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RESEARCH PAPER

Fertilizer management in *Hordeum vulgare* L.

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Abstract : A field experiment was conducted at Bhagwant University, Ajmer during *Rabi,* 2016-17 on loamy sand soil, which consisted of 4 fertility levels (control, 50, 75 and 100% RDF) and 5 foliar spray (water spray, 2% urea, 3% urea, 2% DAP and 2% KCl spray at tillering and flowering) there by making 20 treatment combinations were tested in Randomized Block Design with three replications. Results indicated that application of 100% RDF significantly increased the plant height at harvest, number of tillers per meter row length at 90DAS and at harvest, dry matter accumulation per meter row length, number of spikes per plant, spike length, seeds per spike, yields (seed, straw and biological), total uptake of nitrogen and potassium and net returns over preceding levels. Whereas, plant height at 60, 90 DAS, total number of tillers per meter row length at 60 DAS and potassium concentration in seed and straw and total uptake of phosphorus increased significantly upto 75% RDF. However, in respect of plant height at 30 DAS, chlorophyll content and harvest index and the treatments 50 to 100% RDF remained almost same. Results further indicated that among foliar spray treatments, application of 2 % urea as foliar spray being at par with 2% DAP, 3% urea and 2% KCl spray, significantly increased plant height, total number of tillers per meter row length, dry matter accumulation per meter row length, chlorophyll content in leaves, spike per plant, number of seeds per spike, spike length, yields (seed, straw and biological), protein content, nitrogen, phosphorus and potassium concentration in seed and straw, total uptake of nitrogen, phosphorus, potassium and net returns over water sprayed control. Application of 75% RDF with 2% urea spray proved to be the best treatment combination in terms of number of tillers per meter row length and seed yield.

Key Words : RDF, Biological control, Spray, Protein, Barley

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INTRODUCTION

Barley is the world's fourth most important cereal after wheat, rice and maize. Its flour is used in preparing chapaties and sattu (flour from roasted barley grains mixed with sugar and water). Pearled barley, the round kernel pellets prepared by removing the outer portion of the kernels is used as baby food and also as food for patients. In India, barley is cultivated in an area of 0.92 m ha with an annual production of 1.76 million tonnes of grains (Anonymous, 2016). It is cultivated mainly in the states of Uttar Pradesh, Rajasthan, Madhya Pradesh, Bihar, Haryana and Punjab. In Rajasthan, the crop occupies an area of 1.99 lakh ha producing 5.60 lakh tonnes with an average productivity of 2529kg/ha. The average productivity of barley in the state is far behind

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the attainable yield of 40-50 q /ha mainly because of inadequate and imbalanced supply of nutrients. The major use of barley is in brewing industries for manufacturing malt, which is used to make bear, industrial alcohol, whisky, malt syrups, brandy, malted milk, vinegar and yeast. Its surplus grains are used as concentrates for feeding livestock and poultry. Its straw and husk are good quality roughage for cattle and are used for preparing compost litter bedding and also in paper industry. In Rajasthan, barley is grown both on conserved moisture under tank bed situation and as an irrigated crop on light textured marginal soils. The production of barely is low due to inadequate availability of nutrients and water scarcity. Nitrogen, phosphorus and potassium are the primary nutrients required by crops. Being an important constituent of protein, chlorophyll and enzymes involved in various metabolic processes, nitrogen influences the vegetative and reproductive growth of plants. Phosphorus is constituent of sugar phosphates, nucleotides, nucleic acids, coenzymes and phospholipids (Reddy and Reddy, 2001). Potassium status in our soil is medium and hence, its application may be skipped some times. Regular and judicious use of fertilizers not only help in raising good crop yields on a sustainable basis but can help farmers to gain consistently higher profits. Balanced nutrition is essential for the proper growth and productivity of crops. Fertilizers not only remarkably increase crop yield on lands but has also proved to be the key factors in success or failure of the crops in many cases. Application of fertilizers in nutrient deficient soils has shown commendable effects on various crops including barley. Foliar fertilization is probably as old as any crop production measures practiced in agriculture. The foliar applied nutrients are more effective as compared to soil applied nutrients. Because of higher uptake efficiency, foliar supply of nutrients can increase photosynthetic efficiency by delaying the onset of leaf senescence. The advent of radioisotopes and the development of techniques for plant analysis have greatly stimulated research on both the basic and applied aspects of foliar absorption, translocation and utilization. Recent interest in foliar nutrition is also due to the greater awareness of soil water pollution resulting from indiscriminate or excessive soil fertilization and adverse soil conditions which favor soil fixation of nutrients. Use of foliar sprays has been observed in delaying leaf abscission and increasing dry matter production in apple. Yadav (2006) reported significant improvement in grain yield of chickpea by foliar spray of 2 per cent DAP and urea. Foliar fertilization is more effective when given during the seed filling period in grain crops. The nutrient present in the leaf accumulated during the early growth stages migrate to the grain or fruit during later stages of development. The foliar nutrient depletion affects photosynthesis in the “flag leaf” in particular which supplies the major portion of the photosynthesis to the grain in a few crops. Yadav and Gupta (2007) at Durgapura reported that nitrogen content in gram leaves decreased in foliar spray treatments of 2 per cent urea and 2 per cent DAP at maturity. Keeping the above facts in view, the present investigation on fertilizer management in barley (*Hordeum vulgare* L.) was conducted in loamy sand soil of Jobner during the *Rabi* season, 2016-17 with the following objectives : To explore the effect of fertility levels along with foliar nutrition on growth, yield and quality of barley, to assess the interactive effect of fertility levels and foliar nutrition and to find out the best combination thereof and to work out the economic viability of treatments.

MATERIAL AND METHODS

The details of experimental techniques followed material used and criteria adopted for the evaluation of treatments during the course of investigation are presented in this chapter.

Experimental details:

Treatments:

Experiment comprising of four levels of fertilizer (control, 50% RDF, 75% RDF, and 100% RDF) and five treatments of foliar spray (water spray, urea 2%

Table A : Treatments and their symbols

Treatments	Symbol
Fertility levels	
Control	F_0
50% RDF (40 kg N+ 10 kg P_2O_5 /ha)	F_1
75% RDF (60 kg N+ 15 kg P_2O_5 /ha)	F_2
100% RDF (80 kg N+ 20 kg P_2O_5 /ha)	F_3
Foliar spray	
Water spray at tillering and flowering	S_0
Urea 2% spray at tillering and flowering	S_1
Urea 3% spray at tillering and flowering	S_2
DAP 2% spray at tillering and flowering	S_3
KCl 2% spray at tillering and flowering	S_4

and 3% at Tillering and Flowering, DAP 2% at Tillering and Flowering and KCl 2% at Tillering and Flowering) thereby making 20 treatment combinations was laid out in RBD and replicated three times with the help of Fisher's random number Table A. The various treatments with their notations are given in Table A and other details regarding technical programme is given as follows:

Details of crop rising :

The schedule of different pre and post-sowing operations carried out in the experimental field has been given in Table B and other details of crop rising are as under:

Fertilizer application:

Nitrogen and phosphorus was applied as per treatment through urea and DAP, respectively. Half of the dose of nitrogen was given at sowing of crop and remaining half was top dressed at first irrigation and phosphorus was applied through diammonium phosphate at 8-10cm depth before sowing as per treatments.

Variety (RD-2508):

The variety was released in 1997 and recommended for cultivation under irrigated late sown condition or saline area. It takes about 125-130 days to mature. The 1000-grain weight is 42-45 g. It is resistant to yellow rust, brown rust and aphids, having yield potential of 30 to 35 q/ha.

Seed treatment:

Barley seeds were treated with bavistin at 2g/kg and chloropyriphos 20 EC at 4.5ml/kg before sowing to check the fungal and termite attack, respectively.

Seed rate and sowing:

The seeds were sown using seed rate of 100kg/ha with the help of bullock drawn desi plough using 'pora' (funnel with long tube) attachment in lines spaced 22.5cm apart.

Intercultural operations:

Inter row weeding was done manually about one month after sowing with the help of hoe locally known as "Kassi".

Irrigations:

Irrigation to each plot was given by check basin method.Each irrigation consisted of 5 cm water. The irrigation was applied as per the schedule given in Table B.

Table B : Physico-chemical properties of soil of experimental field

Properties	Values	Method used
Mechanical		
Coarse sand (%)	20.07	International pipette method (Piper, 1966)
Fine sand (%)	59.30	International pipette method (Piper, 1966)
Silt (%)	11.40	International pipette method (Piper, 1966)
Clay (%)	8.45	International pipette method (Piper, 1966)
Textural class	Loamy- sand	Hand Book No. 18 (soil survey Staff, 1975)
Physical		
Bulk density (Mg/m^3)	1.50	Method No. 38,USDA Hand Book No. 60 (Richards, 1968)
Particle density (Mg/m^3)	2.60	Method No. 39,USDA Hand Book No. 60 (Richards, 1968)
Field capacity (%)	11.50	Method No. 33, USDA Hand Book No. 60 (Richards, 1968)
Permanent wilting point (%)	2.60	Method No. 31, USDA Hand Book No. 60 (Richards, 1968)
Chemical composition		
Organic carbon (%)	0.38	Walkley and Black's Rapid titration method (Jackson, 1973)
Total N (%)	0.026	Modified Kjeldahl's method (Bremner, 1960)
Available N (kg/ha)	134.5	Alkaline permanganate method (Subbiah and Asija, 1956)
Available phosphorus (P kg/ha)	18.50	Olsen's method (Olsen *et al.* 1954)
Available K_2O (kg/ha)	148.65	Flame photometer method (Jackson, 1973)
Ec_e at 25 ^0C (dS/m)	1.35	Method No. 4, USDA Hand Book No. 60 (Richards, 1968)
pH (1 :2 soil, water suspension)	8.20	Method No. 21(b), USDA Hand Book No. 60 (Richards, 1968)

Plant protection:

Dimecron 100 EC @ 0.03 per cent solution was sprayed soon after appearance of aphids.

Treatment evaluation:

In order to evaluate the effect of different treatments on plant growth, yield and quality, the following periodical observations were recorded.

Growth characters:

Plant stand :

A metre scale was placed at four random spots in each plot to count plant stand per metre row length at 20 DAS and at harvest and the average was worked out and recorded.

Plant height:

Plant height of five randomly selected tagged plants was recorded at 30, 60, 90 DAS and at harvest in each plot and expressed as average height in cm.

Dry matter accumulation:

For recording dry matter accumulation, plant samples of one metre length were taken from second border row of each plot at 30, 60, 90DAS and at harvest. These samples were first air dried and then kept in hot air oven at 60^0C for 24 hours or till constant weight and then weighed. The weight was expressed as dry matter accumulation per metre row length (g).

Number of tillers:

A metre scale was placed in each plot randomly at three spots along the crop row at 30, 60, 90 DAS and at harvest and the number of tillers per metre row length were counted and their average number was expressed as tillers per metre row length. The numbers of tillers were counted from the same spots at harvest.

Yield and yield attributes:

Number of effective tillers per metre row length:

The number of ear bearing tillers were counted following the same procedure as for total number of tillers and their average was taken as the number of effective tillers or ears per metre row length.

Spike length:

Five ears were taken randomly from each plot. Length of these ears was measured and average length (cm) per ear was worked out.

Number of grains per spike:

Five ears taken from each plot for recording ear length were threshed. The grains were counted and average number of grains per ear was worked out.

Test weight:

One thousand grains were counted from the produce of each plot and their weight was expressed in grams.

Grain yield:

After threshing and winnowing, the weight of grain obtained from net plot area was recorded in kg per plot and then converted into kg per hectare.

Straw yield:

Straw yield was obtained by subtracting the grain yield from the total biological yield of the respective net plot area and expressed in kg per hectare.

Harvest index:

Harvest index was calculated by using the following formula (Singh and Stoskopf, 1971).

$$\text{Harvest index} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

Quality parameters:

For estimation of quality parameters, plot wise representative samples of seed and straw were taken at the time of winnowing. Each dried sample was ground by willey mill.

Chlorophyll content at flag leaf stage:

Chlorophyll content in flag leaves was determined using acetone extraction method (Arnon, 1949) and expressed as mg/g fresh weight of leaves.

Nitrogen concentration in grain and straw:

The ground samples were digested with sulphuric acid using H_2O_2 to remove black colour. Estimation of nitrogen was done by colorimetric method, using Nessler's reagent to develop colour (Snell and Snell, 1949). The results were expressed as per cent N concentration on dry weight basis.

Protein content in grain:

Protein content in seed was calculated by multiplying the per cent nitrogen concentration in grain by 6.25

(A.O.A.C., 1990).

Phosphorus concentration in grain and straw:

Phosphorus concentration in grain and straw were determined by Vanadomolybdo phosphoric yellow colour method. Digestion of samples was done by triacid mixture. Ammonium molybdate-ammonium vanadate solution was used to develop colour and resultant intensity of colour was measured by Klett Summerson photoelectric colorimeter and expressed as per cent phosphorus concentration on dry weight basis (Jackson, 1973).

Potassium concentration in grain and straw:

The potassium concentration in grain and straw was determined by Flame photometer employing the method given by Bhargava and Raghupathi (1993).

Nutrient uptake:

Nutrient uptake by the crop was calculated by using the following formula:

$$\text{Total uptake (kg/ha)} = \frac{\text{Nutrient concentration in grain (\%) x Grain yield (kg/ha)} + \text{Nutrient concentration in straw (\%) x Straw yield (kg/ha)}}{100}$$

RESULTS AND DISCUSSION

Data pertaining to various criteria used for treatment evaluation were analysed statistically to test their significance. The analyses of variance for all these data have been given in Appendices at the end. Some of the important characters have also been presented diagrammatically to provide better understanding and for elucidation of important trends. However, none of the interaction effects was found to be significant, hence, it has not been described.

Growth:

Plant stand:

Data presented in Table 1 revealed that fertility levels and foliar spray treatments had no significant effect

Table 1 : Effect of fertility level and foliar spray on plant stand per metre row length

Treatments	Plant stand per metre row length	
	20 DAS	At harvest
Fertility level		
Control	28.5	26.4
50% RDF	28.5	27.4
75% RDF	28.5	27.9
100% RDF	28.9	28.2
S.E.±	0.7	0.7
C.D. (P = 0.05)	NS	NS
Foliar spray		
Water spray	28.5*	27.0
2% urea spray	28.3*	27.9
3% urea spray	28.6*	27.2
2% DAP spray	28.6*	27.6
2% KCl spray	28.8*	27.5
S.E.±	0.8	0.8
C.D. (P = 0.05)	NS	NS

NS= Non-significant * Treatment was not applied

Table 2 : Effect of fertility level and foliar spray on plant height (cm)

Treatments	Plant height			
	30 DAS	60 DAS	90 DAS	At harvest
Fertility level				
Control	34.0	45.8	55.7	69.0
50% RDF	38.3	51.4	63.6	78.0
75% RDF	40.8	55.9	70.9	85.9
100% RDF	41.8	58.5	74.0	92.3
S.E.±	1.0	1.4	1.7	1.9
C.D. (P = 0.05)	2.8	3.9	4.7	5.5
Foliar spray				
Water spray	38.5*	48.1	58.1	73.9
2% urea spray	39.1*	54.9	68.8	83.9
3% urea spray	38.9*	53.9	67.7	82.4
2% DAP spray	39.0*	54.0	68.2	83.4
2% KCl spray	38.1*	53.6	67.3	82.9
S.E.±	1.1	1.5	1.8	2.1
C.D. (P = 0.05)	NS	4.3	5.3	6.1

NS = Non-significant * Treatment was not applied

on plant stand per metre row length of barely at 20 DAS and at harvest. Thus, plant stand was almost uniform in all plots throughout the growing period.

Plant height:

Data presented in Table 2 revealed that varying levels of fertility significantly increased the plant height over control at all the growth stages. At 30 DAS, increasing fertility levels increased the plant height linearly recording the maximum value at 100% RDF which proved significantly superior to control by 22.9 % and remained at par with 50% and 75% RDF. At later stages of growth *i.e.* at 60 and 90 DAS, the trend remained same, where in 100% RDF significantly increased the plant height over its preceding levels. The enhancement in plant height due to 100% RDF was 22.1, 8.8% at 60 DAS and 27.3, 11.5% at 90 DAS, respectively, over control and 50% RDF. at harvest, the application of 100% RDF significantly increased the plant height indicating an increase of 33.8, 18.3 and 7.5%, respectively, over control, 50% and 75% RDF. However, at later stages, plant height was significantly increased due to foliar spray of fertilizers as compared to water spray. Foliar application of 2% urea at tillering and flowering being at par with 2% DAP and 3% urea and 3% KCl gave significantly higher plant height by 14.1% at 60DAS, 18.4% at 90DAS and 13.5% at harvest as compared to water spray.

Total number of tillers:

A reference to data revealed that increasing levels of fertility upto 100% RDF significantly increased total number of tillers per metre row length of barely. Application of full dose of fertilizers significantly increased the total number of tillers per metre row length registering an increase of 23.6% at 60 DAS, 32.9% at 90 DAS and 23.9% at harvest, respectively over control. However, treatments 75% and 100% RDF remained at par at 60 DAS and at harvest, respectively. The maximum total tillers per metre row length was recorded due to foliar spray of 2% urea which proved significantly superior indicating an increase of 16.1, 15.4 and 16.0% at 60, 90 DAS and at harvest, over control, respectively. Foliar spray of 2% DAP, 3% urea and 2% KCl remained at par with 2% urea.

Dry matter accumulation:

It is evident from data that increasing levels of fertility upto 100% RDF significantly increased the dry matter accumulation per metre row length of barely over its preceding levels at all the growth stages. The increase in dry matter accumulation per metre row length due to 100% RDF was 45.8, 20.6 and 8.2% at 30DAS, 46.0 23.6 and 8.8% at 60DAS, 42.6, 21.3 and 8.9% at 90DAS and 56.3, 28.0 and 11.0% at harvest, respectively, over control. However, at later stages, dry matter accumulation significantly increased due to foliar spray. The application of 2% urea at tillering and flowering being at par with 2% DAP, 3% urea and 2% KCl produced significantly higher dry matter accumulation indicating an increase of

Table 3: Effect of fertility level and foliar spray on total number of tillers per metre row length

Treatments	Total number of tillers per metre row length		
	60 DAS	90 DAS	At harvest
Fertility level			
Control	58.0	58.6	57.3
50% RDF	65.8	66.9	65.5
75% RDF	71.7	73.0	71.0
100% RDF	75.8	78.0	74.5
S.E.±	1.8	1.7	1.6
C.D. (P = 0.05)	5.0	4.9	4.8
Foliar spray			
Water spray	60.9	62.2	60.6
2% urea spray	70.7	71.8	70.3
3% urea spray	69.2	70.2	68.2
2% DAP spray	69.7	71.5	69.0
2% KCl spray	68.6	69.7	67.2
S.E.±	1.9	1.9	1.9
C.D. (P = 0.05)	5.6	5.5	5.5

Table 4 : Effect of fertility level and foliar spray on dry matter accumulation per metre row length (g)

Treatments	Dry matter accumulation per metre row length			
	30 DAS	60 DAS	90 DAS	At harvest
Fertility level				
Control	25.3	39.1	73.9	119.2
50% RDF	30.6	46.2	86.9	145.5
75% RDF	34.1	52.5	96.8	167.8
100% RDF	36.9	57.1	105.4	186.3
S.E.±	0.8	1.2	2.3	4.0
C.D. (P = 0.05)	2.3	3.6	6.7	11.4
Foliar spray				
Water spray	31.5*	41.6	77.4	126.8
2% urea spray	31.7*	51.7	95.4	164.5
3% urea spray	31.3*	49.6	93.6	160.5
2% DAP spray	31.7*	50.7	94.2	162.2
2% KCl spray	32.4*	50.0	92.9	159.4
S.E.±	0.91	1.4	2.6	4.5
C.D. (P = 0.05)	NS	4.0	7.5	12.8

NS = Non-significant * Treatment was not applied

24.3, 23.3 and 29.7% 60, 90DAS and at harvest over control, respectively.

Chlorophyll content:

A perusal of data in Table 5 revealed that increasing levels of fertilizers to barley significantly increased the total chlorophyll content in plant leaves at pre-flowering stage upto 50% RDF. The increase in chlorophyll content due to 50% RDF was 10.1% over control. However, application of 75% and 100% RDF was found at par with 50% RDF. The maximum chlorophyll content was recorded due to foliar spray of 2% urea which indicated an increase of 16.0, 6.3, 3.8 and 1.6% over control, 2% KCl, 2% DAPS and 3% urea, respectively.

Table 5 : Effect of fertility level and foliar spray on chlorophyll content at pre-flowering stage

Treatments	Chlorophyll content (mg/g)
Fertility level	
Control	2.465
50% RDF	2.715
75% RDF	2.889
100% RDF	2.906
S.E.±	0.079
C.D. (P = 0.05)	0.227
Foliar spray	
Water spray	2.489
2% urea spray	2.888
3% urea spray	2.843
2% DAP spray	2.782
2% KCl spray	2.717
S.E.±	0.089
C.D. (P = 0.05)	0.254

Yield attributes and yield:

Number of effective tillers per metre row length:

A reference to data in Table 6 revealed that number of effective tillers per metre row length was significantly influenced due to fertility levels wherein application of 100% RDF recorded the maximum number of effective tillers per metre row length indicating an increase of 41.0, 17.8 and 7.5% ove r control, 50 and 75% RDF, respectively. Foliar application of 2% urea being at par with 2% DAP, 3% urea and 2% KCl increased the number of effective tillers by 22.4% over water spray.

Spike length:

Data presented in Table 6 revealed that varying

Table 6 : Effect of fertility level and foliar spray on yield attributes

Treatments	Effective tillers / metre row length	Spike length (cm)	Grains / spike	Test weight (g)
Fertility level				
Control	41.3	6.2	34.1	39.0
50% RDF	50.1	8.0	41.0	40.8
75% RDF	55.9	8.8	46.6	41.4
100% RDF	60.9	9.4	50.5	41.9
S.E.±	1.4	0.2	1.1	1.0
C.D. (P = 0.05)	4.1	0.6	3.1	NS
Foliar spray				
Water spray	45.0	7.3	36.4	40.4
2% urea spray	55.1	8.5	45.9	41.0
3% urea spray	53.3	8.1	44.3	41.8
2% DAP spray	54.4	8.4	44.9	40.9
2% KCl spray	52.7	8.1	43.6	40.9
S.E.±	1.6	0.2	1.2	1.1
C.D. (P = 0.05)	4.6	0.7	3.4	NS

NS = Non-significant

fertility levels brought about a significant improvement on spike length of barely. Application of 100% RDF significantly increased the spike length over control, 50 and 75% RDF registering an increase of 51.6, 17.5 and 6.8%, respectively. Foliar application of 2% urea recorded significantly higher spike length of barley over control and remained at par with other treatments. The per cent increase due to 2% urea was 16.4% over control.

Number of grains per spike:

Data presented in Table 6 indicated that application of increasing levels of fertility significantly increased the grains per spike. The maximum number of grains per spike recorded with 100% RDF registered an increase of 8.4, 23.2 and 48.1% over 75%, 50% RDF and control, respectively. Foliar spray of 2% urea at tillering and flowering being at par with 2% DAP 3% urea and 2% KCl spray treatments, represented an increase of 26.1% over control.

Test weight:

Data given in Table 7 indicated that the application of different levels of recommended dose of fertilizers could not bring any significant increase in test weight of barley.

Seed yield:

Application of 100% RDF recorded the maximum

Table 7 : Effect of fertility level and foliar spray on seed, straw and biological yields and harvest index

Treatments	Yield (kg/ha)			Harvest index (%)
	Seed	Straw	Biological	
Fertility level				
Control	2232	3473	5705	38.9
50% RDF	3075	4304	7379	41.7
75% RDF	3552	4857	8409	42.3
100% RDF	3735	5234	8969	41.8
S.E.±	49	111	135	0.7
C.D. (P = 0.05)	143	318	386	1.9
Foliar spray				
Water spray	2744	3873	6617	40.6
2% urea spray	3287	4657	7944	41.4
3% urea spray	3240	4547	7787	41.5
2% DAP spray	3273	4691	7964	41.1
2% KCl spray	3199	4562	7766	41.3
S.E.±	56	124	151	0.7
C.D. (P = 0.05)	160	356	432	NS

NS = Non-significant

seed yield and represented a significant increase of 67.7, 21.5 and 5.2% over control, 50% and 75% RDF, respectively. Foliar application of 2% urea, 2% DAP, 3% urea and 2% KCl represented an increase of 19.2, 18.1 and 16.6% respectively, over water sprayed control. However, all the foliar spray treatments remained at par with each other.

Straw yield:

Data presented in Table 7 showed that different fertility levels brought about a significant improvement in straw yield wherein 100% RDF recorded the maximum straw yield. The increase in straw yield due to 100% RDF was 50.7, 21.6 and 7.8% over control, 50% and 75% RDF, respectively. Foliar application of DAP @ 2% represented an increase of 21.1% over water spray. The effect of foliar spray of 2% urea, 3% urea and 2% KCl was also found significant over control.

Biological yield:

A reference to data in Table 7 revealed that application of increasing levels of doses of fertility significantly increased the biological yield wherein 100% RDF recorded the maximum biological yield of barley and registered an increase of 57.2, 21.6 and 6.7% over control, 50% and 75% RDF, respectively. Foliar spray of 2% DAP, 2% urea, 2% KCl and 3% urea registered of 20.4, 20.2, 17.8 and 17.4% increase over water sprayed control.

Harvest index:

The data in Table 7 clearly showed that different fertility levels significantly influenced the harvest index of barley. Application of 75% RDF registered the maximum harvest index and represented a significant increase of 9.0% over control but remained at par with 100 and 50% RDF.

Quality :

Protein content in grain:

Data presented in Table 8 revealed that protein content in grain was affected significantly due to different levels of fertility wherein application of 100% RDF increased the protein content in seed by 23.2 and 9.9% over control and 50% RDF, respectively but it remained at par with 75% RDF. Foliar spray of 2% urea increased the protein content by 19.0% over water spray; however, it remained at par with other foliar spray treatments.

Table 8 : Effect of fertility level and foliar spray on nitrogen concentration in seed and straw, nitrogen uptake and protein content in seed

Treatments	N concentration (%)		Total N uptake (kg/ha)	Protein content in grain (%)
	Seed	Straw		
Fertility level				
Control	1.586	0.450	51.2	9.9
50% RDF	1.780	0.524	77.8	11.1
75% RDF	1.912	0.568	95.0	11.9
100% RDF	1.963	0.594	104.7	12.2
S.E.±	0.046	0.014	2.8	0.3
C.D. (P = 0.05)	0.131	0.041	8.0	0.8
Foliar spray				
Water spray	1.594	0.476	62.9	10.0
2% urea spray	1.895	0.577	89.0	11.6
3% urea spray	1.901	0.552	89.6	11.9
2% DAP spray	1.793	0.535	87.5	11.7
2% KCl spray	1.787	0.530	83.2	11.2
S.E.±	0.051	0.016	3.2	0.3
C.D. (P = 0.05)	0.147	0.046	9.1	0.9

Nutrient content and uptake :

Nitrogen content in grain:

A reference to data showed that increasing fertility levels significantly increased the nitrogen content in grain of barley. Application of 100% RDF being at par with 75% RDF recorded the maximum N content in grain,

indicating an increase of 23.8 and 10.3% over control and 50% RDF, respectively. A perusal of data further revealed that application of fertilizers as foliar spray also showed significant increase in nitrogen content in grain wherein, application of 2% urea registered an increase of 19.3% over water spray, however, it remained at par with other foliar spray treatments.

Nitrogen content in straw:

It is evident from data that increasing doses of fertilizers significantly increased the nitrogen content in straw. Application of 100% and 75% RDF being at par with each other registered a significant increase of 32.2 and 26.2% over control and 13.4 and 8.4% over 50% RDF, respectively. Foliar feeding of 3% urea, 2% urea, 2% DAP and 3% KCl registered an increase of 21.2, 16.0, 12.4 and 11.3%, respectively, over water sprayed control.

Total uptake of nitrogen:

A perusal of data showed that total nitrogen uptake of barley was significantly increased due to different fertility levels as compared to control. Application of 100% RDF recorded a significant increase of 104.5, 34.4 and 10.2% over control, 50% and 75% RDF, respectively. Foliar application of 2% urea registered an increase of 42.6, 7.7, 2.5 and 0.8% over water spray, 2% KCl spray, 2% DAP spray and 3% urea spray, respectively.

Phosphorus content in grain:

A critical examination of data revealed that application of different levels of fertilizers significantly increased phosphorus content in grain of barley. Application of 100% RDF being at par with 75% RDF, significantly enhanced the phosphorus content in grain, indicating an increase of 26.5 and 9.3% over control and 50% RDF, respectively. foliar spray of 2% urea, 2% DAP, 3% urea and 2% KCl registered increases of 14.3, 13.5, 11.1 and 10.3%, respectively over water sprayed control.

Phosphorus content in straw:

A critical examination of data indicated that phosphorus content in straw increased significantly with each increasing level of fertilizers upto 75% RDF. The treatment 100% RDF being at par with 75% RDF, significantly enhanced the phosphorus content in straw, indicating an increase of 49.1 and 17.9% over control and 50% RDF, respectively. Foliar application of 2% DAP brought about a significant increase of 21.7% over water spray.

Total phosphorus uptake:

A reference to data in Table 9 revealed that phosphorus uptake increased significantly with different levels of fertilizers. Application of full dose of RDF indicated an increase of 114.3 and 34.3% over control and 50% RDF, respectively, but remained at par with 75% RDF. Foliar application of 2% urea registered a significant increase of 36.6 % over water spray and it remained at par with other foliar spray treatments.

Table 9 : Effect of fertility level and foliar spray on phosphorus concentration in seed and straw and phosphorus uptake

Treatments	P concentration (%)		Total P uptake (kg/ha)
	Seed	Straw	
Fertility level			
Control	0.355	0.053	9.8
50% RDF	0.411	0.067	15.6
75% RDF	0.445	0.076	19.6
100% RDF	0.449	0.079	20.9
S.E.±	0.011	0.002	0.6
C.D. (P = 0.05)	0.030	0.005	1.6
Foliar spray			
Water spray	0.378	0.060	13.1
2% urea spray	0.429	0.073	17.9
3% urea spray	0.420	0.071	17.0
2% DAP spray	0.432	0.072	17.8
2% KCl spray	0.417	0.067	16.6
S.E.±	0.012	0.002	0.6
C.D. (P = 0.05)	0.034	0.005	1.8

Potassium content in grain:

A perusal of data in Table 10 revealed that application of recommended dose of fertilizers significantly enhanced the K content wherein 100% RDF registered an increase of 27.7 and 10.2% over control and 50% RDF, respectively, however, it was found at par with 75% RDF. Foliar application of 2% KCl registered an increase of 18.9% over control but remained at par with rest of the foliar spray treatments.

Potassium content in straw:

Data revealed that potassium concentration in straw was significantly increased with different levels of

Table 10 : Effect of fertility level and foliar spray on potassium concentration in seed and straw and potassium uptake

Treatments	K concentration (%)		Total K uptake (kg/ha)
	Seed	Straw	
Fertility level			
Control	0.409	0.839	38.6
50% RDF	0.463	1.108	62.4
75% RDF	0.500	1.223	77.6
100% RDF	0.510	1.281	86.5
S.E.±	0.012	0.028	2.6
C.D. (P = 0.05)	0.035	0.080	7.5
Foliar spray			
Water spray	0.423	0.977	47.8
2% urea spray	0.468	1.142	70.3
3% urea spray	0.471	1.123	67.6
2% DAP spray	0.488	1.134	70.6
2% KCl spray	0.503	1.188	72.0
S.E.±	0.014	0.031	2.9
C.D. (P = 0.05)	0.039	0.089	8.4

fertilizers. Application of 75% RDF being at par with 100% RDF recorded a significant increase of 52.7 and 15.6% over control and 50% RDF, respectively. The increase in potassium content due to 2% KCl, 2% urea, 2% DAP and 3% urea was 21.6, 16.9, 16.1 and 14.9% respectively over control.

Total potassium uptake:

Data revealed that total potassium uptake significantly increased due to different fertility levels. Application of 100% RDF recorded a significant increase of 123.5, 38.6 and 11.5% over control, 50% RDF and 75% RDF, respectively. Foliar application of 2% Kcl, 2% DAP, 2% urea and 3% urea registered an increase of 41.7, 39.0, 38.4 and 33.1%, respectively over water sprayed control.

Correlation and regression:

The results of correlation co-efficients presented in Table 11 revealed that seed yield was significantly and positively correlated with tillers per metre row length, spike length, grains per spike and test weight, total nitrogen uptake, total phosphorus uptake and total potassium uptake. The regression equations showed that with a unit increase in number of tillers per metre row length, grains per spike, spike length and test weight and total nitrogen, phosphorus and potassium uptake, the

Table 11: Correlation co-efficients and linear regression equations showing relationship between independent variables (yield attributes and uptake of nutrients)

Dependent variable (Y)	Independent variables (X)	Correlation co-efficient (r)	Regression equation Y = a +byx X
Seed yield	Effective tillers per	0.980**	$Y = -675 + 73\ X_1$
(kg/ha)	metre row length		
	Spike length (cm)	0.993**	$Y = -733 + 480\ X_2$
	Grains per spike	0.973**	$Y = -460 + 84\ X_3$
	Test weight (g)	0.931**	$Y = -16375 + 477\ X_4$
	N uptake (kg/ha)	0.988**	$Y = 959 + 27\ X_5$
	P uptake (kg/ha)	0.996**	$Y = 988 + 131\ X_6$
	K uptake (kg/ha)	0.983**	$Y = 1200 + 30\ X_7$

** indicate significance of value at P=0.01

corresponding increase in seed yield was 73, 84, 480, 27, 131 and 30kg/ha, respectively.

Net returns:

A perusal of data revealed that all the treatments of fertility significantly increased the net returns of barley as compared to control. the application of 100% RDF to barley recorded the maximum and significantly higher net returns as compared to control, 50% RDF and 75% RDF. The increase in net returns due to application of 100% RDF was 121.0, 37.6 and 9.2% over control, 50% and 75% RDF, respectively. Foliar spray of 2% urea being at par with 2% DAP and 3% urea 2% KCl proved

Table 12 : Effect of fertility level and foliar spray on net returns

Treatments	Net returns (Rs./ha)
Fertility level	
Control	13932
50% RDF	22376
75% RDF	28202
100% RDF	30790
S.E.±	630
C.D. (P = 0.05)	1804
Foliar spray	
Water spray	19114
2% urea spray	25531
3% urea spray	24711
2% DAP spray	25280
2% KCl spray	24489
S.E.±	704
C.D. (P = 0.05)	2017

significantly superior to control, representing an increase of Rs. 6417/ha.

Conclusion:

Effect of fertility levels:

There was no significant effect on plant stand due to varying fertility levels indicating a uniform plant population in all the plots. The increasing fertility levels up to 100% RDF significantly increased the plant height, number of tillers per meter row length, dry matter accumulation per meter row length, chlorophyll content. However, some of the growth characters remained at par between 100% RDF, 75% RDF and 50% RDF at early stage of growth. The number of spikes per plant and grains per spike increased significantly with increase in each level of fertilizers upto 100% RDF. The test weight did not differ significantly due to application of fertilizers. Application of 100% RDF produced significantly higher grain yield by 67.3, 21.5 and 5.2, straw yield by 50.7, 21.6 and 7.8 and biological yield 57.2, 21.5 and 6.6%, respectively over control, 50% and 75% RDF. However, harvest index was significantly increased upto 50% RDF only. Nitrogen, phosphorus and potassium content in grain and straw, uptake of phosphorus and protein content in grain were significantly higher with 75% RDF. However, uptake of nitrogen and potassium increased significantly upto 100% RDF. Application of fertilizer at 100% RDF fetched net returns of Rs. 13932/ ha, which were significantly higher by Rs. 16858/ha, Rs. 8414/ ha and Rs. 2588/ha over control, 50% and 75% RDF, respectively.

Effect of foliar spray:

Plant stand was not influenced with the foliar application of fertilizers at harvest. The significantly higher plant height, number of tillers per meter row length, dry matter accumulation per meter row length and chlorophyll content in leaves were recorded with foliar spray of 2% urea, which was found at par with the foliar spray of 2% DAP, 2% urea and 2% KCl. Foliar application of 2% urea recorded significantly higher number of spikes per plant, number of grains per spike and spike length over water spray, which remained at par with 2% DAP, 3% urea and 2% KCl spray. However, test weight did not differ significantly due to foliar spray treatments. Foliar spray of 2% urea recorded significantly higher grain yield by 19.8% over water spray, whereas, foliar spray of 2% DAP recorded significantly higher straw yield by 21.1% and biological yield by 20.4% over water spray which was at par with 2% urea and 2% KCl spray. However, harvest index was not varied significantly due to foliar spray treatments. Foliar application of 2% urea recorded significantly higher nitrogen and phosphorus content in grain, total N and P uptake and protein content over water spray, whereas, phosphorus content in straw was significantly higher due to foliar application of 2% DAP over water spray. In respect of potassium concentration in grain and straw and total uptake of potassium, 2% KCl spray provided superior to control. Foliar application of urea @ 2% fetched the net returns of Rs 25531/ha, which were significantly higher over water spray but almost same with 3% urea, 2% DAP and 2% KCl spray. Interactive effect between fertility levels and foliar spray treatments were not found significant in any of the parameters studied. Based on results of one year experimentation, it may be concluded that application of 100% RDF fetched significantly higher yield and net returns over the preceding treatments as regards to foliar spray all the treatments remained equally effective but significantly superior to water spray. These results are only indicative and require further experimentation to arrive at some more consistent and final conclusion.

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