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Vijay Kumar Rajpoot
Department of Soil Conservation and Water Management CS Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India

Awasthi UD
Department of Soil Conservation and Water Management CS Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India

Rahul Ranjan
Department of Soil Science and Agricultural Chemistry CS Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India

Amar Kant Verma
Department of Soil Conservation and Water Management CS Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India

Corresponding Author:
Vijay Kumar Rajpoot
Department of Soil Conservation and Water Management CS Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India

Studies on barley based intercropping systems as influenced by integreted nutrient management on root development and consumptive use under moisture scarce condition

Vijay Kumar Rajpoot, Awasthi UD, Rahul Ranjan and Amar Kant Verma

Abstract
A field experiment was carried out at Soil Conservation and Water Management Farm of C S Azad University of Agriculture and Technology, Kanpur during *rabi* seasons of 2017-18 and 2018-19. The experiment comprising nine cropping systems *viz.* C_1: Barley sole, C_2: Lentil sole, C_3: Chickpea sole, C_4: Barley + lentil (2:1), C_5: Barley + lentil (4:1), C_6: Barley + Chickpea (2:1) and C_7: Barley + Chickpea (4:1) and 3 integrated nutrient management *viz.* N_1: RDN, N_2: 75% RDN + 25% N through FYM and N_3: 75% RDN + 25% N through FYM + culture + PSB in split plot design with three replications keeping cropping systems in main plots and INM in subplots to find out suitable row ratio of barley + lentil/checkpea in intercropping systems under rainfed condition. The results revealed that barley performed better in intercropping than sole cropping. Among different cropping systems, Barley + Chickpea (2:1) in case of integrated nutrient management 75% RDN + 25% N through FYM + culture + PSB exhibited maximum root development during the two years of experimentation.

Keywords: Rainfed, integrated nutrient management, root development, consumptive use

Introduction
Barley (*Hordeum vulgare* L.) is the fourth most important cereal crop of the world after wheat, rice and maize. The crop was grown on 6.71 lakh hectares and recorded a production of 17.30 lakh tonnes with a average yield of 2.58 t ha^{-1} in India. The major barley producing states in India are Rajasthan, UP, Haryana, MP, and Punjab. In Uttar Pradesh it was grown on 1.56 lakh hectares with a production of 4.50 lakh tonnes with an average yield of 2.88 t ha^{-1} (Anonymous, 2019) [1].

The integrated nutrient management has now gaining importance because of the present negative balance and neither the chemical fertilizers alone nor can the potential alternative source of nutrient achieve the production sustainability of soils and crops under intensive cultivation. Under such conditions integration of indigenously available organic sources of nutrients with inorganic sources is of vital significance for sustaining the productivity and fertility of soil (Sharma *et al.* 2017) [4]. Vermicompost is a good organic source of plant nutrient and growth hormone which enhance plant growth and microbial population (Singh *et al.* 2011) [6].

Soil moisture is the key input in rainfed agriculture. The crop production is often low due to poor soil moisture is *rabi* season when the crop is raised on conserved soil moisture. The availability of moisture in rainfed condition is very critical during crop period. Water management in intercropping system are generally recommended for rainfed crops to get stable yields. The total water used in intercropping system is almost the same as for sole crops, but yields are increased. Thus, water-use efficiency of intercropping is higher than sole crops (Singh *et al.* 2018) [5].

Materials and Methods
A field experiment was conducted during *rabi* seasons of 2017-18 and 2018-19 at Soil Conservation and Water Management Farm of C S Azad University of Agriculture and Technology, Kanpur in alluvial soil under rainfed condition. The soil of the experimental field was sandy loam in texture and slightly calcareous having organic carbon 0.31%, total nitrogen 0.032%, available P_2O_5 16.5 kg ha^{-1}, available K_2O 156.2 kg ha^{-1}, pH 7.5, electrical conductivity 0.35 dS m^{-1}, water holding capacity 29.7%, Bulk density 1.44 Mg m^{-1}, Particle density 2.54 Mg m^{-1} and porosity 56.69%. The field experiment was conducted in split plot

design with three replications, keeping cropping systems in main plots and INM in subplots. The treatment comprising 7 cropping systems *viz.* C_1: Barley sole, C_2: Lentil sole, C_3: Chickpea sole, C_4: Barley + lentil (2:1), C_5: Barley + lentil (4:1), C_6: Barley + Chickpea (2:1) and C_7: Barley + Chickpea (4:1) and 3 integrated nutrient management *viz.* N_1: RDN, N_2: 75% RDN + 25% N through FYM and N_3: 75% RDN + 25% N through FYM + culture + PSB. Crops were sown on 30.11.2017 and 01.12.2018 during the first and second year of experimentation, respectively.

Root study was done at harvest by selecting three plants from each treatment randomly. The roots were subjected to wash with a jet of water spray so that the fine rootlets are not broken. Observations were made on depth of root penetration, number of root plants^{-1} and dry weight of root plants^{-1}.

Results and Discussion

The information on root development of barley, lentil and chickpea for different treatments indicated that the root development was significantly influenced by the different treatments over the periods of experimentation (Table-2, 3 & 4). Root development was significantly highest under Barley + Chickpea (2:1) followed by Barley + Chickpea (4:1) whereas lowest root development was obtained in the treatment of barley sole among different cropping systems during two different years. Application of 75% RDN + 25% N through FYM + culture + PSB brought about significantly highest root development and lowest values under RDN might be due to integrated application of fertilizers and organic sources has been also reported by Dubey *et al.* (2015) [3], Verma *et al.* (2017) [7] and Verma *et al.* (2018) [8].

Consumptive use (mm) Table-1 were maximized in the treatment of Barley + lentil (4:1) followed by Barley + lentil (2:1) the minimum values of these parameters recorded under flat sowing lentil sole. These results are in accordance with those of Ansari & Rana, (2012) [2] and Verma *et al.* (2019) [9].

Table 1: Effect of cropping systems and integrated nutrient management on consumptive use (mm m^{-1} soil depth) at different intervals

Treatment	Sowing time	30 DAS	60 DAS	90 DAS	120 DAS to at harvest
Cropping systems	**2017-18**				
Barley sole	38.1	68.7	87.4	61.0	-
Lentil sole	37.3	53.2	71.0	44.1	-
Chickpea sole	37.6	53.9	72.0	45.7	7.2
Barley + lentil (2:1)	37.8	62.9	81.9	55.7	-
Barley + lentil (4:1)	37.9	65.4	84.2	57.8	-
Barley + Chickpea (2:1)	37.7	61.1	78.9	52.1	6.0
Barley + Chickpea (4:1)	37.8	63.8	81.6	55.2	5.1
Integrated nutrient management					
RDF	37.5	60.5	78.8	52.2	5.5
75% RDN + 25% N through FYM	37.8	61.4	79.7	53.2	6.3
75% RDN + 25% N through FYM + culture + PSB	37.9	62.0	80.3	53.9	6.6
Cropping systems	2018-19				
Barley sole	35.4	69.8	90.0	63.4	-
Lentil sole	34.7	56.3	75.8	48.9	-
Chickpea sole	34.8	57.1	76.6	50.0	8.8
Barley + lentil (2:1)	35.0	64.7	84.8	58.0	-
Barley + lentil (4:1)	35.2	67.2	87.4	60.0	-
Barley + Chickpea (2:1)	34.9	61.4	82.5	55.4	6.7
Barley + Chickpea (4:1)	35.1	63.5	84.5	56.9	6.2
Integrated nutrient management					
RDF	34.9	61.9	82.3	55.4	6.9
75% RDN + 25% N through FYM	35.0	62.9	83.1	56.1	7.3
75% RDN + 25% N through FYM + culture + PSB	35.1	63.8	83.9	56.7	7.6

DAS= days after sowing

Table 2: Effect of cropping systems and integrated nutrient management on root development of barley

Treatment	Root depth (cm)	Primary roots plant^{-1}	Dry weight of roots plant^{-1}
Cropping systems	**2017—18**		
Barley sole	25.6	11.1	1.45
Barley + lentil (2:1)	26.8	12.7	1.61
Barley + lentil (4:1)	26.2	11.9	1.52
Barley + Chickpea (2:1)	27.6	14.3	1.69
Barley + Chickpea (4:1)	26.9	13.0	1.63
Integrated nutrient management			
RDF	25.0	10.8	1.42
75% RDN + 25% N through FYM	26.8	12.7	1.60
75% RDN + 25% N through FYM + culture + PSB	28.0	14.3	1.72
Cropping systems	2018-19		
Barley sole	26.3	12.2	1.48
Barley + lentil (2:1)	27.4	13.7	1.66
Barley + lentil (4:1)	27.0	12.8	1.56
Barley + Chickpea (2:1)	28.1	15.5	1.76
Barley + Chickpea (4:1)	27.7	14.8	1.69
Integrated nutrient management			

RDF	25.7	12.1	1.48
75% RDN + 25% N through FYM	27.4	13.6	1.65
75% RDN + 25% N through FYM + culture + PSB	28.8	15.7	1.76

Table 3: Effect of cropping systems and integrated nutrient management on root development of lentil

Treatment	Root depth (cm)	Number of primary roots plant^{-1}	Number of secondary roots plant^{-1}	Dry weight of roots plant^{-1} (g)
Cropping systems	**2017-18**			
Lentil sole	18.2	8.9	17.3	1.02
Barley + lentil (2:1)	16.4	7.2	15.4	0.93
Barley + lentil (4:1)	15.8	6.7	14.6	0.89
Integrated nutrient management				
RDF	15.4	6.4	13.7	0.87
75% RDN + 25% N through FYM	16.9	7.7	15.9	0.96
75% RDN + 25% N through FYM + culture + PSB	18.1	8.8	17.7	1.02
Cropping systems	2018-19			
Lentil sole	19.5	9.2	18.6	1.10
Barley + lentil (2:1)	17.9	7.6	16.6	0.99
Barley + lentil (4:1)	17.1	7.2	16.0	0.94
Integrated nutrient management				
RDF	16.9	6.8	14.8	0.95
75% RDN + 25% N through FYM	18.3	8.0	17.2	1.02
75% RDN + 25% N through FYM + culture + PSB	19.3	9.3	19.2	1.06

Table 4: Effect of cropping systems and integrated nutrient management on root development of chickpea

Treatment	Root depth (cm)	Number of primary roots plant^{-1}	Number of secondary roots plant^{-1}	Dry weight of roots plant^{-1} (g)
Cropping systems	**2017-18**			
Chickpea sole	45.2	10.6	22.3	1.98
Barley + chickpea (2:1)	43.4	9.1	20.4	1.82
Barley + chickpea (4:1)	42.2	8.2	18.8	1.74
Integrated nutrient management				
RDF	41.7	7.9	18.9	1.65
75% RDN + 25% N through FYM	43.8	9.4	20.6	1.87
75% RDN + 25% N through FYM + culture + PSB	45.3	10.6	22.0	1.74
Cropping systems	**2018-19**			
Chickpea sole	46.4	11.8	23.9	2.02
Barley + chickpea (2:1)	44.8	10.5	22.2	1.87
Barley + chickpea (4:1)	43.4	9.9	20.8	1.78
Integrated nutrient management				
RDF	43.0	9.0	20.9	1.73
75% RDN + 25% N through FYM	45.0	10.9	22.4	1.91
75% RDN + 25% N through FYM + culture + PSB	46.6	12.3	23.6	2.03

Conclusion

Based on two years of experiment it may be inferred that Barley + Chickpea (2:1) supplemented with 75% RDN + 25% N through FYM + culture + PSB showed good consumptive use for sustainable root development and proved to be quite remunerative in rainfed alluvial tract of Uttar Pradesh.

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