temperature which might have caused in lower rate of photosynthesis and lower uptake of nutrients led to reduced accumulation of food materials. Among the contingent crops and delayed sowings in *kharif* season under dryland condition, August 2nd fortnight sowing recorded significantly higher availability of nitrogen, phosphorous and potassium by crops and it was decreasing with delayed sowing of contingent crops. Field bean and french bean were improved the availability of nutrients in the soil after the harvest of crops than remaining crops.

Keywords: Rainfed agriculture, contingent crops, nutrient uptake, changed climate

Introduction

Rainfed agriculture support 42 per cent of India's population of above a billion and play a major role in food security. Over 87 per cent of coarse cereals and pulses, 55 per cent of upland rice, 70 per cent of oilseeds and 65 per cent of cotton are cultivated under rainfed agriculture (Nagaraj, 2013) [7]. Rainfed agriculture in India encounters multiple risks and constraints relating to biophysical and socio-economic problems. Agricultural productivity in rainfed agriculture continues to remain low and imbalanced due to weather aberrations, poor nutrient uptake and poor socio-economic status of farmers. The productivity of crops in dryland conditions varies to a great deal from year to year in response to the variability of climate particularly the rainfall (Guled *et al.*, 2013) [3]. The major source of water for rainfed crops is rainfall, a larger portion of which is received through the South-West monsoon period. The amount of rainfall and its distribution are crucial factors influencing performance of agriculture. The higher variability in rainfall induced greater fluctuations in the crop yields. Hence, the present investigation was taken up to analyze the suitable contingent crops and their nutrient uptake under delayed sowing conditions of rainfed agriculture.

Materials and Methods

A field experiment was conducted during *Kharif* 2018 at Dryland Agriculture Project, GKVK, Bangalore (Karnataka). The experimental site is situated in the Eastern Dry Zone (Zone-5) of Karnataka which is located between 12° 51' N Latitude and 77° 35' E Longitude at an altitude of 930 m above the mean sea level (MSL). The experiment comprised of two factors laid out in Factorial Randomized Complete Block Design (FRCBD) with three replications. Treatments consisted of two factors of three sowing windows *viz.*, August 2nd fortnight (28.08.2018), September 1st fortnight (14.09.2018) and September 2nd fortnight (24.09.2018) and five different crops *viz.*, foxtail millet, finger millet, field bean, french bean (vegetable)

and quinoa. All the recommended agronomic and plant protection measures were adopted as per the package of UAS, Bangalore. All the contingent crops sown under different delayed sowings germinated except quinoa sown during September 2nd fortnight. It might be due to occurrence of high rainfall that lead to formation of crust on small size seeds of quinoa lead to unavailability of oxygen (hypoxia) and sunlight. It resulted in poor germination of the quinoa crop. It is also due to high rainfall on the day of sowing created the water logged conditions in plot due to more clay content of soil. It is also lead to hypoxia of quinoa seeds. Emergence is poor if continuous rain prevails immediately after sowing or because of the mortality of young seedlings caused by submergence (Ismail *et al.*, 2009) [4]. And because of high day temperatures of October month and moisture stress leads to death of germinated quinoa seedlings.

Yield of various contingent crops were recorded from net plot area and extrapolated to hectare basis. The soil was red sandy

loam texture. The physical and chemical properties of soil analysed from soil sample drawn at a depth of 0-20 cm with methodology adopted are furnished in 2.1. The moisture content at field capacity was 17.34 per cent with a bulk density of 1.39 g cc⁻¹. The experimental site is slightly acidic in nature (pH 6.32) with electrical conductivity of 0.37 dS m⁻¹ and organic carbon content was low (0.43%). It has medium available nitrogen (262.4 kg ha⁻¹), high phosphorus (28.7 kg ha⁻¹) and medium potassium (239.1 kg ha⁻¹) in the soil.

Nitrogen, phosphorus and potassium were provided through urea, DAP and MOP. According to the treatment, the full quantity of phosphorus, potash and half of nitrogen was applied as basal dose at the time of sowing, while the remaining half quantity of nitrogen was applied on 45 days after each sowing. The fertilizer application was followed as per package of practices of University of Agricultural Sciences, GKVK, Bengaluru.

Crop	Finger millet	Foxtail millet	Field bean	French bean	Quinoa
RDF (N: P: K)	50:37.5:40	40:40:0	25:50: 25	25:50: 25	100:50: 50

Soil analysis

Soil sampling and preparation of sample

Soil samples were collected before sowing and after harvest of the crop from individual plots of experiment by taking slice of soil from the depth of 0-20 cm. Soil samples were shade dried, powdered using wooden pestle and mortar and sieved in 2 mm sieve and chemically analysed to estimate soil reaction (pH), EC, organic carbon (OC %), available soil nitrogen (N), phosphorus (P₂O₅) and potassium (K₂O).

Analysis of pH

The soil pH was determined in soil by 1:2.5 soil: water suspension using digital pH meter with glass electrode (Jackson, 1973) [5].

Analysis of electrical conductivity (EC)

Electrical conductivity of the clear soil water (1:2.5) extract was determined using electric conductivity (Electrical conductivity expressed in dSm⁻¹) bridge (Jackson, 1973) [5].

Analysis of organic carbon (OC)

A known weight (0.5 g) of 0.2 mm sieved soil was treated with a known excess volume of 1 N potassium dichromate and sulphuric acid (K₂Cr₂O₇ + H₂SO₄) was added. After oxidation of organic carbon to carbon dioxide excess of was back titrated against standard ferrous ammonium sulphate solution using diphenylamine indicator (Walkley and Black, 1934) [14].

Available nitrogen

Available nitrogen in soil was determined by alkaline potassium permanganate method (Subbaiah and Asija, 1956) [13].

Available phosphorus

The available phosphorus was extracted with Bray's No.1 extractant (0.03 N NH₄F + 0.025 N HCl). The phosphorus in the extract was determined by stannous chloride reduced molybdophosphoric blue colour method. The intensity of blue color was read using a spectrophotometer at 660 nm (Bray and Kurtz, 1945) [1].

Available Potassium

Available potassium was extracted from soil using neutral normal ammonium acetate (NH₄OAC) (at 1:5 soil: NH₄OAC ratio) and the concentration of potassium present in the extractant was determined by using flame photometer (Jackson, 1973) [5].

Plant analysis

Digestion of plant samples

One-gram plant and weed samples were pre-digested with di-acid mixture of nitric acid and perchloric acid (9:4). The digested material was made up to 50 ml volume with 6 N HCl and was used for the analysis of all mineral elements.

Nitrogen uptake

Nitrogen content was estimated by modified micro-kjeldhal's method as outlined by Jackson (1973) [5] and expressed in percentage. Nitrogen uptake (kg ha⁻¹) by crop was calculated for each treatment separately by using the following formula.

$$\text{Nitrogen uptake (kg ha}^{-1}\text{)} = \frac{\text{Nitrogen concentration (\%)}}{100} \times \text{Dry matter (kg ha}^{-1}\text{)}$$

Phosphorus uptake

Phosphorus content in plant and weed sample was estimated by Vanadomolybdo phosphoric acid yellow colour method in nitric acid medium and the colour intensity was read at 660 nm wave length as outlined by Jackson (1973) [5]. It is calculated using the following formula.

$$\text{Phosphorous uptake (kg ha}^{-1}\text{)} = \frac{\text{Phosphorous concentration (\%)}}{100} \times \text{Dry matter (kg ha}^{-1}\text{)}$$

Potassium uptake

Potassium content in digested plant and weed sample were estimated by automizing the diluted acid extract in a flame photometer as defined by Jackson (1973) [5]. It is calculated using the following formula.

$$\text{Potassium uptake (kg ha}^{-1}\text{)} = \frac{\text{Potassium concentration (\%)}}{100} \times \text{Dry matter (kg ha}^{-1}\text{)}$$

The data recorded on various observations on yield and soil parameters were subjected to analysis of variance (ANOVA). The level of significance used in 'F' test was at 5 per cent. The critical difference (CD) values are given in the table at 5 per cent level of significance (Gomez and Gomez, 1984) [2].

Results and Discussion

Effect of delayed sowing on yield of contingent crops

Among the dates of sowing, August 2nd fortnight sowing has produced significantly higher seed / vegetable yield (1033 kg ha⁻¹) and followed by September 1st fortnight sowing (670 kg ha⁻¹) and September 2nd fortnight sowing (413 kg ha⁻¹) (Table

1). Among the crops, higher vegetable yield (1789 kg ha⁻¹) was recorded by french bean followed by finger millet and field bean seed yield (659 and 658 kg ha⁻¹, respectively). Lower seed yield produced by quinoa crop (61 kg ha⁻¹). There was no significant difference in seed yield of quinoa under different delayed dates of sowing. However, higher seed yield recorded during August 2nd fortnight sowing (115 kg ha⁻¹) and followed by September 1st fortnight sowing (68 kg ha⁻¹). It is might due to unfavorable climatic conditions and poor establishment of crop in initial stages because of moisture stress.

Table 1: Initial physical and chemical properties of soil of the experimental site

Sl. No.	Particulars	Values	Methods employed
Physical properties			
1	Coarse sand (%)	32.40	International pipette method (Piper, 1966)
2	Fine sand (%)	31.60	
3	Silt (%)	8.90	
4	Clay (%)	26.75	
5	Field capacity (%)	17.34	
6	Permanent wilting point (%)	7.21	
7	Bulk density (g cc ⁻¹)	1.39	
8	Textural class	Sandy loam	
Chemical properties			
1	Soil pH (1:2.5)	6.32	Potentiometric method (Piper, 1966)
2	Electrical conductivity (dS m ⁻¹)	0.37	Conductivity bridge (Jackson, 1973) ^[5]
3	Organic carbon (%)	0.43	Walkley and Black wet oxidation method (Jackson, 1973) ^[5]
4	Available nitrogen (kg ha ⁻¹)	262.4	Alkaline potassium permanganate method (Subbaiah and Asija, 1956) ^[13]
5	Available phosphorus (kg ha ⁻¹)	28.7	Bray’s method (Jackson, 1973) ^[5]
6	Available potassium (kg ha ⁻¹)	239.1	Flame photometer method (Jackson, 1973) ^[5]

Seed / vegetable yield of all contingent crops was reduced gradually by delaying the sowing date. French bean recorded the highest vegetable yield (2394, 1822 and 1150 kg ha⁻¹, respectively) during August 2nd fortnight, September 1st fortnight and September 2nd fortnight sowings followed by finger millet sown in August 2nd fortnight (1102 kg ha⁻¹). Lower seed yield (67.72 kg ha⁻¹) was produced in quinoa during September 1st fortnight sowing. French bean recorded higher vegetable yields in all delayed sowings when compared to other contingent crops was due to short duration of crop, higher photosynthetic rate, higher biomass production, higher water use efficiency and lower transpiration quotient and also a greater number of pods plant⁻¹, higher total dry matter production and its accumulation in pods.

The trend of yield reduction of contingent crops was due to the early sown crops have an advantage of favourable soil moisture, temperature and day length which made the crops to express "their full potentiality". As a result, higher grain yield was obtained with early sowing than that of delayed sowing. The yield reduction in delayed sowing was attributed to greater biotic and abiotic stresses viz., moisture stress, high temperatures and decreased moisture availability and moisture stress that resulted in lesser total dry matter production and its translocation from vegetative parts to reproductive structures.

It was attributed to reduced productive tillers plant⁻¹, number of pods plant⁻¹, panicle weight and pod weight as well as reduced translocation from source to sink with delayed sowing. Similar results have been reported by Patnaik (1968) and Rao *et al.* (1991) [9, 12] in finger millet.

Soil chemical properties, nutrient availability and uptake by contingent crops pH, organic carbon, electrical conductivity and available nutrient status of soil at harvest of contingent crops

There is no significant change in pH, organic carbon and electrical conductivity of soil due to delayed sowing of contingent crops (Table 2). August 2nd fortnight sowing recorded significantly higher availability of nitrogen, phosphorous and potassium after harvest the crops (250.9, 27.85 and 232.83 kg ha⁻¹, respectively) and it was followed by September 1st fortnight sowing (233.51, 24.13 and 221.99 kg ha⁻¹, respectively). Lower availability of nutrients was recorded during September 2nd fortnight sowing (212.87, 22.77 and 214.84 kg ha⁻¹, respectively). The availability of nutrients was reducing with delayed sowing of contingent crops was due to applied nutrients lost by higher rainfall after sowing of crops. On the other hand, due to less moisture availability reduced the microbial activity in the soil.

Table 2: Effect of different delayed dates of sowing on seed or vegetable yield, nutrient availability and nutrient uptake at harvest of contingent crops

Treatment	Seed/vegetable yield (kg ha ⁻¹)	pH	OC (%)	EC (dS m ⁻¹)	Available N (kg ha ⁻¹)	Available P ₂ O ₅ (kg ha ⁻¹)	Available K ₂ O (kg ha ⁻¹)	N (kg ha ⁻¹)	P ₂ O ₅ (kg ha ⁻¹)	K ₂ O (kg ha ⁻¹)
Sowing window (S)										
S ₁	1033	6.29	0.44	0.35	250.90	27.85	232.83	24.67	9.33	15.55
S ₂	670	6.27	0.44	0.34	233.51	24.13	221.99	16.39	6.11	9.84

S ₃	413	6.27	0.43	0.33	212.87	22.77	214.84	9.41	3.72	5.96
S.Em+	154.1	0.16	0.12	0.13	5.82	1.25	2.37	3.03	1.06	1.82
CD (5%)	268.3	NS	NS	NS	10.12	2.18	4.12	5.26	1.85	3.16
Crops (C)										
C ₁	361	6.27	0.43	0.35	226.26	22.38	212.65	10.78	4.55	8.39
C ₂	659	6.26	0.44	0.34	219.72	23.44	222.42	18.54	7.02	12.22
C ₃	658	6.29	0.44	0.34	259.16	28.50	234.32	16.39	6.85	11.92
C ₄	1789	6.26	0.44	0.35	247.16	26.63	225.90	30.33	11.58	16.54
C ₅	61	6.30	0.42	0.33	209.83	23.64	220.80	8.08	1.92	3.17
S x C										
S ₁ C ₁	661	6.28	0.43	0.37	243.89	25.56	222.72	18.27	7.71	14.21
S ₂ C ₁	294	6.27	0.44	0.34	232.14	21.81	206.57	9.64	4.07	7.50
S ₃ C ₁	126	6.25	0.43	0.34	202.74	19.78	193.67	4.44	1.88	3.46
S ₁ C ₂	1102	6.27	0.44	0.35	236.45	27.17	226.26	29.35	11.12	20.08
S ₂ C ₂	581	6.26	0.43	0.32	223.84	22.34	221.81	16.88	6.40	10.66
S ₃ C ₂	293	6.24	0.45	0.35	198.87	20.82	203.18	9.38	3.55	5.92
S ₁ C ₃	894	6.31	0.45	0.34	284.51	31.12	235.85	21.86	9.14	15.90
S ₂ C ₃	583	6.29	0.46	0.36	258.27	28.67	223.39	14.51	6.07	10.55
S ₃ C ₃	496	6.27	0.42	0.32	234.71	25.71	205.71	12.80	5.35	9.31
S ₁ C ₄	2394	6.28	0.44	0.35	268.36	29.45	234.57	39.46	15.07	21.52
S ₂ C ₄	1822	6.26	0.45	0.35	251.44	26.17	225.29	31.13	11.89	16.98
S ₃ C ₄	1150	6.25	0.43	0.34	221.67	24.27	217.84	20.41	7.79	11.13
S ₁ C ₅	115	6.29	0.42	0.33	221.27	25.97	216.76	14.43	3.61	6.01
S ₂ C ₅	68	6.27	0.43	0.34	201.87	21.67	204.87	9.80	2.15	3.50
S ₃ C ₅	0	6.33	0.42	0.31	206.34	23.29	211.78	0.00	0.00	0.00
S.Em+	68.05	0.11	0.09	0.08	2.60	0.56	1.06	1.35	0.48	0.81
CD (5%)	199.5	NS	NS	NS	7.54	1.62	3.07	3.92	1.38	2.36

Factor- A: Sowing window (S)

S1: August 2nd fortnight (28.08.2018)

S2: September 1st fortnight (14.09.2018)

S3: September 2nd fortnight (24.09.2018)

Factor- B: Crops (C)

C1: Foxtail millet

C2: Finger millet

C3: Field bean

C4: French bean

C5: Quinoa

Out of five contingent crops, field bean recorded the higher availability of nitrogen, phosphorous and potassium (259.16, 28.50 and 234.32 kg ha⁻¹, respectively) followed by french bean (247.16, 26.63 and 225.90 kg ha⁻¹, respectively). Field bean and french bean are capable to produce nitrogen by biological nitrogen fixation but french bean is less efficient than field bean. Even though, the both crops are made higher availability of nutrients after their harvest when compared to other contingent crops. Lower availability of nutrients was recorded in foxtail millet (226.26, 22.38 and 212.65 kg ha⁻¹, respectively) due to more production of vegetative structures and more non-productive tillers.

Uptake of nitrogen, phosphorus and potassium (kg ha⁻¹) by contingent crops under different delayed sowings

The uptake of the nutrients by contingent crops showed significant differences due to delayed sowings at harvest. August 2nd fortnight sowing recorded significantly higher uptake of nitrogen, phosphorous and potassium by crops (24.67, 9.33 and 15.55 kg ha⁻¹, respectively) and it was followed by September 1st fortnight sowing (16.39, 6.11 and 9.84 kg ha⁻¹, respectively). Lower uptake of nutrients was recorded during September 2nd fortnight sowing (9.41, 3.72 and 5.96 kg ha⁻¹, respectively). The uptake of nutrients was reduced with delayed sowing of contingent crops due to lower dry matter production of crops because of unfavorable climatic conditions and moisture stress.

Out of five contingent crops, french bean recorded the higher uptake of nitrogen, phosphorous and potassium (30.33, 11.58 and 16.54 kg ha⁻¹, respectively) followed by finger millet (18.54, 7.02 and 12.22 kg ha⁻¹, respectively). Due to its short duration nature, french bean absorbed more quantity of nutrients under residual soil moisture and produced higher dry

matter compared to other contingent crops. Lower uptake of nutrients was recorded in quinoa (8.08, 1.92 and 3.17 kg ha⁻¹, respectively) due to its less dry matter production. These results are similar with Patel and Patel (2002), Mandloi (2012) and Prashant (2013) [8, 6, 11] findings.

Conclusion

Under delayed sowings of contingent crops, there was non-significant change in pH, organic carbon and electrical conductivity of soil. August 2nd fortnight sowing recorded significantly higher availability of nitrogen, phosphorous and potassium by crops and it was decreasing with delayed sowing of contingent crops. Field bean and french bean were improved the availability of nutrients in the soil after the harvest of crops than remaining crops.

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