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# Effect of Methods and Levels of Irrigation on Growth and Yield of Barley

*by*

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**Synopsis:** An experiment to study the effect of different levels and methods of irrigation on the grain yield of barley was conducted at the Irrigation Research Station, Bikramganj, in Bihar. The results of the experiments revealed that for optimum grain yield of paddy, two irrigations–first one month after germination and the second at preflowering stage–were best suited.

**Introduction:** Canal irrigated areas in the districts of Shahabad, Patna and Gaya are grown largely with paddy of 'Aman' group followed by broadcasted gram or *Khesari*. Gram and *Khesari* are grown under unirrigated conditions. Crops responsive to irrigation and manuring that can follow 'Aman' paddy, therefore, need to be adopted for efficient utilisation of available irrigation water during the 'Rabi' season to boost up crop production. Barley is grown over 0.4 million hectare in Bihar, the average yield of which is hardly 4.8 quintals per hectare. Introduction of barley in rotation with 'Aman' paddy under irrigated condition with basal application of manure would greatly increase food production. Absence of reliable data on the methods, quantum and frequency of irrigation is a great handicap in raising a successful crop of barley after 'Aman' paddy. A properly designed experiment was, therefore, laid out to study the effect of methods and levels of irrigation on the growth and yield of barley.

**Materials and Methods:** The experiments were conducted at the Irrigation Research Station, Bikramganj, Shahabad within the Sone Canal command areas during the years 1961—'62, 1962—'63 and 1963—'64. The soil was loam having coarse sand 17·5, fine sand 43·7, silt 14·9 and clay 21·05 per cent. The specific gravity and volume weight were 2·62 and 1·54 respectively. Field capacity and wilting point were found to be 20 and 12 per cent, respectively on dry weight basis. Soil samples for soil moisture studies were taken with the help of a soil auger from depths of 7·5, 22·5 and 45 cm and oven dried at 110°C, a day before the scheduled date of irrigation to find out the exact quantum of irrigation to bring the root zone to field capacity.

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*Treatments:* The experiment was laid out in a split plot design having plot size 28 m x 3·5 m with the following treatments.

(a) Methods of Irrigation:

B. — Border method.

C. — Corrugation method.

(b) Levels of Irrigation:

$I_1$ — Control (no irrigation).

$I_2$ — One irrigation 30 days after germination.

$I_3$ — Two irrigations, first 30 days after germination and second at pre-flowering stage.

$I_4$ — One irrigation at pre-flowering stage.

*Manures:* A basal dose of manures consisting of 45·0 kg/ha each of nitrogen and phosphate in the form of ammonium sulphate and single super phosphate, respectively was applied at the time of seeding.

**Seed-bed Preparation and Layout:** The preceding crop in the experimental field was paddy, BR. 34 which was harvested by late November each year. Immediately after harvesting paddy a '*plewa*' of 50 mm was applied for land preparation and to induce optimum germination of seeds. The field was ploughed four times, rolled and levelled. Water measuring devices were fitted up in the channels, previously constructed, for accurate measurement of irrigation water. Plots receiving irrigation by corrugation method were provided with spiles (1" diameter bamboo tubes) for uniform distribution of irrigation in each corrugation. Water was measured for application over one-foot wide iron-weirs having sliding gates.

Average monthly crop-weather data of rainfall, evaporation, temperature and humidity for (1961 to 1964) are given in Table I.

TABLE I.

*Average Monthly Crop Weather Data (1961-'62 to 1963-'64)*

| Month | Rainfall | Evap. | Temp. °C | | Humidity (7a m) |
|---|---|---|---|---|---|
| | mm | mm | Max | Min | % |
| October | 90·1 | 106·1 | 30·7 | 22·0 | 87·7 |
| November | 3·3 | 103·8 | 27·9 | 15·7 | 84·5 |
| December | 4·9 | 79·2 | 27·0 | 9·7 | 82·7 |
| January | 6·2 | 96·5 | 22·1 | 5·3 | 78·8 |
| February | 10·7 | 101·3 | 24·2 | 12·0 | 75·8 |
| March | 16·3 | 243·0 | 32·2 | 17·0 | 62·8 |

Rainfall received between December to March relating to crop period is presented in Table II.

TABLE II.

*Rainfall (mm) distribution between December – March.*

| Months | 1961—'62 | 1962—'63 | 1963—'64 | Mean |
|---|---|---|---|---|
| December | 7·62 | 7·11 | Nil | 4·9 |
| January | 11·43 | 7·11 | Nil | 6·2 |
| February | 12·19 | 10·92 | 10·16 | 10·7 |
| March | 11·43 | 37·59 | Nil | 16·3 |
| Total | 42·67 | 62·73 | 10·16 | 38·1 |

Results: Dates of sowing, flowering, harvesting and the total crop period are given in Table III.

TABLE III.

*Year-wise Dates of Sowing, Flowering, Harvesting and Crop Period.*

| Particulars | 1961—'62 | 1962—'63 | 1963—'64 |
|---|---|---|---|
| Date of sowing | 6-12—'61 | 8-12—'62 | 9-12—'63 |
| Date of flowering | 26—2—'62 | 20—2—'63 | 21—2—'64 |
| Date of harvesting | 31—3—'62 | 6—4—'63 | 27—3—'64 |
| Crop period in days | 114 | 118 | 107 |

The depths of irrigation applied to treatments are presented in Table IV for the years 1961—'62, 1962—'63 and 1963—'64.

TABLE IV.

*Depths of Irrigation (mm)*

| Year | $I_1$ | $I_2$ | $I_3$ | $I_4$ |
|---|---|---|---|---|
| 1961—'62 | Nil | 86·3 | 193·0 | 95·4 |
| 1962—'63 | Nil | 86·3 | 167·6 | 99·0 |
| 1963—'64 | Nil | 87·4 | 180·5 | 101·6 |
| Mean | Nil | 86·6 | 180·3 | 98·6 |

No irrigation was applied to $I_1$ but treatments $I_2$, $I_3$ and $I_4$ received one, two and one irrigation applications, respectively, according to stages of plant growth.

(i) *Tillering:* The tiller counts for the three years 1961—'62, 1962—'63 and 1963—'64 are presented in Table V.

TABLE V.

*Tiller counts.*

| Year | Method | $I_1$ | $I_2$ | $I_3$ | $I_4$ | Mean | C. D. at 5% |
|---|---|---|---|---|---|---|---|
| | B | 20·0 | 31·7 | 31·2 | 25·2 | 27·0 | |
| 1961—'62 | C | 24·5 | 28·5 | 24·5 | 22·8 | 25·0 | N. S. |
| | Mean | 23·2 | 30·1 | 27·8 | 24·0 | 26·0 | |
| | B | 17·8 | 20·1 | 21·2 | 17·1 | 19·0 | |
| 1962—'63 | C | 15·7 | 20·5 | 18·0 | 16·3 | 17·6 | C.D.(I) 1·78 |
| | Mean | 16·7 | 20·3 | 19·6 | 16·7 | 18·3 | |
| | B | 12·0 | 14·0 | 15·0 | 12·0 | 13·2 | |
| 1963—'64 | C | 12·0 | 15·0 | 18·0 | 13·0 | 14·5 | C.D.(I) 1·78 |
| | Mean | 12·0 | 14·5 | 16·5 | 12·5 | 13·8 | |

Effect of irrigation on the number of tillers was significant during the years, 1962—'63 and 1963—'64. The effect of methods of irrigation was non-significant. Treatment $I_3$ was superior to the rest in respect of number of tillers followed by treatment $I_2$.

(ii) *Height of Plants:* The data on the final height of plants are given in Table VI.

TABLE VI.

*Average Height of Plants (cm)*

| Year | Method | $I_1$ | $I_2$ | $I_3$ | $I_4$ | Mean | C. D. at 5% |
|---|---|---|---|---|---|---|---|
| | B | 66·7 | 82·9 | 87·6 | 75·2 | 78·1 | |
| 1961—'62 | C | 76·6 | 86·4 | 88·3 | 76·3 | 81·9 | C.D.(MxI)7·22 |
| | Mean | 71·6 | 84·6 | 87·9 | 75·7 | 80·0 | |
| | B | 62·3 | 72·3 | 70·0 | 58·5 | 65·7 | |
| 1962—'63 | C | 62·0 | 73·3 | 72·0 | 64·5 | 68·1 | C.D.(I) 4·37 |
| | Mean | 62·1 | 72 8 | 71·0 | 61·5 | 66·9 | |
| | B | 72·1 | 67·0 | 77·7 | 75·5 | 73·0 | |
| 1963—'64 | C | 68·7 | 80·5 | 81·2 | 69·7 | 75·0 | C.D.(I) 5·35 |
| | Mean | 70·4 | 73·7 | 79·5 | 72·6 | 74·0 | |

The effect of irrigation on the final height of plants was significant during the years 1962—'63 and 1963—'64, whereas method of irrigation was not significant in any of the years of trial. In both the years treatments $I_2$ and $I_3$ showed their superiority over treatments $I_1$ and $I_4$.

(iii) *Length of 'ear':* Table VII presents the data on the length of 'ear' for the three years, 1961—'62, 1962—'63 and 1963—'64.

TABLE VII.

*Length of 'ear' (cm)*

| Year | Method | $I_1$ | $I_2$ | $I_3$ | $I_4$ | Mean | C. D. at 5% |
|---|---|---|---|---|---|---|---|
| | B | 5·95 | 6·35 | 7·23 | 7·08 | 6·65 | |
| 1961—'62 | C | 6·03 | 6·65 | 6·98 | 6·58 | 6·56 | C.D.(I) 0·74 |
| | Mean | 5·99 | 6·50 | 7·10 | 6·83 | 6·60 | |
| | B | 5·90 | 6·00 | 7·00 | 6·30 | 6·30 | |
| 1962—'63 | C | 5·90 | 6·30 | 7·20 | 6·30 | 6·42 | C.D.(I) 0·44 |
| | Mean | 5·90 | 6·15 | 7·10 | 6·30 | 6·32 | |
| | B | 6·22 | 7·08 | 7·12 | 6·55 | 6·74 | |
| 1963—'64 | C | 6·05 | 7·18 | 7·38 | 6·10 | 6·68 | C.D.(I) 0·42 |
| | Mean | 6·15 | 7·13 | 7·25 | 6·32 | 6·71 | |

In all the three years of trial the effect of irrigation was significant. The treatment $I_3$ was superior to control. Methods of irrigation were non-significant.

(iv) *Number of Grains per 'ear':* Table VIII presents the average number of grains per 'ear' for the three years, 1961—'62, 1962—'63 and 1963—'64.

TABLE VIII.

*Average number of grains per 'ear'*

| Year | Method | $I_1$ | $I_2$ | $I_3$ | $I_4$ | Mean | C. D. at 5% |
|---|---|---|---|---|---|---|---|
| | B | 36·55 | 37·00 | 42·50 | 43·00 | 39·76 | |
| 1961—'62 | C | 32·25 | 39·05 | 41·55 | 41·40 | 38·56 | C.D.(I) 2·27 |
| | Mean | 34·40 | 38·02 | 42·02 | 42·20 | 39·16 | |

TABLE VIII. *(Contd.)*

| Year | Method | $I_1$ | $I_2$ | $I_3$ | $I_4$ | Mean | C. D. at 5% |
|---|---|---|---|---|---|---|---|
| | B | 29·30 | 30·30 | 35·50 | 29·70 | 31·20 | |
| 1962—'63 | C | 32·00 | 37·00 | 39·90 | 29·80 | 34·67 | C.D.(I) 1·66 |
| | Mean | 30·65 | 33·65 | 37·70 | 29·75 | 32·93 | |
| | B | 37·00 | 40·00 | 45·00 | 39·00 | 40·25 | |
| 1963—'64 | C | 37·00 | 42·00 | 45·00 | 38·00 | 40·50 | C.D.(I) 2·94 |
| | Mean | 37·00 | 41·00 | 45·00 | 38·50 | 40·37 | |

Effect of irrigation on the number of grains per 'ear' was significant in all the years. Treatment $I_3$ was significantly superior to treatments $I_1$ and $I_2$ in all the three years and also to treatment $I_4$ during 1962—'63 and 1963—'64.

(v) *Grain weight (1000 grains):* The experimental data on the weight of 1000 grains are given in Table IX.

TABLE IX.

*Weight of 1,000 Grains (gm)*

| Year | Method | $I_1$ | $I_2$ | $I_3$ | $I_4$ | Mean | C. D, at 5% |
|---|---|---|---|---|---|---|---|
| | B | 32·68 | 33·40 | 35·08 | 35·53 | 35·15 | |
| 1961—'62 | C | 33·53 | 34·95 | 35·48 | 34·70 | 34·67 | C.D.(I) 1·54 |
| | Mean | 33·10 | 34·17 | 35·28 | 35·11 | 34·41 | |
| | B | 43·00 | 42·00 | 46·00 | 45·00 | 44·00 | |
| 1962—'63 | C | 45·00 | 45·00 | 46·00 | 47·00 | 45·75 | N. S. |
| | Mean | 44·00 | 43·50 | 46·00 | 46·00 | 44·37 | |
| | B | 38·00 | 37·50 | 41·00 | 39·50 | 39·00 | |
| 1963—'64 | C | 37·50 | 33·50 | 38·75 | 41·00 | 37·69 | C.D.(I) 2·42 |
| | Mean | 37·75 | 35·50 | 39·87 | 40·25 | 38·34 | |

Effect of irrigation on thousand grain weight was significant in two out of three years, 1961—'62 and 1963—'64. The treatment $I_4$ being at par with $I_3$ was significantly superior to $I_1$ only.

(vi) *Grain Yield :* The results of grain yield in quintal per hectare are presented in Table X.

TABLE X.

*Average grain yield of Barley (quintal per hectare)*

| Year | Method | $I_1$ | $I_2$ | $I_3$ | $I_4$ | Mean | C. D. at 5% |
|---|---|---|---|---|---|---|---|
| | B | 8·08 | 10·90 | 14·50 | 13·60 | 11·77 | |
| 1961—'62 | C | 9·98 | 11·38 | 13·30 | 12·30 | 11·74 | C.D.(I) 1·61 |
| | Mean | 9·03 | 11·14 | 13·90 | 12·95 | 11·75 | |
| | B | 8·88 | 12·40 | 13·40 | 11·82 | 11·62 | |
| 1962—'63 | C | 9·90 | 12·70 | 13·82 | 9·60 | 11·51 | C.D.(I) 2·06 |
| | Mean | 9·39 | 12·55 | 13·16 | 10·70 | 14·56 | |
| | B | 9·83 | 14·10 | 16·30 | 12·32 | 13·16 | |
| 1963—'54 | C | 10·82 | 12·90 | 15·30 | 12·60 | 12·90 | C.D.(I) 0·92 |
| | Mean | 10·32 | 13·50 | 15·80 | 12·46 | 13·03 | |
| | B | 8·90 | 12·50 | 14·80 | 12·55 | 12·19 | |
| Mean | C | 10·30 | 12·10 | 14·10 | 12·60 | 12·55 | C.D.(I) 1·24 |
| | Mean | 9·60 | 12·30 | 14·45 | 12·57 | 12·18 | |

Only the effect of irrigation on grain yield was significant. From the results of individual years as well as from the combined analysis of the grain yield it appears that the effect of treatment $I_3$ was significantly superior to the treatment $I_1$. Differences in yield due to methods of irrigation were non-significant. Treatments $I_3$ and $I_4$ which remained at par were found significantly superior to the treatment $I_1$ (control).

(vii) *Straw yield :* Table XI presents the straw yield data for the years 1961—'62, 1962—'63 and 1963—'64.

TABLE XI.

*Average yield of straw (quintal / hectare)*

| Year | Method | $I_1$ | $I_2$ | $I_3$ | $I_4$ | Mean | C. D. at 5% |
|---|---|---|---|---|---|---|---|
| | B | 12·10 | 19·25 | 21·40 | 18·10 | 17·70 | |
| 1961—'62 | C | 15·90 | 19·40 | 19·25 | 17·80 | 18·10 | C.D.(I) 3·17 |
| | Mean | 14·00 | 19·32 | 20·32 | 17·95 | 17·90 | |
| | B | 20·95 | 22·60 | 26·40 | 23·30 | 23·00 | C.D.(M)2·69 |
| 1962—'63 | C | 17·75 | 18·45 | 23·30 | 19·30 | 19·80 | C.D.(I) 1·92 |
| | Mean | 19·35 | 20·52 | 24·85 | 20·80 | 21·40 | |

TABLE XI. *(Contd.)*

| Year | Method | $I_1$ | $I_2$ | $I_3$ | $I_4$ | Mean | C. D. at 5% |
|---|---|---|---|---|---|---|---|
| 1963—'64 | B | 15·50 | 20·20 | 24·20 | 18·30 | 19·55 | |
| | C | 17·00 | 19·10 | 23·30 | 18·70 | 19·40 | C.D.(I) 1·56 |
| | Mean | 16·25 | 19·65 | 23·75 | 18·50 | 19·48 | |
| Mean | B | 16·38 | 20·68 | 24·00 | 22·98 | 20·08 | |
| | C | 16·88 | 18·98 | 21·95 | 18·60 | 19·10 | C.D.(I) 1·86 |
| | Mean | 16·53 | 19·93 | 22·98 | 20·79 | 19·59 | |

In respect of yield of straw the effect of irrigation was significant over the control, ($I_1$) in all the three years of trials. The effect of method of irrigation was significant during the year 1962—'63 only. Treatment $I_3$ was found to be superior to treatment $I_1$ in all the three years.

**Discussion :** Seed bed for sowing barley was prepared after harvesting early 'Aman' paddy and the crop was usually sown by the first week of December (Table III). At the end of November, the top soil is usually dry unless there is rain during that month. Therefore, in order to provide adequate soil moisture ensuring normal germination of seeds as well as for maintaining uniformity in the initial germination, 50 mm basal irrigation was applied each year. Weather conditions were conducive and light rains though varied, occurred during the years of experimentation. The contribution from rainfall towards soil moisture amounted to 42·67, 62·73 and 10·16 mm during the years 1961—'62, 1962—'63 and 1993—'64, respectively. The irrigation levels to the treatments $I_1$, $I_2$, $I_3$ and $I_4$ including rainfall were 42·67, 128·97, 235·67 and 138·07 mm, respectively during the year 1961—'62 and the corresponding grain yields obtained were 9·03, 11·14, 13·90 and 12·95 Q./ha. The increase in grain yield over control ($I_1$) amounted to 2·11, 4·87 and 3·92 Q./ha in treatments $I_2$, $I_3$ and $I_4$, respectively. The percentage increase worked out to 23·3, 53·9 and 43·4, respectively. The irrigation levels including rainfall were 62·73, 149·03, 230·33, 161·73 mm during 1962—'63 and 10·16, 97·56, 190·66 and 111·76 mm during 1963—'64 for treatment $I_1$, $I_2$, $I_3$ and $I_4$, respectively and the corresponding grain yields were 9·39, 12·55, 13·16 and 10·70 Q./ha for 1962—'63 and 10·32, 13·50, 15·80 and 12·46 Q./ha for 1963—'64. The increase in grain yield over control amounted to 3·16, 3·77 and 1·31 during 1962—'63 and 3·18, 5·48 and 2·14 during 1963—'64 in respect of the treatments $I_2$, $I_3$ and $I_4$, respectively. The percentage increases over control worked out to 33·6, 40·1 and 14·0 for 1962—'63 and 30·8, 53·1 and 20·7 for 1963—'64, respectively.

Thus it is clear from the combined analysis data that the treatment $I_2$ receiving two irrigations, first one month after sowing and the second at pre-flowering stage, has recorded significant increase in grain yield over the treatment receiving either no irrigation ($I_1$) or those receiving only one irrigation i. e. $I_3$ and $I_4$. As regards grain yield the treatments $I_2$ and $I_4$ receiving one irrigation were both significantly superior to the treatment $I_1$ receiving no irrigation at all. A single irrigation applied either 30 days after sowing or at the pre-flowering stage did not exhibit significant difference in grain yield as revealed from combined analysis data (Table X). The effect of methods of irrigation on grain yield were not significant in all the years of the trial.

In respect of straw yield the treatment $I_2$ was significantly superior to the treatment $I_1$ in all the years (Table XI).

As regards tiller number, height of plants, number of grains per 'ear' and length of 'ear', the treatment $I_2$ was significantly superior to the treatment $I_1$ in all the years, while in respect of weight of thousand grains the treatment $I_4$ was significantly superior to the treatment $I_1$ closely, followed by the treatment $I_2$.

From the study it appears that for an optimum grain yield of barley two irrigations of 90 mm each scheduled at 30 days interval from the date of germination are necessary.

Summary and Conclusions: An experiment on barley was conducted at the Irrigation Research Station, Bikramganj in the District of Shahabad for three years (1961—'62 to 1963—'64) in order to study the effect of different levels and methods of irrigation on the grain yield.

The conclusions that emerged from the results of the experiment are: (1) if barley is sown after early '*Aman*' paddy crop, one pre-sowing irrigation to the extent of 50 mm appears necessary; (2) for optimum grain yield of barley two irrigations first, one month after germination of the crop and the second at pre-flowering stage appear to be suitable; (3) giving irrigation to the barley crop either one month after germination or at pre-flowering stage is of significant advantage to giving no irrigation at all; (4) there was no significant difference in grain yield of barley between treatments receiving single irrigation, one month after germination and at pre-flowering stage; and (5) there was no significant difference in grain yield due to different methods of irrigation.