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Assessment of Productivity and Quality of Barley (*Hordeum vulgare* L.) through Nitrogen and Zinc scheduling

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Abstract

The present field experiment entitled "Assessment of productivity and quality of barley (Hordeum vulgare L.) through Nitrogen and Zinc scheduling" was conducted at Agricultural Research Farm, R.B.S. College, Bichpuri, Agra. To fulfill the requirement of objectives of the investigation field experiment was conducted during Rabi season of 2020-21. A "Randomized Block Design" with nine treatments replicated three times was adopted. The soil of experimental field was sandy loom in texture with a pH 8.2. The soil was low in available nitrogen (181.57 kg ha^{-1}), medium in available phosphorus (28.21 kg P_2O_5 ha^{-1}) and potash (285.68 kg K_2O ha^{-1}). The electric conductivity was 1.81 ds m^{-1} at 25 ^{0}C. The maximum number of shoots $metre^{-2}$ was recorded with T_9-1/3 at basal + 1/3 at tillering (35-40 DAS) + 0.5% urea + 0.5% $ZnSO_4.7H_2o$ spray at anthesis stage (80-90 DAS) at all the stages of crop growth which was significantly superior over other treatments. Shoot height revealed that the effect of treatments on shoot height was found to be significant than T_6-1/2 at basal + 1/4 at tillering (35-40 DAS) + 0.5% urea spray at anthesis stage (65-70 DAS) at all the stages of crop growth. The maximum dry matter accumulation was recorded with treatment T_1-1/2 at basal + 1/2 at tillering (35-40 DAS). All the practices required significantly less days for 75 per cent spike emergence and for maturity than that of T_6-1/2 at basal + 1/4 at tillering (35-40 DAS) + 0.5% urea spray at anthesis stage (65-70 DAS). Yield contributing characters of barley such as number of spikes $metre^{-1}$ row length, length of spike, number and weight of grains $spike^{-1}$ and 1000 grain weight were significantly improved with the over T_9. T_6 was at a par with T_9 and produced appreciably higher yield attributes over all other treatments. Among the treatments application of T_6 registered appreciably higher values of yield attributes as compared to other treatments Better expression of growth parameters under the conditions in which plots were kept T_6 is self-explanatory. The highest net profit of Rs. 66139 ha^{-1} was obtained from treatment T_6-1/2 at basal + 1/4 at tillering (35-40 DAS) + 0.5% urea spray at anthesis stage (65-70 DAS) followed by treatment T_9-1/3 at basal + 1/3 at tillering (35-40 DAS) + 0.5% urea + 0.5% $ZnSO_4.7H_2o$ spray at anthesis stage (80-90 DAS), gave net return of Rs. 65486 ha^{-1}.The additional net profit Rs. 653 to Rs. 10781 and Rs.2528 to Rs.10128 were obtained by these treatments, respectively as compared to all other treatments.

Key words : Nitrogen, zinc, productivity, quality, barley.

Introduction

The exact origin of barley is debatable, possibly originating in Egypt, Ethiopia, the Near East or Tibet. However, it is fairly certain that barley was among the earliest cultivated grains, around the same time as domestication of wheat. Barley was grown in the Middle East prior to 10,000 BC but barley's cultivation in China and India probably occurred later. Barley was grown on the Korean Peninsula by 1500-850 BC along with millet and wheat.

Among other cereal grain crops, barley is considered fourth largest cereal crop in the world with a share of 7% of the global cereal production[5]. Barley Production during 2018-19 was 139.50 million tonnes. The United States Department of Agriculture (USDA) estimates that the World Barley

Production 2019-20 will be 151.86 million metric tonnes could represent an increase of 12.37 million tonnes or 8.87%in barley production around the globe. The major barley growing countries in the world are Russia, Australia, Turkey, Ukraine, Kazakhstan and Canada cultivate barley on 7.78, 3.72, 3.60, 2.57, 2.52 and 2.40 and 1.99 million hectares land during 2018-19, respectively with the production of 16.74, 8.40 8.31, 7.60, 7.40 and 3.97 million metric tonnes respectively.

India accounts for only around one per cent of world barley production. India's annual production of Barley has been steadily around 1.2-1.7 million tonnes in the recent years, with production of 1.78 million tonnes in 2018-19. (World Agricultural Production, USDA, July2019.). Therefore, in view of the above consideration the present investigation was conducted to find out the suitable nitrogen and zinc scheduling for barley crop, to work out the economic feasibility of different treatments.

Material and Methods

The present field experiment entitled "*Assessment of productivity and quality of barley (Hordeum vulgare L.) through Nitrogen and Zinc scheduling*" was conducted during *Rabi* season of 2020-2021 at Agricultural Research Farm, R.B.S. College, Bichpuri, Agra. The experimental crop of wheat crop was raised after fallow in *Kharif* season at the Agricultural Research Farm, Raja Balwant Singh College, Bichpuri, Agra which is located at altitude of 27.20^0 North and longitude of 77.90^0 East with an elevation of 163.4 m above the mean sea level. The research farm is located at the distance of about 11 km to the west of Agra city on Agra-Bharatpur Road. This region falls under south-western semi-arid zone of Uttar Pradesh. The soil of experimental field was Gangetic alluvial with calcareous layer at the depth of about 1.5–2.0 meters and was well drained. To ascertain the fertility status and other physico-chemical properties of the soil of experimental area, a composite soil sample from the 0-30 cm. depth was taken just before sowing and was subjected to various mechanical and chemical analyses. To fulfill the requirement of objectives of the investigation field experiment was conducted during *Rabi* season of 2020-21. A "Randomized block design" with nine treatment replicated with three times was adopted. Other details about treatments are given below:

Treatments details
(N and Zn scheduling)

T_1-1/2 at basal + 1/2 at tillering (35-40 DAS)
T_2-1/2 at basal +1/4 at tillering (35-40 DAS) +1/4 at anthesis stage (80-90 DAS)
T_3- 1/3 at basal + 1/3 at tillering (30-40 DAS) + 1/3 at flag leaf stage (65-70 DAS)
T_4-1/2 at basal + 1/2 at tillering (35-40 DAS) + 0.5% urea spray at anthesis stage (80-90 DAS)
T_5-1/2 at basal + 1/2 at tillering (35-40 DAS) + 0.5% urea + 0.5% $ZnSO_4.7H_2o$ spray at anthesis stage (80-90 DAS)
T_6-1/2 at basal + 1/4 at tillering (35-40 DAS) + 0.5% urea spray at anthesis stage (65-70 DAS)
T_7-1/2 at basal + 1/4 at tillering (35-40 DAS) + 0.5% urea + 0.5% $ZnSO_4.7H_2o$ spray at flag leaf (65-70 DAS) and 0.5% urea spray at anthesis stage (80-90 DAS)
T_8-1/3 at basal + 1/3 at tillering (30-40 DAS) + 0.5% at flag leaf stage (80-90 DAS)
T_9-1/3 at basal + 1/3 at tillering (35-40 DAS) + 0.5% urea + 0.5% $ZnSO_4.7H_2o$ spray at anthesis stage (80-90 DAS)

Result and Discussion

The present investigation "*Assessment of productivity and quality of barley (Hordeum vulgare L.) through Nitrogen and Zinc scheduling*" was undertaken to study the enhancement of the effect of different treatments on growth, development, yield and economics of barley crop and N and Zn scheduling.

Table 1 Germination count at 15 DAS and number of shoots metre^{-1} row length of barley at successive stages of crop growth

Treatments	Germination count	Number of shoots metre^{-1} row length			
	15 DAS	30 DAS	60 DAS	90 DAS	At harvest
T_1	47.08	86.93	123.08	119.32	99.68
T_2	45.66	86.80	115.92	110.03	89.08
T_3	45.92	84.65	113.38	109.42	88.81
T_4	47.62	84.18	118.12	115.24	95.38
T_5	46.32	85.55	119.14	115.96	96.49
T_6	46.84	84.31	121.23	119.03	98.94
T_7	47.1	86.87	119.32	117.1	98.79
T_8	45.64	85.83	121.32	117.2	97.3
T_9	48.15	89.49	126.98	119.6	102.92
SEm±	0.78	0.16	2.09	2.01	1.81
CD at 5%	NS	NS	6.21	5.98	5.3

Germination count and no. of shoots metre^{-1} row length

The number of shoots metre^{-1} row length was significantly affected due to Nitrogen and Zinc at various stages of crop growth except at 30 DAS, T_6 treatment resulted in significantly higher number of shoots metre^{-1} row length, T_1-1/2 at basal + 1/2 at tillering (35-40 DAS) except T_9-1/3 at basal + 1/3 at tillering (35-40 DAS) + 0.5% urea + 0.5% $ZnSO_4.7H_2O$ spray at anthesis stage (80-90 DAS) at all the stages of crop growth and at harvest.

Table 2 Shoot height of barley at successive stages of crop growth

Treatments	Shoot Height (cm)			
	30 DAS	60 DAS	90 DAS	At harvest
T_1	7.37	45.08	67.66	69.18
T_2	7.19	42.14	63.92	64.78
T_3	7.05	41.64	63.88	64.50
T_4	6.87	42.72	64.80	65.08
T_5	7.30	43.37	65.01	65.21
T_6	7.17	44.14	65.20	66.58
T_7	6.96	43.75	64.92	66.23
T_8	7.05	43.94	66.03	66.62
T_9	7.47	47.35	68.60	70.74
SEm±	0.13	1.07	1.50	1.41
CD at 5%	NS	3.13	4.40	4.38

Shoot height

Table 2 show that nitrogen and zinc treatment significantly increased shoot height over T_6-1/2 at basal + 1/4 at tillering (35-40 DAS) + 0.5% urea spray at all the stages of crop growth except at 30 DAS. T_1-1/2 at basal + 1/2 at tillering (35-40 DAS) was statistically at par with T_9-1/3 at basal + 1/3 at tillering (35-40 DAS) + 0.5% urea + 0.5% $ZnSO_4.7H_2o$ spray at anthesis stage (80-90 DAS) and appreciably increased shoot height over T_4-1/2 at basal + 1/2 at tillering (35-40 DAS) + 0.5% urea spray at anthesis stage (80-90 DAS) and other treatments at all the stages of crop growth except at 30 DAS.

Dry matter accumulation in plants of 25 cm row length

An examination of the data presented in Table 4.3 reveal that treatments appreciably increased dry matter accumulation in plants of 25 cm row length over T_1-1/2 at basal + 1/2 at tillering (35-40 DAS) at all the stages of crop growth except at 30 DAS. At harvest, the magnitude of increase in dry matter accumulation in plants of 25 cm row length with treatments was to the tune of 11.42 to 22.58 per cent over T_9-1/3 at basal + 1/3 at tillering (35-40 DAS) + 0.5% urea + 0.5% $ZnSO_4.7H_2o$ spray at anthesis stage (80-90 DAS).

Table 3 Dry matter accumulation in plant of 25 cm row length at successive stages of crop growth

Treatments	Dry matter accumulation in plants(g)			
	30 DAS	60 DAS	90 DAS	At harvest
T_1	4.54	37.66	74.82	115.96
T_2	4.48	35.82	70.68	110.30
T_3	4.36	35.50	70.31	110.13
T_4	4.30	36.98	72.28	112.63
T_5	4.28	37.16	72.15	113.31
T_6	4.31	37.56	72.56	115.19
T_7	4.28	37.60	72.64	115.39
T_8	4.41	37.94	72.93	114.93
T_9	4.48	39.83	75.76	119.76
SEm±	0.11	0.99	1.40	1.77
CD at 5%	NS	2.63	4.13	5.22

There was fast rate of dry matter accumulation in plant after 30 days of seeding. On an average, the dry matter accumulation in plants of 25 cm row length was to the tune of 3.48 per cent in first 30 days, 28.98 per cent in another 30 days, 31.24 per cent in next 30 days and 36.30 per cent between 90 days and harvest of the crop.

Development studies

Days to 75 per cent spike emergence and days to maturity

All the practices required significantly less days for 75 per cent spike emergence and for maturity than that of T_6-1/2 at basal + 1/4 at tillering (35-40 DAS) + 0.5% urea spray at anthesis stage (65-70 DAS). T_9-1/3 at basal + 1/3 at tillering (35-40 DAS) + 0.5% urea + 0.5% $ZnSO_4.7H_2o$ spray at anthesis stage (80-90 DAS)required appreciably less days to 75 per cent spike emergence and for maturity than other treatments. The differences in days to 75 per cent spike emergence and days to maturity due to different treatments were nominal and could not reach the level of significance.

Table 4 Days to 75 per cent spike emergence and days to physiological maturity of barley

Treatments	Days to 75% spike emergence	Days to maturity
T_1	74.90	124.52
T_2	73.33	124.32
T_3	75.33	124.63
T_4	74.35	124.28
T_5	73.38	124.78
T_6	74.93	124.92
T_7	74.50	125.33
T_8	73.32	125.00
T_9	73.18	125.41
SEm±	0.72	0.93
CD at 5%	2.18	2.48

Post-harvest Studies

Yield attribute

The data presented in Table 5 reveal that T_6 treatment significantly produced the higher number of shoots metre^{-1} row length by 4.73 to 16.40 per cent than T_1-1/2 at basal + 1/2 at tillering (35-40 DAS) and treatments except spray of T_9-1/3 at basal + 1/3 at tillering (35-40 DAS) + 0.5% urea + 0.5% $ZnSO_4.7H_2o$ spray at anthesis stage (80-90 DAS). So far comparison of treatments is concerned, T_6-1/2 at basal + 1/4 at tillering (35-40 DAS) + 0.5% urea spray at anthesis stage (65-70 DAS) significantly increased the number of spikes metre^{-1} row length over T_1-1/2 at basal + 1/2 at tillering (35-40 DAS), T_3-1/3 at basal + 1/3 at tillering (30-40 DAS) + 1/3 at flag leaf stage (65-70 DAS), T_7-1/2 at basal + 1/4 at tillering (35-40 DAS) + 0.5% urea + 0.5% $ZnSO_4.7H_2o$ spray at flag leaf (65-70 DAS) and 0.5% urea spray at anthesis stage (80-90 DAS), T_8-1/3 at basal + 1/3 at tillering (30-40 DAS) + 0.5% at flag leaf stage (80-90 DAS) which were nominal among themselves and could not reach the level of significance.

Table 5 Yield attributing characters

Treatments	No. of spikes metre^{-1} row length	Length of spike (cm)	No. of grains spike^{-1}	Grain weight spike^{-1} (g)	1000 grain Weight (g)
T_1	91.84	6.50	39.38	1.52	38.27
T_2	94.94	6.72	42.25	1.72	41.45
T_3	91.94	6.54	39.75	1.58	38.50
T_4	95.66	6.74	42.50	1.72	42.75
T_5	94.77	6.70	41.75	1.67	40.10
T_6	98.50	6.93	43.58	1.98	43.92
T_7	93.58	6.64	40.75	1.61	39.25
T_8	92.50	6.63	40.50	1.60	39.05
T_9	96.55	6.91	43.16	1.75	43.53
SEm±	1.51	0.10	0.50	0.16	0.75
CD (P=0.05)	4.80	0.30	1.42	0.22	2.21

The number of grains spike^{-1} significantly increased by 1.71 to 13.43 per cent due to different treatment over T_1-1/2 at basal + 1/2 at tillering (35-40 DAS). T_9-1/3 at basal + 1/3 at tillering (35-40 DAS) + 0.5% urea + 0.5% $ZnSO_4.7H_2o$ spray at anthesis stage (80-90 DAS)was at par with T_6-1/2 at basal + 1/4 at tillering (35-40 DAS) + 0.5% urea spray at anthesis stage (65-70 DAS) and produced appreciably higher number of grains spike by 4.43 to 11.52 per cent than all other treatments.

Table 5 reveal that T_6-1/2 at basal + 1/4 at tillering (35-40 DAS) + 0.5% urea spray at anthesis stage (65-70 DAS) had significantly higher grain weight spike^{-1} by 7.80 to 45.39 per cent than T_1-1/2 at basal + 1/2 at tillering (35-40 DAS).

Higher 1000 grain weight by 6.01 to 22.16 per cent than T_9-1/3 at basal + 1/3 at tillering (35-40 DAS) + 0.5% urea + 0.5% $ZnSO_4.7H_2o$ spray at anthesis stage (80-90 DAS). T_9-1/3 at basal + 1/3 at tillering (35-40 DAS) + 0.5% urea + 0.5% $ZnSO_4.7H_2o$ spray at anthesis stage (80-90 DAS)was at par with T_6-1/2 at basal + 1/4 at tillering (35-40 DAS) + 0.5% urea spray at anthesis stage (65-70 DAS) and significantly increased 1000 grain weight by 1.31 to 15.23 per cent over rest treatments. T_6-1/2 at basal + 1/4 at tillering (35-40 DAS) + 0.5% urea spray at anthesis stage (65-70 DAS) had significantly higher 1000 grain weight than all other treatments of T_1-1/2 at basal + 1/2 at tillering (35-40 DAS) which were not appreciable among themselves.

Yield (qha^{-1})

Treatment significantly increased biological yield by 6.07 to 16.76 per cent over T_6-1/2 at basal + 1/4 at tillering (35-40 DAS) + 0.5% urea spray at anthesis stage (65-70 DAS).

Table 6 Biological, grain, straw yield and harvest index

Treatments	Biological yield (q ha^{-1})	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest index (%)
T_1	114.58	40.33	74.25	35.20
T_2	119.82	44.83	74.99	37.41
T_3	120.12	45.00	75.12	37.45
T_4	116.50	44.00	72.50	37.76
T_5	115.79	43.63	72.16	37.68
T_6	124.26	47.33	76.92	38.08
T_7	120.78	45.47	75.32	37.64
T_8	118.16	44.42	73.74	37.59
T_9	123.25	46.67	76.58	37.86
SEm±	1.37	0.74	1.01	0.10
CD (p=0.05)	3.91	2.10	2.97	NS

Treatment0.5% $ZnSO_4.7H_2o$ spray at anthesis stage (80-90 DAS)and T_7-1/2 at basal + 1/4 at tillering (35-40 DAS) + 0.5% urea + 0.5% $ZnSO_4.7H_2o$ spray at flag leaf (65-70 DAS) and 0.5% urea spray at anthesis stage (80-90 DAS) produced appreciably higher biological yield by 5.00 to 10.07 per cent than rest of the treatments.

Table 6 reveal that different treatments resulted in conspicuously higher grain yield by 12.53 to 38.67 per cent than T_1-1/2 at basal + 1/2 at tillering (35-40 DAS). Further, treatment T_6-1/2 at basal + 1/4 at tillering (35-40 DAS) + 0.5% urea spray at anthesis stage (65-70 DAS) was statistically at par with T_9-1/3 at basal + 1/3 at tillering (35-40 DAS) + 0.5% urea + 0.5% $ZnSO_4.7H_2o$ spray at anthesis stage (80-90 DAS)and gave appreciably higher grain yield by 4.39 to 17.79 per cent than all other treatments.

Treatment T_6-1/2 at basal + 1/4 at tillering (35-40 DAS) + 0.5% urea spray at anthesis stage (65-70 DAS) produced conspicuously higher straw yield by 6.59, 10.29, 11.01, 7.67 and 10.97 per cent than T_1-1/2 at basal + 1/2 at tillering (35-40 DAS), T_4-1/2 at basal + 1/2 at tillering (35-40 DAS) + 0.5% urea spray at anthesis stage

Result and Discussion

Treatment T_6-1/2 at basal + 1/4 at tillering (35-40 DAS) + 0.5% urea spray at anthesis stage (65-70 DAS) treatment resulted in significantly higher number of shoots $metre^{-1}$ row length, T_1-1/2 at basal + 1/2 at tillering (35-40 DAS) except T_9-1/3 at basal + 1/3 at tillering (35-40 DAS) + 0.5% urea + 0.5% $ZnSO_4.7H_2o$ spray at anthesis stage (80-90 DAS) at all the stages of crop growth and at harvest.

At harvest, the magnitude of increase in shoot height with T_9-1/3 at basal + 1/3 at tillering (35-40 DAS) + 0.5% urea + 0.5% $ZnSO_4.7H_2o$ spray at anthesis stage (80-90 DAS) was to the tune of 5.72 to 28.07 per cent over rest of the treatments. Treatment T_1-1/2 at basal+1/2 at tillering (35-40 DAS) at all the stages of crop growth except at 30 DAS.

The experimental barley crop attained 75 per cent spike emergence in between 71 and 79 days and physiological maturity in between 122 and 127 days after sowing.

(80-90 DAS), T_5-1/2 at basal + 1/2 at tillering (35-40 DAS) + 0.5% urea + 0.5% $ZnSO_4.7H_2o$ spray at anthesis stage (80-90 DAS), T_8-1/3 at basal + 1/3 at tillering (30-40 DAS) + 0.5% at flag leaf stage (80-90 DAS) and T_4-1/2 at basal + 1/2 at tillering (35-40 DAS) + 0.5% urea spray at anthesis stage (80-90 DAS), respectively which were statistically at par among themselves.

All the treatments enhanced the harvest index significantly over T_9 treatment and the maximum harvest index was noticed with T_6-1/2 at basal + 1/4 at tillering (35-40 DAS) + 0.5% urea spray at anthesis stage (65-70 DAS) (38.08%). Among the treatments T_1-1/2 at basal + 1/2 at tillering (35-40 DAS) and T_2-1/2 at basal +1/4 at tillering (35-40 DAS) +1/4 at anthesis stage (80-90 DAS) were at par and registered significantly lower harvest index than rest of the treatments.

All the practices required significantly less days for 75 per cent spike emergence and for maturity than that of T_6-1/2 at basal + 1/4 at tillering (35-40 DAS) + 0.5% urea spray at anthesis stage (65-70 DAS). T_9-1/3 at basal + 1/3 at tillering (35-40 DAS) + 0.5% urea + 0.5% $ZnSO_4.7H_2o$ spray at anthesis stage (80-90 DAS)required appreciably less days to 75 per cent spike emergence and for maturity than other treatments.

The data presented in Table 4.5 reveal that T_6 treatment significantly produced the higher number of shoots $metre^{-1}$ row length by 4.73 to 16.40 per cent than T_1-1/2 at basal + 1/2 at tillering (35-40 DAS) and treatments except spray of T_9-1/3 at basal + 1/3 at tillering (35-40 DAS) + 0.5% urea + 0.5% $ZnSO_4.7H_2o$ spray at anthesis stage (80-90 DAS). So far comparison of treatments is concerned, T_6-1/2 at basal + 1/4 at tillering (35-40 DAS) + 0.5% urea spray at anthesis stage (65-70 DAS)[2].

The practices produced appreciably higher length of spike by 19.05 to 26.92 per cent than that of T_1-1/2 at basal + 1/2 at tillering (35-40 DAS), T_9-1/3 at basal + 1/3 at tillering (35-40 DAS) + 0.5% urea + 0.5% $ZnSO_4.7H_2o$ spray at anthesis stage (80-90 DAS) had significantly higher length of spike by 2.17 to 8.62 per cent than all the treatments[4].

The number of grains spike^{-1} significantly increased by 1.71 to 13.43 per cent due to different treatment over T_1-1/2 at basal + 1/2 at tillering (35-40 DAS).

T_9-1/3 at basal + 1/3 at tillering (35-40 DAS) + 0.5% urea + 0.5% $ZnSO_4.7H_2o$ spray at anthesis stage (80-90 DAS) treatment had appreciably higher grains weight spike^{-1} by 17.14 to 34.87 per cent than T_4-1/2 at basal + 1/2 at tillering (35-40 DAS) + 0.5% urea spray at anthesis stage (80-90 DAS) which appreciably increased grains weight spike^{-1} by 13.14 to 30.26 per cent over rest of the treatments.

Treatments had appreciably higher 1000 grain weight by 6.01 to 22.16 per cent than T_9-1/3 at basal + 1/3 at tillering (35-40 DAS) + 0.5% urea + 0.5% $ZnSO_4.7H_2o$ spray at anthesis stage (80-90 DAS).

The data presented in Table 4.6 indicate that treatment significantly increased biological yield by 6.07 to 16.76 per cent over T_6-1/2 at basal + 1/4 at tillering (35-40 DAS) + 0.5% urea spray at anthesis stage (65-70 DAS). Among treatments, T_6-1/2 at basal + 1/4 at tillering (35-40 DAS) + 0.5% urea spray at anthesis stage (65-70 DAS) at a par with T_7-1/2 at basal + 1/4 at tillering (35-40 DAS) + 0.5% urea + 0.5% $ZnSO_4.7H_2o$ spray at flag leaf (65-70 DAS) and 0.5% urea spray at anthesis stage (80-90 DAS) and T_3-1/3 at basal + 1/3 at tillering (30-40 DAS) + 1/3 at flag leaf stage (65-70 DAS) produced significantly higher biological yield by 3.45 to 8.45 per cent than remaining treatments[6].

That different treatments resulted in conspicuously higher grain yield by 12.53 to 38.67 per cent than T_1-1/2 at basal + 1/2 at tillering (35-40 DAS). T_3-1/3 at basal + 1/3 at tillering (30-40 DAS) + 1/3 at flag leaf stage (65-70 DAS), T_4-1/2 at basal + 1/2 at tillering (35-40 DAS) + 0.5% urea spray at anthesis stage (80-90 DAS), T_5-1/2 at basal + 1/2 at tillering (35-40 DAS) + 0.5% urea + 0.5% $ZnSO_4.7H_2o$ spray at anthesis stage (80-90 DAS) did not differ significantly among themselves but produced higher grain yield when compared to T_8-1/3 at basal + 1/3 at tillering (30-40 DAS) + 0.5% at flag leaf stage (80-90 DAS) and T_7-1/2 at basal + 1/4 at tillering (35-40 DAS) + 0.5% urea + 0.5% $ZnSO_4.7H_2o$ spray at flag leaf (65-70 DAS) and 0.5% urea spray at anthesis stage (80-90 DAS)[7].

The straw yield by 27.4 to 32.87 per cent over T_4-1/2 at basal + 1/2 at tillering (35-40 DAS) + 0.5% urea spray at anthesis stage (80-90 DAS). Treatment T_6-1/2 at basal + 1/4 at tillering (35-40 DAS) + 0.5% urea spray at anthesis stage (65-70 DAS) produced conspicuously higher straw yield by 6.59, 10.29, 11.01, 7.67 and 10.97 per cent than rest of the treatments namely T_2-1/2 at basal +1/4 at tillering (35-40 DAS) +1/4 at anthesis stage (80-90 DAS), T_3-1/3 at basal + 1/3 at tillering (30-40 DAS) + 1/3 at flag leaf stage (65-70 DAS), T_5-1/2 at basal + 1/2 at tillering (35-40 DAS) + 0.5% urea + 0.5% $ZnSO_4.7H_2o$ spray at anthesis stage (80-90 DAS)[3].

The harvest index significantly over T_9 treatment and the maximum harvest index was noticed with T_6-1/2 at basal + 1/4 at tillering (35-40 DAS) + 0.5% urea spray at anthesis stage (65-70 DAS) (38.08%).

The highest net profit of Rs. 66139 ha^{-1}was obtained from treatment T_6-1/2 at basal + 1/4 at tillering (35-40 DAS) + 0.5% urea spray at anthesis stage (65-70 DAS) followed by treatment T_9-1/3 at basal + 1/3 at tillering (35-40 DAS) + 0.5% urea + 0.5% $ZnSO_4.7H_2o$ spray at anthesis stage (80-90 DAS), gave net return of Rs. 65486 ha^{-1}.

Conclusion

On the basis of the findings of present one year experimentation it can be concluded that treatment T_6 ***i.e.***1/2 at basal + 1/4 at tillering (35-40 DAS) + 0.5% urea spray at anthesis stage (65-70 DAS) resulted in highest yield and net returns. So, it may be the best option to get higher crop productivity and economic benefit.

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