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ROLE OF CLIPPING MANAGEMENT IN RESILIENCE PERFORMANCE OF BARLEY (*Hordeum vulgare* L.) VARIETIES IN CENTRAL PUNJAB

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ABSTRACT

The performance of three barley varieties (DWRUB 52, PL 807 and PL 426) under five different clipping management practices {control, clipping at 50 days after sowing (DAS), clipping at 60 DAS, clipping at 50 DAS + 0.5% Zn foliar application at anthesis and early milk stage (Zn (s) and clipping at 60 DAS + 0.5% Zn foliar application at anthesis and early milk stage (Zn (s)} were recorded. Variety DWRUB 52 gave highest plant height (95.5 and 98.8 cm) and leaf area index (4.62 and 4.78) at harvest during 1st and 2nd year of study, respectively. Zn spray at anthesis and early milk stage with clipping at 50 and 60 DAS increased the plant height (93.2 and 91.5 cm), leaf area index (4.56 and 4.47) and chlorophyll index (46.1 and 44.7) of crop at maturity. There was an increase of 11.6% in grain yield when clipping was done at 50 DAS (38.8 and 40.9 q ha^{-1}) with Zn spray and an increase of 7.8% in grain yield when clipping was done at 60 DAS (37.6 and 39.5 q ha^{-1}) with Zn spray than control crop (34.5 and 36.3 q ha^{-1}) during 1st and 2nd year of study, respectively.

INTRODUCTION

Barley (*Hordeum vulgare* L.) is the fourth most important cereal crop of the world after wheat, rice and maize. It is an important coarse cereal crop of India, being grown in rabi season in northern plains as well as in northern hills, mostly under rainfed or limited irrigation conditions on poor to marginal soils (Kharub *et al*., 2013). Today, barley accounts for 15 per cent of world coarse grains in use. Traditionally, it is considered as a poor man's crop and in India is it is favoured because of its low input requirement and better adaptability to harsh environments, likely drought, salinity/alkalinity and marginal lands. A variety of any crop having good yield potential, resistance to insect-pest and disease sometimes becomes susceptible to such biotic factor and thus loses the yield potential. Over the time, they also start behaving differently to the applied nutrients.

Clipping an annual plant at progressively later stages of growth would also be expected to decrease total production and especially seed production. However, the ultimate plant height was reduced when clipping was done at the jointing and booting stages. Highest reduction in the final plant height occurred when clipping was done at booting stage. The highest forage yield was obtained when barley plants were clipped at tillering stage. This indicates that clipping at the tillering, did not impede regrowth of barley under semi-arid conditions (El-Shatnawi *et al*., 1999). Micronutrient malnutrition is a global health problem affecting more than 3 billion people world-wide (Cakmak *et al*., 2010). About 44% children under five years of age are zinc (Zn) deficient in India (Kapil and Jain, 2011). About 66 and 85% women and children are iron-anaemic in Punjab and India, respectively (Singh, 2009). Deficiency of Zn cause serious human health complications such as stunting, infections, impaired brain functions, poor mental-development, weak babies and anaemia (Fraga, 2005). Low dietary-intake is the main cause of microelement deficiencies in humans (Cakmak *et al*., 2010). Zn is also essential in human body as a co-factor for more than 200 enzymatic reactions which are vital for growth, development, immune function and resistance to infections (Fischers and Black, 2004). In a global study initiated by FAO, it was shown that about 30% of the cultivated soils of the world are Zn deficient. It is estimated that Zn deficiency is the most widespread micronutrient deficiency in cereals and also the inadequate application not only reduces the crop yields but also reduced quality of crop products (Prasad *et al*., 2014). More recent studies with wheat showed good transport of Zn from stem and leaves to developing grain, as well as from one root to another, indicating involvement of phloem transport (Keram *et al*., 2014).

Foliar spraying of different nutrients make them readily absorbed by plant leaves and are not lost through fixation, decomposition and leaching. The positive effect of spraying zinc on growth and yield of different crops has been reported by several investigators. One of the major requirements in crop planning is to determine the suitable variety and nutrient enrichment grains. It is an important factor that influence vegetative and reproductive growth period. Clipping also affects other production factors, harvest, quality and ultimately crop yield and quality. Therefore, there must be specific clipping time as well as Zn biofortification for different varieties to obtain maximum yield.

Keeping the above in view the present was undertaken with the objectives of selecting the most suitable variety, clipping practices through Zn biofortification under Indo-Gangetic Plains of India. The study was aimed to find out the effect of clipping on the growth and productivity of different barley varieties through Zn spray.

MATERIALS AND METHODS

A field experiment was conducted at the research farm of the Department of Agronomy, Punjab Agricultural University, Ludhiana during two consecutive barley growing seasons (2015–16 and 2016–17). The experimental site is situated at 30º54/N latitude and 75º48/E longitude at a height of 247 m above the mean sea level. The site is characterized by subtropical and semi-arid type of climate with average annual rainfall of 755 mm, 75–80% of which is received in July–September. The soil of the experimental field was studied by the Bouyoucos Hydrometer method (Bouyoucos, 1962) and recorded loamy sand. It had a pH of 7.3 which was determined by the glass electrode pH meter (Jackson, 1973). The organic carbon content was determined by Walkley and Black rapid titration method (Walkley and Black, 1934) and was reported to be medium (0.36%). Available nitrogen (186.0 kg ha^{-1}), phosphorous (29.9 kg ha^{-1}) and potassium (147.5 kg ha^{-1}) were all recorded to be in the medium range and they were determined by the Alkaline permanganate method (Subbiah and Asija, 1956), Bray and Kurtz method (Jackson, 1973) and Flame Photometer method (Jackson, 1973), respectively.

Daily rainfall and maximum, minimum and mean temperatures during barley growing seasons (2015–16 and 2016–17) and long term averages of last 30 years (normal) were measured at the PAU meteorological station, located approximately 200 m away from the experimental site. Seasonal weather data including maximum temperature, minimum temperature, mean temperature and cumulative monthly rainfall recorded during 2015–16 and 2016–17 have been presented in Figs. 1 and 2. The maximum temperature, minimum temperature and mean temperature during 2015–16 growing season were 26.3ºC, 12.8ºC and 19.6ºC, respectively. During 2016–17, the maximum temperature, minimum temperature and mean temperature were 26.9ºC, 12.7ºC and 19.8ºC, respectively (Figs. 1 and 2).

The experiment comprised of 15 treatments was laid out in split plot design with four replications having three varieties, *viz*. DWRUB 52, PL 807 and PL 426 were taken in main plot. Five different clipping management practices, *viz*. control, clipping at 50 DAS, clipping at 60 DAS, clipping at 50 DAS + 0.5% Zn foliar application at anthesis and early milk stage (Zn (s) and clipping at 60 DAS + 0.5% Zn foliar application at anthesis and early milk stage (Zn (s) were taken as sub plot treatment. Recommended dose of nutrients to barley was applied at 62.5 kg N/ha, 30 kg P_2O_5 and 15 kg K_2O through urea (46% N), single super phosphate (16% P_2O_5) and muriate of potash (60% K_2O), respectively at the time of sowing. The site was a under sunhemp-wheat (*Triticum aestivum* L.) cropping system for 3 years before the establishment of the experiment.

Ten plants per plot were selected randomly to measure the height from ground level to the tip of longest leaf at 30 days after sowing (DAS), up to the base of top most fully opened leaf at 60 DAS, up to the base of flag leaf at 90 DAS and up to the base of the ear at 120 DAS and at harvest. Chlorophyll content index (CCI) was measured periodically at 30, 60, 90 and 120 DAS from fully expanded apical leaves, using a portable SPAD Chlorophyll Meter (Model-CCM-200, Opti-Sciences, Inc.). Periodic leaf area index was recorded at 30, 60, 90 and 120 DAS by using Sunscan leaf area meter. Sunscan instrument works on the principle of Beer-lamber's law. Sunscan meter was first calibrated in full sunlight between 12:00 to 2:00 pm and also in partial shade conditions. After calibration of the instrument leaf area index was taken between 12:00 to 2:00 pm, from three different locations in the each plot and average of these three values from each plot was taken as the leaf area index of that plot.

RESULTS AND DISCUSSION

Plant height (cm)

The plant height of varieties was found to be non-significant at 30 DAS during both the years of study (Table 1). The plant height of variety PL 807 was significantly higher at 60 DAS than DWRUB 52 and PL 426 during 1st and 2nd year, respectively. At 90 DAS, the maximum plant height was recorded in PL 807 and was statistically at par with DWRUB 52 but significantly higher than PL 426 in both the years. Similarly, PL 807 recorded the maximum plant height at 120 DAS which was statistically at par with DWRUB 52 and significantly higher than PL 426. At maturity, the maximum plant height of PL 807 and was statistically at par with DWRUB 52, significantly higher than PL 426 during 1st and 2nd year, respectively. The differences in plant height of varieties were attributed to their genetic constitution. Similar results were also reported by Berry and Spink (2012). Plant height at all the stages of plant growth except 30 DAS differed significantly

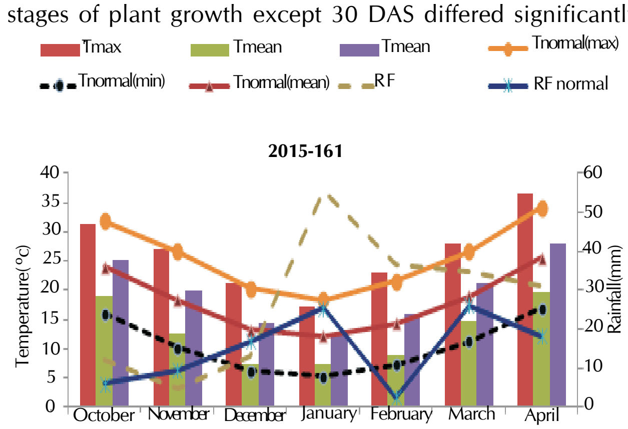

Figure 1: Monthly and long term average (normal) max temperature, min temperature, mean temperature and rainfall during 2015-16.

Table 1: Periodic plant height of barley as affected by varieties and clipping management

Treatment	30 DAS		60 DAS		90 DAS		120 DAS		At maturity	
	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
Varieties										
DWRUB 52	30.1	31.1	55.9	58	76.2	74.1	93.4	88.9	95.5	90.8
PL 807	28.6	30.4	58.7	61	77	76.1	93.5	90.8	95.7	92.6
PL 426	30.3	32.4	54	55.9	72	71.1	90.6	85.2	92.4	86.6
LSD (P=0.05)	NS	NS	2.1	2.3	1.6	2.8	1.6	2.8	1.8	2
Clipping management										
Control	29.9	31.3	57.8	60.1	79.5	78.5	94.9	91.8	95.8	93.2
Clipping at 50 DAS	29.6	31.6	53.9	55.9	75.6	74.2	92.9	88.3	94.4	90
Clipping at 60 DAS	29.7	31.5	57.4	59.6	72.6	71	90.4	85.3	92.6	87.2
Clipping at 50 DAS + Zn (s)	29.6	30.7	54.2	55.7	75.2	74.1	93.1	89.2	95.7	90.7
Clipping at 60 DAS + Zn (s)	29.3	31.4	57.9	60.1	72.4	71.1	91.3	86.9	94.3	88.7
LSD (P=0.05)	NS	NS	1.6	2.6	1.7	1.9	1.6	1.9	1.7	1.7

Table 2 : Leaf area index (LAI) of barley as affected by varieties and clipping management

Treatment	30 DAS		60 DAS		90 DAS		120 DAS	
	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
Varieties								
DWRUB 52	0.97	0.99	4.07	4.3	5.2	5.35	4.62	4.78
PL 807	0.93	0.96	3.79	4.12	4.83	4.96	4.42	4.53
PL 426	0.85	0.92	3.44	3.99	4.64	4.77	3.98	4.21
LSD (P=0.05)	NS	NS	0.16	0.15	0.27	0.29	0.1	0.23
Clipping management								
Control	0.93	0.97	4.01	4.33	4.78	5	4.27	4.46
Clipping at 50 DAS	0.93	0.97	3.46	3.86	5.01	5.08	4.33	4.5
Clipping at 60 DAS	0.91	0.97	3.98	4.33	4.82	4.98	4.22	4.38
Clipping at 50 DAS + Zn (s)	0.91	0.96	3.44	3.86	5.01	5.08	4.49	4.63
Clipping at 60 DAS + Zn (s)	0.91	0.96	3.96	4.32	4.83	4.98	4.39	4.55
LSD (P=0.05)	NS	NS	0.23	0.17	NS	NS	0.14	0.15

Table 3 : Chlorophyll content index (CI) of barley as influenced by varieties and clipping management

Treatment	30 DAS		60 DAS		90 DAS		120 DAS	
	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
Varieties								
DWRUB 52	26.7	24	31.9	37.1	46.1	54.5	42.4	48.5
PL 807	22.6	22.8	25.8	30.5	42.3	49.1	38.8	45.3
PL 426	22.2	22.7	21.1	25.9	39.6	44.8	34.9	41.7
LSD (P=0.05)	NS	NS	4.2	3.6	3.7	1.4	2.5	2.1
Clipping management								
Control	24.1	23.1	25.2	30.5	42.7	50.4	37.5	46.2
Clipping at 50 DAS	24.1	22.8	27.6	31.9	44.7	50.8	39.2	47.4
Clipping at 60 DAS	23.7	23.6	25.6	30.6	40.6	48	34.9	42.8
Clipping at 50 DAS + Zn (s)	23.7	23.2	27.4	32.1	45	50.7	41.5	50.6
Clipping at 60 DAS + Zn (s)	23.6	23.1	25.4	30.6	40.4	47.7	40.4	48.9
LSD (P=0.05)	NS	NS	NS	NS	3.3	1.9	2.2	2.5

Table 4: Effect of varieties and clipping management on grain yield of barley

Treatment	Grain yield (q ha^{-1})	
	2015-16	2016-17
Varieties		
DWRUB 52	38.6	41.8
PL 807	36.9	38.6
PL 426	31.8	33.5
LSD (P=0.05)	1.5	2.3
Clipping management		
Control	34.5	36.3
Clipping at 50 DAS	35.8	38.2
Clipping at 60 DAS	32.3	35
Clipping at 50 DAS + Zn (s)	38.8	40.9
Clipping at 60 DAS + Zn (s)	37.6	39.5
LSD (P=0.05)	2.7	2.6

with clipping management during both the years of study. At 60 DAS, the crop with clipping at 50 DAS and clipping at 50 DAS + Zn (s) treatment produced significantly lower plant height than control, clipping at 60 DAS and clipping at 60 DAS + Zn (s) treatment during 1st and 2nd year, respectively. Control crop recorded significantly higher plant height at 90 DAS and 120 DAS than other clipping treatments during 1st and 2nd year, respectively. The increase in plant height (after 90 DAS) in clipping at 50 DAS + Zn (s) and clipping at 60 DAS + Zn (s) treatments is attributed to the physiological role of Zn in plant metabolism and growth due to which higher photo-synthetic activity. At maturity, plant height in clipping at 50 DAS, clipping at 50 DAS + Zn (s), clipping at 60 DAS + Zn (s) and control crop was statistically at par with each other and significantly higher than clipping at 60 DAS during 1st year of

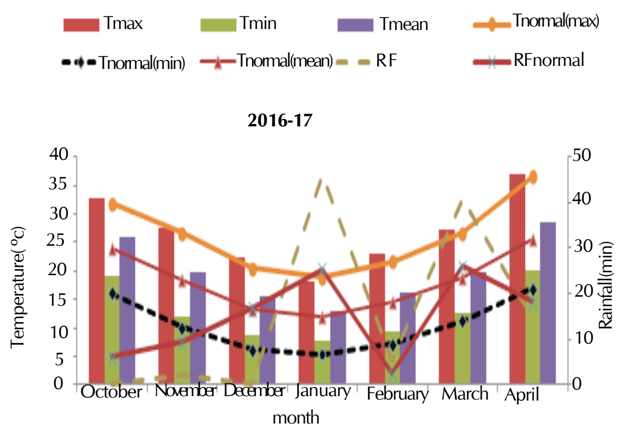

Figure 2: Monthly and long term average (normal) max temperature, min temperature, mean temperature and rainfall during 2016-17.

study. Control crop produced significantly more plant height at maturity than other clipping treatments during 2nd year of study.

Leaf area index (LAI)

The perusal of the data revealed that the LAI continued to increase sharply up to 90 DAS and it reached a plateau and attained its maximum at this growth stage (Table 2). There was non-significant difference at 30 DAS during both the years of study. Whereas, variety DWRUB 52 recorded significantly higher LAI than PL 807 and PL 426 at 60, 90 and 120 DAS. At 120 DAS, leaf area index of DWRUB 52 was 4.3 and 5.2 per cent higher than PL 807 and 13.9 and 11.9 per cent higher than PL 426 during 1st and 2nd year, respectively. The LAI decreased at 120 DAS, because of shedding of leaves due to crop senescence. Similar results were also reported by Berry and Spink (2012). Clipping management had no significant effect on LAI at 30 and 90 DAS during both the years of study. However, at 60 DAS, LAI of clipping at 60 DAS, clipping at 60 DAS + Zn (s) and control crop was statistically at par, but significantly higher than clipping at 50 DAS and clipping at 50 DAS + Zn (s) which might be due to removing vegetation by clipping reduced leaf area. The LAI at 120 DAS of clipping at 50 DAS, clipping 50 DAS + Zn (s) and clipping 60 DAS + Zn (s) was statistically at par among each other, but significantly higher than control and clipping at 60 DAS. This might be due to the reason that due to foliar application of Zn caused higher photosynthetic activities under these treatments.

Chlorophyll content index (CI)

DWRUB 52 had significantly higher chlorophyll index than PL 807 and PL 426 at 60, 90 and 120 DAS, respectively (Table 3). The differences among different varieties in the chlorophyll index were attributed to genetic potential of varieties. Clipping management had non-significant effect on chlorophyll index of crop at 30 and 60 DAS during both the years of study. However, at 90 DAS, significantly lower value of chlorophyll index was recorded in clipping at 60 DAS with and without Zn foliar spray than control, clipping at 50 DAS and clipping at 50 DAS + Zn (s) and later treatments were statistically at par with each other during 1st and 2nd year, respectively due to Zn foliar application was applied after 90 days after sowing. At 120 DAS, Zn foliar application with both clipping stages *viz*. 50 DAS and 60 DAS recorded significantly higher chlorophyll index values than other clipping treatments during 1st and 2nd year, respectively. The chlorophyll contents increased due to Zn application as Zn acts as a structural and catalytic component of proteins, enzymes and as co-factor for normal development of pigment biosynthesis (Balashouri, 1995).

Grain yield (q ha^{-1})

Barley variety DWRUB 52 recorded significantly higher grain yield than varieties PL 807 and PL 426 (Table 4). Variety PL 426 produced significantly lower grain yield than both the varieties. Variety DWRUB 52 resulted 4.4 and 7.7 per cent higher grain yield than PL 807. Whereas, 17.6 and 19.9 per cent higher grain yield of DWRUB 52 than PL 426 during 1st and 2nd year, respectively. It was attributed to genetic potential of the variety to synthesis more photosynthates and their translocation to grains. Reduction in the grain yield of PL 426 was attributed to lower leaf area index (Table 2) which causes reduction in photosynthates and their poor translocation to grains. Varietal differences for grain yield were also reported by Berry and Spink (2012). Clipping at 50 DAS + Zn (s) treatment (38.8 and 40.9 q ha^{-1}) gave significantly higher grain yield which was statistically at par with clipping at 60 DAS + Zn spray (37.6 and 39.5 q ha^{-1}), but significantly higher than clipping at 50 DAS (35.8 and 38.2 q ha^{-1}), clipping at 60 DAS (32.3 and 35.0 q ha^{-1}) and control crop (34.5 and 36.3 q ha-1) during 1st and 2nd year, respectively. There was an increase of 12.5 and 12.7 per cent in grain yield when clipping was done at 50 DAS with foliar application of Zn and an increase of 9.0 and 8.8 per cent in grain yield when clipping was done at 60 DAS with foliar application of Zn than control crop during 1st and 2nd year, respectively. Grain yield of control crop was statistically at par with both clipping stages *i.e.* at 50 and 60 DAS during both the years of study. Grain yield was higher in clipping at 50 DAS than control which might be due to removal of foliage at this stage increased the growth attributes *viz*. plant height (Table 1) and leaf area (Table 2) at 90 and 120 DAS because of better growth after clipping due to which increase the grain yield under this treatment *i.e.* clipping at 50 DAS than control. Moreover, apical meristems were removed by clipping operation, grain yield will be substantially reduced. There was non-significant effect of clippings done at 50 and 60 DAS on the grain yield of crop.

There was significant effect of foliar application of Zn with both clipping stages *i.e.* at 50 and 60 DAS on grain yield of crop during both the years of study. Zn increased membrane-integrity, heat-tolerance, synthesis of carbohydrates, cytochrome and nucleotide synthesis, auxin-synthesis, chlorophyll synthesis, and metabolism of nitrogen (Marschner *et al*., 1996) thereby increasing the rate of photo-synthesis, more production of photosynthates and their translocation to grain and increasing grain yield in the treatments such as clipping at 50 DAS + Zn (s) and clipping at 50 DAS + Zn (s). Kutman *et al*. (2010), Shi *et al*. (2010) and Jan *et al*. (2013) were also reported that enhance the grain yield due to Zn foliar application.

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