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Response of Chickpea to Supplemental Irrigation at Different Irrigation Levels at pawe district in Metekel Zone, North West Ethiopian

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Abstract: Adequate soil moisture is a requirement for obtaining an optimum plant stand, good growth and consequent high productivity of chickpea. The study was conducted at vertisoil of pawe districts in Metekel zone, North Western Ethiopia in order to maximize productivity and determine yields, and water requirement of chick pea. There were no significant differences among treatments on grain and biomass yields of chick pea during all cropping season. But yield advantages among treatments were observed. The highest yield (grain= 9.73 q/ha and biomass=32.6q/ha during 2017 cropping season, grain= 9.47 q/ha and biomass=17.8/ha during 2018 cropping season and grain= 19.7 q/ha and biomass=45.4/ha during 2019 cropping season respectively) were recorded. The lowest yield (grain= 5.52q/ha and biomass=22.2 q/ha during 2017 cropping season, grain= 4.43 q/ha) and biomass=11.4q/ha during 2018 cropping season and, grain= 10.9 q/ha at treatment 2(full supplemental irrigation) during 2019 crop growing season respectively) were recorded and biomass=33.8q/ha at no supplemental irrigation during 2019 cropping season) was obtained. From the result conclusion can make what relative yield advantage obtained at supplementing of irrigation water at flowering stage for chickpea production in pawe district.
Key words: Supplemental, Chickpea, Metekel, pawe, Irrigation,

1. Introduction

Supplemental irrigation may be defined as 'the addition of small amounts of water to essentially rain fed crops during times when rainfall fails to provide sufficient moisture for normal plant growth, in order to improve and stabilize yields' (Oweis and Hachum, 2003).

Ilbeyi *et al*. (2006) indicated that, when rainfall was inadequate for crop germination, supplemental irrigation given at sowing substantially increased wheat yield by more than 65% (from about 2.0 t ha−1 to the average dry farming yield of 3.2 t ha−1) in the Central Anatolian Plateau of Turkey. Zhang and Oweis (1999) showed that yields and water use efficiency in northern Syria increased significantly by applying 75 to 212 mm of supplemental irrigation in the beginning to the end of flowering.

Deficit irrigation is an optimizing strategy by which crops are deliberately allowed to sustain some degree of water deficit and yield reduction in order to maximize the productivity per unit of water used. One important merit of deficit supplemental irrigation is the greater potential for benefiting from unexpected rainfall during the growing season owing to the availability of larger storage space in the crop root zone. Results on wheat, obtained from farmers' field trials conducted in a Mediterranean climate in northern Syria, reported significant improvement in SI water productivity at lower application rates than at full irrigation. In northern Syria, water short farmers apply half the amount of full SI water requirements to their wheat fields. By doing so, the area under SI is doubled using the same amount of water, and total farm production increases by 33%. Research in the WANA region has shown that applying only 50% of full SI requirements cause yield reduction of only 10–15%. A farmer having a 4-ha farm would on average produce 33% more grains from his farm if he adopted deficit irrigation for the whole area than if the full irrigation were applied to half of the area (Oweis & Hachum, 2009).

Supplemental irrigation as a response shortage of soil moisture in the dry rainfed areas often occurs during the most sensitive growth stages (flowering and grain filling) of the crops. Supplemental irrigation, using a limited amount of water, if applied during the critical crop growth stages, can result in substantial improvement in yield and water productivity. In addition to yield increases, SI also stabilizes rainfed crop production (Oweis and Hachum, 2003).

Chickpea crop *(Cicer arietinum)* is the third most widely grown legume crop (after soybean and bean) and of Particular significance in developing countries, as providing an important source of farmer income and nutrition to poor farmers. Chickpea (C. arietinum L.) is an important grain legume (pulse) crop, which in 2010 was grown globally on 12 million hectares with a total production of 11 million tonnes (FAOSTAT, 2012).

Ethiopia is the largest producer of chickpea in Africa. Ethiopian chickpea production is expected to continue growing and the number of smallholder farmers growing chickpea in Ethiopia has increased from 154,281 ha (2003) to 239,512 ha (2012).

Yield production of chickpea in pawe district is not as expected and it is because of to water stress due to terminal drought moisture logging on the cropping season of chickpea.

Therefore, supplemental irrigation (SI) is needed to alleviate the adverse impact of soil moisture stress on the yield of chieakpea at pawe district in Metekel zone with the objectives of the following:

- To maximize productivity of chick pea
- To determine the effect of supplementary irrigation on yield of chick pea

2. Materials and Methods

2.1. Description of the Study Area

The demonstration was conducted in Pawe district which is one of the seven districts in the Metekel administrative zone of Benshangul Gumuz Regional state. It is located geographically between 36°20'-36° 32' longitude and 11°12'-11°21' latitude with an altitude of 1120 m.a.s.l. The district has 20 kebeles and the climate of the area is hot humid and characterized by unimodal rainfall pattern with high and torrential rainfall that exceeds from May to October. The area experiences a temperature ranging from 19.4°C to 37.6°C with a mean annual rainfall of 1586.32 mm. The district covers a total area of 63,400 hectares. The farming system of the districts is characterized by a mixed crop-livestock farming system dominated by crop production. The major crops grown in the districts include; maize, finger millet, soybean, sesame, groundnut and rice (PWoA, 2018).

Pawe is located 575 kilometers away from Addis Ababa. According to (Tafere M. and Desta A.; 2022). The area is characterized by its high rainfall with an extended period (April/May to September/October), high temperature, and black soil.

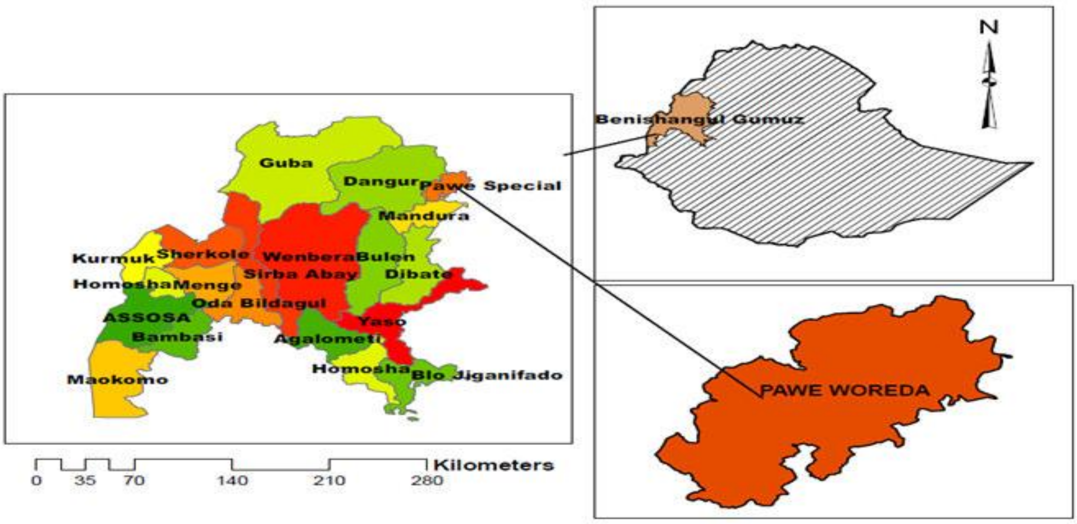

Figure 1: Location map of the study area

2.2. Treatments and Experimental Design

The experiment was consisting of seven levels of irrigation treatment and a control treatment (Rain fed agriculture). The treatments were, Rain fed / No SI , Full SI (100 % ETc), 3/4 SI (75% ETc), ½ SI (50% ETc), 1/4 SI (25% ETc), One SI at flowering stage, One SI at fruit setting stage and Two SI at flowering and fruit setting stage.

These treatments have been laid out in a RCBD with total experimental area 17 m by 40 m and arranged in randomize complete block design with three replications. Plot sizes were 3m by 3m, between blokes 4m, between plots 2m and furrow irrigation system was used.

The chickpea (local variety) was sown on first November during all growing season (2017, 2018 and 2019) in village 24 with row spacing 30 cm and with the seed rate of 25kg/ha and all the recommended agronomic practices for the area were applied during the growing seasons.

Figure 2: performance of chickpea at flowering stage

2.3. Data Collection and Analysis

To run models various input data were collected from observations and measurements that were necessary to affect the specific area or location.

2.3.1. Soil Sampling, preparation, and Analysis

Composite disturbed soil sample from the experimental area at soil depths (0 – 15cm, 15 – 30 cm, 30-60 cm, 60-90 cm, 90-120 cm) have been collected Using auger. Texture analysis along with, analysis of soil texture, and soil reaction (pH) soil had been done. Particle size distribution was determined in the laboratory by the modified Bouyoucos hydrometer method (Bouyoucos, 1962). Soil pH analysis was measured using a digital pH-meter. Field capacity (FC) and permanent wilting point (PWP) were determined by pressure plate apparatus.

2.3.2. Climate data

Long-term monthly values of the weather variables such as minimum temperature and maximum, wind speed, relative humidity, sunshine hour, and rainfall collected from the National Metrological Agency (NMA). Based on the e long term climate data, reference evapotranspiration (ETO) have been determined by using CROPWAT model version 8.

2.3.3. Crop characteristics data

Characteristics of chickpea (growing stages, maximum rooting depth, crop coefficient, critical depletion infraction, yield response factor, crop height used as an input for CropWat.

2.4. Crop and Irrigation Water Requirements

Crop water requirement computed using CropWat 8.0 and using monthly ETo values together with rainfall, crop type including cropping calendar.

Kc for every growth stage was adapted from Allen *et al*. (1998) and then, ETc was calculated.

$ETc = ETo * kc$, Where, ETc = crop evapotranspiration (mm), ETo = reference evapotranspiration (mm), Kc = crop factor.

The irrigation requirement was calculated using the following equation.

$$NIR = ETc - Pe$$

Where, NIR = net irrigation water requirement (mm), ETc = crop water requirement (crop evapotranspiration) (mm), Pe = effective rainfall (mm). effective rain fall was determined according to USDA soil conservation service for agricultural production,

The amount of water applied during an irrigation event (gross irrigation) is equal to the net irrigation required between irrigation and that needed for efficiencies in the irrigation system.

In this study, water was assumed to apply with precise measurements. As a result, there was no run-off and the only loss would be deep percolation and evaporation which are expected to be not much in a deficit irrigation practice. Therefore, a higher value of application efficiency (60%) was adopted.

$$GIR = NIR/Ea$$

Where, GIR = gross irrigation requirement, NIR = net irrigation water requirement and Ea= water application efficiency=60%. The amounts of water to apply each irrigation were measured using appropriate measuring devices Parshall flume.

2.5. Irrigation Scheduling using CropWat model

Irrigation scheduling was worked out using CropWat 8.0 windows by selecting 100% readily available soil moisture depletion and refill to field capacity depth criteria.

3. Results and Discussion

Table 1: Soil sample analysis in the study area

Depths (cm)	Sand in%	Silt in%	Clay in%	Class	Soil type	pH 1:2.5	FC (V %)	PWP (V %)	TAW mm/m
0-15	22	10	68	Clay	Black	6.93	45.61	27.66	179.5
15-30	14	18	68	Clay	Black	6.53	36.8	25.11	116.9
30-60	18	14	68	Clay	Black	6.74	39.04	26.37	126.7
60-90	24	12	64	Clay	Black	6.88	39.9	26.94	129.6
90-120	22	12	66	Clay	Black	7.06	44.18	27.39	167.9
Average	20	13.2	66.8	Clay	Black	6.828	41.106	26.694	144.12

** V%=volume percentage

As shown in Table 1, the average total available soil moisture was 144.12 mm/m and the soil moisture contents on a volume basis in the study area were in the range of 25.11% and 27.66%, and 36.8 and 44.18%, respectively at PWP and FC in the district.

Long -term climatic data of the study area were analyzed and reference evapotranspiration (ETO) was calculated based on the FAO Penman-Monteith method (Allen *et al.*, 1998) and the results are given in the following tables

Table 2: long-term climate data of the study area

Month	Max. Tem. (0C)	Min. Tem. (0C)	Humidity (%)	Wind speed (Km/day)	Sun shine hours
January	34.19	11.81	38.25	39.85	9.67
February	36.18	14.49	40.29	53.58	9.28
March	37.64	17.93	44.69	65.49	8.71
April	37.43	19.35	48.10	75.89	8.85
May	34.91	19.39	58.30	78.53	8.02
June	30.06	18.09	66.62	78.70	6.45
July	27.76	17.81	71.68	58.69	4.56
August	27.74	17.57	71.12	51.06	4.80
September	29.05	17.30	67.16	46.71	6.12
October	30.46	16.84	62.51	29.68	7.27
November	32.36	14.12	46.89	27.69	9.29
December	33.70	12.15	40.23	41.35	9.77
Average	32.62	16.40	54.65	53.93	7.73

**Reference evapotranspiration ($ET_{O)}$ value was simulated using CropWat in *Pawe* district using the long term climate data shown on table 2.

Since there was no determined crop coefficient, rooting depth, critical depletion, and yield response factor, so far for this area, the FAO recommended values for the chickpea are used to calculate CWR using Cropwat.

Irrigation requirements were estimated using effective rain fall that was determined according to USDA soil conservation service for agricultural production.

The local planting dates of the crops had been used for the computation and including soil charactestics data irrigation scheduling have been determined to each treatment with 60% application efficiency.

Table 3: Analyzed grain and biomass Yield of chickpea.

Treatments	2017 Cropping Season		2018 Cropping Season		2019 Cropping Season	
	Gy.(q/ha)	Bmy.(q/ha)	Gy.(q/ha)	Bmy.(q/ha)	Gy.(q/ha)	Bmy.(q/ha)
No SI	7.44	23.5	6.44	16.7	13.2	33.8
Full SI	5.52	22.2	4.43	11.4	10.9	38.2
75% SI	7.07	26.8	7.08	14.5	11.5	35.8
50%SI	8.29	27.6	9.03	12	13.3	35.9
25% SI	8.59	25.1	9.38	11.7	13.7	42.1
Flow SI	9.73	32.6	9.47	17.8	19.7	45.4
Fru SI	7.54	25.5	7.49	16	13.2	39.9
Fl +Fr SI	7.61	25.5	5.26	16.9	15.3	40.2
Mean	7.72	26	7.19	14.4	13.8	38.9
Cv(%)	35	13.3	26.7	43.3	30.4	27
LCD(0.05)	NS	NS	NS	NS	NS	NS

** Gy=grain yield, Bmy=Biomass yield, q/ha= quntal per hectare.

As shown in table 3, Eventhogh there were no significant differences among treatments on grain and biomass yields of chick pea during all cropping season, supplementing full irrigation at flowering stages increase grain yield of chickpea compared to the controlled (no supplemental irrigation) with 30.7% ,47% and 49.2% during 2017, 2018 and 2019 cropping season respectively.

Supplementing full irrigation also increase biomass yield of chickpea compared to the controlled (no supplemental irrigation) with 38.7%, 6.3%, 3.9% during 2017, 2018 and 2019 cropping season respectively.

Irrigating full irrigation and 75%ETC decrease grian yields of chickpea compared to the controlled (no irrigation) with 34.7%, 0.52% respectively during 2017 cropping season respectively and irrigating full irrigation and irrigating at flowering and fruit setting stages decrease grian yields of chickpea compared to the controlled(no irrigation) with 45.4% and 22.4% during 2018 cropping season but irrigating 75% increases grain yields with 9.9% compared to the control .

Irrigating full irrigation and 75%ETC decrease grian yields of chickpea compared to the controlled (no irrigation) with 29.3%, and 14.7% respectively during 2019 cropping season and equal yield (13.2q/ha) obtained at control treatments and irrigating at fruit setting stages and this may due to moisture residual effects which was irrigated during flowering stages.

Generally the yields were not consistence with the treatments and this may due to, the experiment was conducted on farm where there are higher external errors.

4. Summary and Conclusion

Relative yield advantage obtained at supplementing of irrigation water at flowering stage for chickpea production in pawe district.

Irrigation 50% ETc, 25% ETc and irrigating at flowring stages increase grain yield of chickpea during all cropping season.

Application of full irrigation decrease grain yield of chickpea during all cropping season.

Generally in areas where there is no scarcity of irrigation water irrigating at flowring stages increase grain yield of chickpea in the study area should be recommended for the farmers.

Conflicts of Interest

The authors declare no conflict of interest.

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