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Effect of Urea Fertilizer on on Growth Response of Food Barley (*Hordeum vulgare* L.)

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Abstract: Soils in the highlands of Ethiopia usually have low levels of essential plant nutrients and low organic matter content especially low availability of nitrogen that has been demonstrated to be the major constraint to cereal production. Nitrogen fertilizer application is among the most critical decisions for barley production due to its large impact on growth, development and yield of the crop. Therefore, a field experiment was conducted at Jimma University, College of Agriculture and Veterinary Medicine. The objective was to evaluate the effects of N application rates on growth and development of food barley. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications having four nitrogen levels (0, 46, 66, 92 kg N/ha). The results of the study indicated that N application rates had a significant influence on some growth parameters studied and non significant on other. The maximum fresh weight (7.60 g) was recorded from the treatment that received the highest N rate (92 kg/ha) and the lowest fresh weight (7.48 g) was obtained from the control plot. These indicate that treatment four are recommended for the end users because as plant height and fresh weight increase the end product is also increase. Similarly, the lowest (86 cm) and the highest (78 cm) plant height were recorded from the treatments that received 0 and 92 kg N ha, respectively, indicating that N was a major growth limiting factor for barley production. On the other hand, the effects of N application rates on tiller number, length of spikelet and number of kernels were found to be significant.

Key words: Urea fertilizer, barley seed (Dimtu variety), growth parameter, maximum, recommended, significant

INTRODUCTION

Barley (*Hordeum vulgare* L.) is an annual, self pollinating cereal crop that belongs to the same plant family (Poaceae or Gramineae) as maize, oats, rice and wheat; tribe Triticeae and genus Harem. It is world's fourth most important cereal crop after wheat, maize and rice and fifth after teff (*Eragrostis tef* L.) wheat, maize and sorghum in area coverage in Ethiopia (Alkoz *et al*., 1993). Barley is among the major grain cereals dominantly cultivated in the central highlands of Ethiopia where the soils are often acidic in reaction.

Barley grows under a wide range of soil and climatic conditions. However, it is best adapted to fertile and well drained silt to clay loam soils and warm dry climates (Anderson *et al*., 1993). In Ethiopia, barley is grown best at an altitude ranging from 2000-2800 M Above sea level (m.a.s.l) with average annual rainfall between 700 and 1000 mm (Anonymous, 2008). It is the fifth cereal crop after maize, wheat, teff and sorghum in total production. On average, 1.1 mln.ha of land is covered by barley with average production of 1.21 mln.ton (t) annually. The predominant barley growing areas are show, Bale, Arish, Go jam and Gondar. The highlands of the SNNPRS, Tigray and Wollega are also producing considerable quantities of barley. In the 2004/2005 "mother'' season in the SNNPRS, barley production was 98,934.7 tons from an area of 84.936 ha the average productivity of which is 1.17 ton/ha (Anonymous, 2001).

Though barley grain has many uses, including livestock feed, human food and production of malt in Ethiopia, the grain is mainly produced for human consumption and sold for cash. About 90% of the grain is used for human food and it accounts for over 60% of the food for the inhabitants of the highlands (Anonymous, 1996). The rest is used for local and industrial beverages. The straw is the second preferred animal feed next to teff straw. Stem stubs of barley are also used for roof thatching.

Despite its long history of cultivation and wide range of uses by different communities, the average yield of barley in Ethiopia is 1.27 tm/ha compared to the world average, 5.87-6.31 ton/ha. The main limiting factors are poor soil fertility (Darota, 2003). Low levels of chemical fertilizer usage and low pH. Since, the major barley producing areas of the country are mainly located in the highlands, severe soil erosion, continuous mono-cropping, lack of appropriate soil conservation practices and lack of appropriate crop rotation system (Alemu, 2001) have resulted in soils with low fertility and pH. Thus, managing soil fertility becomes crucial for improving agricultural productivity in the country.

Fertilizers, particularly those containing nitrogen are the major inputs affecting the yield and quality of barley. Edney and Tipless (1997), Bulman and Smith (1993) and Hailu *et al.* (1996) and proper use of N fertilizer can markedly increase the yield and improve the quality of malt barley. Grando and Helena (2005) reported that soils in the highlands of Ethiopia usually have low levels of essential plant nutrients and low organic matter content especially, low availability of nitrogen that has been demonstrated to be the major constraint to cereal production. Barley responds well to balanced application of N fertilizer (Anonymous, 1997).

Statement of problem: Based on observation farmers of Ethiopa, they use inappropriate rate of urea fertilizers, then the problem of good vegetative growth and other growth factor occur. Moreover, the effect of urea fertilizer on vegetative growth and biomass of food barley had not been studied in good way in farmer area. Information about the effect of urea fertilizers on vegetative growth of food barley is lacking around the farmer.

Objectives

General objective:

- To evaluate Effect of urea fertilizer on on Growth response of food barley

Specific objective:

- To evaluate the effect of urea fertilizer on growth and development of food barley
- To determine the optimum dose of urea fertilizer food barley growth response and recommend for the growers

Significance of the study: The study would believe to have the following important point. Serve as general guide line for farmer or development agency. Providing an excellent starting point for further investigation serve as means of increasing the yield of barley.

Hypothesis:

- H_0: there is no significantly difference between treatment
- H_1: there is significantly difference between treatment

Literature review

Role of urea in plant nutrition: Nitrogen is the most abundant mineral nutrient in plants. It constitutes 2-4% of plant dry matter. Nitrogen is the key nutrient input for achieving higher yields of barley. Barley is very sensitive to insufficient nitrogen and very responsive to nitrogen fertilization. Nitrogen plays a central role in plant biochemistry. Alam *et al.* (2007) indicated that the most important role of nitrogen in the plant is its presence in the structure of protein and nucleic acids which are the most important building and information substances from which the living material or protoplasm of every cell is made. In addition, nitrogen is also found in chlorophyll, the green coloring matter of plants. Since, N is part of so, many essential compounds, it is not surprising that growth without added N is slow (Maqsood *et al*., 1999).

Nitrogen is an indispensable elementary constituent of numerous organic compounds of general importance; amino acid, proteins, nucleic acids and hormones (Mengel and Kirkby, 1987). It is involved in all major processes of plant growth and development and yield formation. Besides, a good supply of nitrogen to the plant stimulates root growth and development as well as uptake of other nutrients (Olsen and Cole, 1954). Nitrogen is responsible for the dark green color of the stem and leaves, vigorous vegetative growth, branching/tillering, leaf production, size enlargement and yield formation.

Adequate supply of N is associated with high photosynthetic activity. According to Tsidale *et al.* if N is used property in conjunction with other soil fertility inputs it can speed up the maturity of crops such as maize and small cereals. The supply of N is related to carbohydrate utilization. When N supplies are insufficient, carbohydrates will be deposited in vegetative cells, causing them to thicken whereas under adequate N supplies and favorable condition for growth, proteins are formed from manufactured carbohydrates resulting in more protoplasm (Havlin *et al*., 1999).

A low supply of N has a profound influence on crop growth and may lead to a great loss in grain yield (Ottman, 2009). Nitrogen deficiency in plants results in a marked reduction in growth rate. A deficiency of N limits cell division and expansion, chloroplast development, chlorophyll concentration and enzyme activity. N-deficient plants have a short and spindly appearance. Tillering is poor and leaf area is small. As N is a constituent of chlorophyll, its deficiency appears as a yellowing or chlorosis of the leaves. This yellowness usually appears first on the lower leaves while upper leaves remain green as they receive some N from older leaves. The effects of N toxicity are less evident than those of its deficiency. They include prolonged growing (vegetative) period and delayed crop maturity. High ammonium in solution can be toxic to plant growth, particularly where the solution is alkaline. The toxicity results from ammonia (NH_3) which is able to diffuse through plant membranes and interfere with plant metabolism.

Soil conditions and urea uptake: Nitrogen is one of the most widely distributed elements in nature and the atmosphere is the main reservoir. The soil accounts for only a minute fraction of lithosphere N and of this soil N, only a very small proportion is directly available to plants in the form of NO_3^- and NH_4^+ ions. Nitrogen is a very mobile element circulating between the atmosphere, the soil and living organisms (Mingel and Kirkby, 1987). Inorganic N exists in the form of NH_4^+, NO_3^-,NO_2^-, N_2O, NO and elemental; Nitrogen (N_2). The organic forms include proteins, amino acids, amino sugars and other NO_3^- and NO_2^- which are produced from aerobic decomposition of organic matter or addition of fertilizers to the soil and are the most important in plant nutrition. Gaseous N_2, N_2O, and NO are forms of N lost through denitrification (Tigre *et al*., 2014).

Nitrogen is a unique plant nutrient, since, plants absorb both NH_4^+ and NO_3^-. The ratio of ammonium to nitrate in the soil depends on the presence of satisfactory conditions for nitrification which is inhibited by low soil pH and anaerobic conditions. The type and age of plant, the environment and other factors determine preference of plants either to NH_4^+ or NO_3^- ion. For most crops, the N form (NH_4^+ or NO_3^-) is of minor importance although some plants appear to have a specific preference for one or the other. Crops would prefer NH_4^+ as it is directly usable for protein synthesis where as NO_3^- must first be reduced to NH_4^+ which requires energy. Barley can utilize either the NH_4^+ or NO_3^- form of N; slightly higher seed set has been obtained with the NH_4^+ form.

Arable crops mainly take up NO_3^- even NH_4^+ fertilizers are in the soil. However, plant growth is improved when the plants are nourished with both NH_4^+ and NO_3^- compared to either NH_4^+ or NO_3^- alone. Grain yields increased from 7-47% with NH_4^+ and NO_3^- compared to yields with NO_3^- alone which was related to increased numbers of tillers and kernels per plant (Rashid and Khan, 2007). In normal cropped soils where ammonium is added through fertilizers or released from organic matter or crop residues by mineralization it is usually nitrified rapidly to nitrate. N added in the amide form as in urea is first hydrolyzed to ammonium with the help of urea's enzyme. It can then be absorbed by roots as such or converted to nitrate and then absorbed.

Effect of urea fertilizer on growth and yield components of barley: According to Burger and Berge, nitrogen is a major requirement for high yields of barley and nitrogen fertilization are often essential on soils of low organic matter content or when re-cropping after non-legumes. Crop response to N fertilizer is influenced by factors such as nitrogen fertilizer management, soil type, crop sequence and supply of residual and mineralized nitrogen. When plants are deficient in N, they become stunted and yellow in appearance. Nitrogen deficiency in cereals results in restricted root growth, poor tillering, thinner and smaller stems, premature ripening of grains and low number of ears per unit area and low number of grains per ear (Mengel and Kirkby, 1987). The grains are small but often relatively high in protein content, due to a decrease in the import of carbohydrate into grains during the later stages of the grain filling stage (Mengel and Kirkby, 1987).

The rate of N fertilizer application is among the most critical decisions for malting barley production due to its large impact on grain yield, yield components and quality (Bekele *et al*., 1996). The amount of N to be applied depends on the difference between crop requirement and the supply of available soil N which depends on mineralization of organic matter and residual N from previous applications. Optimal N fertilization is essential for achieving a successful, high yielding barley crop. On soils low in available N application of moderate rates of N usually result in yield increases. When soil N levels are high or high rates of N are applied, both yield and protein content are increased as well as the risk of lodging. According to Conry (1994), a heavy lush crop resulting from high N levels may be prone to lodging and more susceptible to disease under certain climatic conditions. Seed set may also be reduced and maturity may be delayed. On the other hand, inadequate N inputs result in loss of grain yield and in low protein. Riley *et al*., reported that either lower or higher amounts of applied N resulted in loss of yield while GPC increased with increasing applied N.

Nitrogen fertilization has an important effect on the final harvest, therefore, if this element is not available in sufficient amount yield is impaired. N deficiencies diminish grain number and yield both in wheat and barley (Geleto *et al*., 1996). According to Dale and Wilson an increased N does generally increases number of kernels per ear while deficiencies of this element can cause important reductions in this parameters estimated by these researcher to be around 40-60%. N fertilization has a crucial effect on barley yield which results harmed by either shortage or excess of this element (Tariku, 2007). Working with influence of N fertilizer on yield of malt barley reported that the main effect of the N dose was decisive on all the parameters measured and the treatment without N supply was the least productive.

Fertilization, particularly of N is a major input in barley production, affecting yield, yield components and quality. Agronomic traits and yield components were positively influenced by N application. Khaliq *et al.* (1999) reported that plant height, grains per spike, spikes per m^2 and grain yield increased with increasing N levels from 0-175 kg Nha. Weston *et al.*, concluded that N caused an increase in grain yield and GPC in spring barley. Costa and Dwyer, Stewart and Smith reported that the effect of N application on spike length was significant. Also, several authors. Khaliq *et al.* (1999) have reported direct relation between N application and plant height. Eberseder and Hege found that N application affects spikes per m^2. Also, Afoul *et al.* and Mossedq and Smith reported that increasing N application caused increase in grains in per unit area.

Importance of nitrogen to barley growth and development: Nitrogen is one of the major plant nutrients were satisfactory level of grain and foliage production on verti soil depend on its adequate supply. Although, nitrogen requirements of crop met through addition of nitrogen fertilizer it is an expensive input and these reflects its low consumption in Ethiopia highlandss. Nitrogen plays vital role in all living tissue of the plant. No other elements has such an effect on promoting vigorous plant growth. Abundant of protein tends to increase the size of the leaves accordingly, to bring about an increase in carbohydrate synthesis. Nitrogen play a vital role in increasing the yield of the crop. The application of proper amount of nitrogen is key to obtain better crop of barely. High nitrogen supply favors the conversion of carbohydrate into protein which in turn promotes the formation of protoplast. Split N-application has little effect on yield but could result deceased logging and spike population while grain weight is increased.

N-application at 120 kg/ha^{-1} has been recommended by As various research workers reported N application increased spike numbers, grain weight, grain yield which increased level of nitrogen and also increased grain yield with increase in nitrogen level.

Amount of N-effects single spike weight and the spike weight increased as the amount of N-increased from control level to 200 kg/h.

MATERIALS AND METHODS

Description of the study area: This senior research project was conducted at Jimma University, College of Agriculture and Veterinary Medicine at Horticultural field during 2015 cropping season under semi-irrigation condition. The area is situated in Oromia Region, Jammer zone of South Western part of Ethiopia which is located at 7°33' lattitude and 36°57" longitudes and the altitude of 1710 m.a.s.l. The area receives an annual rainfall of 1500 mm. The maximum and the minimum temperature of the area is 26.8 and 11.4°C, respectively. The soil of the area is characteristically reddish brown clay soil with pH from 5.07-6.

Experimental material: The main experimental materials used during this study were barley seed (Dimtu variety) nitrogen fertilizer (urea).

Experimental design and treatment: The field experiment was laid out in Randomized Complete Block Design (RCBD) with three replication and four treatments. The treatment we used were Treatment one (T1) 0 kg N/ha used as control, Treatment two (T2) 46kg N/ha, Treatment three (T3) 69 kg N/ha and Treatment four (T4) 92 kg N/ha. The experimental area was divided into small homogenous blocks and each replication contained complete set of treatment which was allocated to plots within each block at random. The arrangement of our block was against concentration gradient, since, concentration of gradient is perpendicular (North-South). Each plot had four rows and the size of the main plot is 3.4×5.1 m and the distance of 0.5 m was maintained between block and plot. Each plot size is 0.8×0.9 m with space between rows of 20 cm.

Experimental procedures: The experimental field was prepared following the conventional tillage practice before planting the seed. In accordance with the specifications of the design, a field layout was prepared and each treatment is assigned randomly to experimental plots within a block.

Seed was sown at the recommended rate of 75 kg/ha in rows on February 20, 2015. N fertilizer was applied within the rows as basal application at planting. The remaining half dose of nitrogen fertilizer was top dressed 15 days after planting and nitrogen fertilizer is used during sowing time. Plots were kept free of weeds to produce a successful barley crop.

Data collection: Data collected consists of fresh weight, leaf number, plant height, number of kernels, number of tillers and length of spikelet. Plant height was determined from randomly selected five plants with in the net plot area and the average value was recorded. Number of tillers was determined from the central row within the net plot area and counted. Freshweight is also taken randomly from center and weighted by sensitive balance and finally after the crop is flowering number of kernels and length of spikelet was measured.

Statistical analysis: The collected data was subjected to statistical analysis using SAS Software. Significant differences between and/or among treatments was separated by Least Significant Differences (LSD) test. Interpretations were done following the procedures described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

The vegetative growth response of food barley was influenced by different rate of N with 92kg/ha as compared to other tratments. The analysis of variance revealed that, plant height, lengths of spikelet and number of kernels was significantly ($p \leq 0.05$) influenced by N application rates. The analysis of variance did not detect significant effects of N rates on number of tillering, leaf number and fresh weight. From the result obtained it is possible to conclude that N application rates had a significant influence on some of the growth parameters studied.

Means followed by the represented the same letters are not significantly different at 5%, NS Non Significant CV Coefficient of Variation, LSD Least Significant Difference, pH Plant Height. NL Number of Leaf, NT Number of Tiller.

Number of leaf: The analysis of variance revealed that leaves number was non-significantly ($p \leq 0.05$) influenced by amount of N applied Table 1. Each amount of N fertilizer no much effect on leaves number change. So, it was agree with the previous research which says as the amount of urea increase days of emergence also increase (Ridge *et al*., 1985).

Number of tillers: As we were observed from Table 1. According to Table 1, there is no significance difference between different N levels (0, 46, 66 and 92 kg N/ha) on barley(hordeum vulgare) with respect to tillers number. But different researcher investigates that as the dosage of nitrogen levels increase tiller number also increase (Alam and Haider, 2005).

Table 1: Applications of different nitrogen rate on growth response of leaves number, tillering number and plant height

Values	LN	pH	NT
0 (kg N/ha)	4.93	76.26^b	3.86
46	5.33	78.20^b	3.93
66	5.13	78.46^b	3.73
92	4.26	86.86^a	3.93
LSD ($p \leq 0.05$)	NS	1.35	NS
CV (%)	0.5286	3.3051	0.7651

Table 2: Applications of different nitrogen rate on growth response (number of kernels, length of spikelet and fresh weight as affected by N)

Values	FW	LS	NK
0 (kg N/ha)	7.48	43.26^b	20.13^b
46	7.42	47.73^a	20.46^b
66	7.56	48.46^a	20.86^b
92	7.60	50.46^a	22.20^a
LSD ($p \leq 0.05$)	NS	1.40	0.66
CV (%)	0.92	3.44	1.60

Plant height: The analysis of variance revealed that plant height was significantly ($p \leq 0.05$) influenced by N application rates (Table 1). The treatment that received the highest N rate (92 kg N/ha) gave significantly higher plant height as compared to the rest of the treatments Table 1. The treatments that received 46, 66 and 92 kg N/ha gave statistically similar plant height to each other. The increase in plant height is related to the increasment of the level of the N rate (agree with).

Means followed by the represented the same letters are not significantly different at 5%, NS Non Significant CV Coefficient of Variation, LSD Least Significant Difference, FW: Fresh Weight, NK: Number of Kernels, LS: Length of Spike let.

Fresh weight: The fresh weight was not significant at ($p \leq 0.05$) and ($p \leq 0.01$) affected by N application rates Table 1. In this study, increasing N rates from 0-92 kg ha has not showed significant effect on fresh weight Table 2. The weight was recorded in the treatment was nearly the same as compared to the control plot and the treatment that received from 0-92 N/ha Table 1. That is disagree with (Mengel and Kirkby, 1987).

Length of spikelet: Length of spikelet was measured by ruler after the plant was flowering. It was measured from five plants which were selected randomly from two rows. The mean of each four treatment were 43.26, 47.73, 48.46 and 50.46 cm, respectively (Table 2).

Therefore, according to our data, application of different rate of N fertilizer (0, 46, 66 and 92 kg N/ha) were significant at ($p \leq 0.05$) with respect to length of spikelet.

But according to previous research length of spikelet is not directly proportional with the amount of urea applied.

Number of kernels: Number of kernels was selected from the two center of rows and counted from five plants. Finally the average of each treatment were taken. Analysis of variance indicate that the application of different dose of N fertilizer are significant at p<0.05 with respect to number of tillering. But the current research done indicate that number of kernels increase as the amount of urea fertilizer increase (Table 3-8).

Table 3: Analysis of variance on length of spiked as affected by N fertilizer

Source	df	SS	MS	F-value	p-value
REP	2	83.13	27.71		
TRE	3	10.44	5.22	9.33	0.0112
Error	6	17.82	2.97		
Total	11	111.39			
CV	3.63				

Table 4: Analysis of variance on fresh weight as affected by N fertilizer

Source	df	SS	MS	F-value	p-value
REP	2	0.10	0.052		
TRE	3	0.05	0.018	0.09	0.9653
Error	6	1.27	0.213		
Total	11	1.43			
CV	6.14				

Table 5: Analysis of variance on number of kernel as affected by N fertilizer

Source	df	SS	MS	F-value	p-value
REP	2	1.62	0.81		
TRE	3	7.39	2.46	3.80	0.0772
Error	6	3.89	0.64		
Total	11	12.91			
CV	3.85				

Table 6: Analysis of variance on number of till ring as affected by N fertilizer

Source	df	SS	MS	F-value	p-value
REP	2	0.34667	0.17333		
TRE	3	0.08000	0.02667	0.18	0.9050
Error	6	0.88000	0.14667		
Total	11	1.30667			
CV	9.90				

Table 7: Analysis of variance on leaf number as affected by N fertilizer

Source	df	SS	MS	F-value	p-value
REP	2	0.08667	0.04333		
TRE	3	0.28000	0.09333	1.33	0.3486
Error	6	0.42000	0.07000		
Total	11	0.78667			
CV	5.12				

Table 8: Analysis of variance on plant height as affected by N fertilizer

Source	df	SS	MS	F-value	p-value
REP	2	0.14	0.07		
TRE	3	200.01	66.67	24.36	0.001
Error	6	16.42	2.73		
Total	11	216.57			
CV = 2.07					

CONCLUSION

Barley (*Hordeum vulgare* L.) is an annual, self pollinating cereal crop that belongs to the same plant family (Poaceae or Gramineae) as maize, oats, rice and wheat; tribe Triticeae and genus Hordium. Fertilizers, particularly those containing nitrogen are the major inputs affecting the yield and yield components of barley. Barley responds well to balanced application of N fertilizer. This senior research project was therefore, proposed to evaluate the effects of nitrogen fertilizer application rates on growth and development of food barley.

A Randomized Complete Block Design (RCBD) with three replications having four Nitrogen levels (0, 46, 66 and 92 kg N\ha) was conducted. In accordance with the specifications of the design, a field layout was prepared and each treatment was assigned randomly to experimental plots within a block. Data collected consisted of leaf number, fresh weight, plant height, number of tillers, length of spikelet and number of kernels.

The collected data were subjected to statistical analysis using SAS Software. The analysis of variance revealed that, plant height, lengths of spikelet and number of kernels was significantly ($p\leq 0.05$) influenced by N application rates. The analysis of variance did not detect significant effects of N rates on number of tillering, leaf number and fresh weight. From the result obtained it is possible to conclude that N application rates had a significant influence on some of the growth parameters studied. The maximum plant height (86.68 cm) was recorded from the treatment that received the highest N rate (92 kg/ha^{-1}) and the lowest plant height (76.26 cm) was obtained from the control plot. Similarly, the lowest (7.48) and the highest (7.60) fresh weight recorded from the treatments that received 0 and 92 kg N/ha 1. So from these point we recommend thattreatment four (92 kg N/ha) gives the best yield because as plant height and kerenels number of increase yield is also increase.

RECOMMENDATIONS

The most cereal crop produced in Ethiopia are wheat, maize, rice, teff and barley. Among them barley is one of the most important cereal crop which is cultivated for home consumption in high land area specially in Arsi and Bale zone. Even though the country has potential to producce this crop, there is no satisfactory production maintained due to in appropriate application of urea fertilizer. Urea fertilizers have great problem on germination and vegetative growth of food barley due to application of it above recommendation or below recommendation. This would create the problem on vegetative growth and biomass of food barley. So, according to statically analysis mention above treatment four is recommended for the end users which give the highest plant height and number of kerenels because as plant height and number of kerenels increase yield is also increase. In addition to this:

- Empirical analysis of urea fertilizer on vegetative growth and biomass of food barley would be needed to overcome the problem
- Researcher and agricultural exporter should try to determine the optimum dose of urea fertilizer for good vegetative growth and biomass of food barley
- Farmer should be try to sowing urea at recommended applicationFurther research must be done on different agro ecological condition

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