तक्ता क्र. १ भाजीपाला पिकांची पाण्याची व सिंचनाची गरज

अ.क्र.	पिके	पेरणीची वेळ/ लावणीची वेळ	पिकाचा कालावधी (दिवस)	पाण्याची गरज (मि.मी.)	सिंचनाची गरज (मि.मी.)
१.	कांदा	जून-जुलै	११०-१२०	५००-५५०	२००-२५०
		सप्टेंबर-ऑक्टोबर		५००-५५०	४५०-५५०
		नोव्हेंबर-डिसेंबर		६००-६५०	५५०-६५०
		जानेवारी		७००-७५०	६५०-७५०
२.	मिरची	जून-जुलै	१८०-२००	८५०-९००	४००-५००
		जानेवारी-फेब्रुवारी	-	१०००-१२००	१०००-१२००
३.	वांगे	जून-जुलै	१८०-२००	८००-८५०	४००-४५०
		डिसेंबर-जानेवारी		१०००-११००	९५०-११००
४.	टोमॅटो	जुलै -	१२५-१५०	६५०-७५०	३००-३५०
		सप्टेंबर-ऑक्टोबर	-	६५०-७५०	६००-७५०
		जानेवारी	-	११००-१३००	१०५०-१२५०
५.	कोबी	सप्टेंबर-ऑक्टोबर	८०-९०	४५०-५००	४००-५००
६.	फुलकोबी	जून-जुलै	९०-१२०	६००-६५०	२००-३००
		जुलै-ऑगस्ट	-	६००-६५०	२००-३००
		ऑक्टोबर-नोव्हेंबर	-	६००-६५०	५५०-६५०
		डिसेंबर-जानेवारी	-	७५०-८५०	७००-८५०
७.	बटाटा	जून-जुलै	९०-१२०	५००-६००	२००-३००
		ऑक्टोबर-नोव्हेंबर	-	५००-६००	४५०-६००
८.	भेंडी	जून-जुलै	१००-१२५	४५०-५००	१००-१५०
		सप्टेंबर	-	४५०-५००	४००-५००
		जानेवारी-फेब्रुवारी	-	७००-७५०	७००-७५०
९.	गवार	जून-जुलै	९०-१२०	४५०-५००	१५०-२००
		जानेवारी-फेब्रुवारी	-	६५०-७००	६५०-७००

१०.	लसूण	ऑक्टोबर	१२०-१५०	६००-६५०	६००-६५०
		नोव्हेंबर	-	६५०-७००	६००-७००
११.	वाल	जून-जुलै	१००-१२०	४००-४५०	१५०-२००
		सप्टेंबर-ऑक्टोबर	-	४००-४५०	३५०-४००
		जून-जुलै	१८०-२००	७००-७५०	३५०-४५०
		सप्टेंबर-ऑक्टोबर	-	७५०-८५०	७००-८५०
१२.	आले	मे	२४०-२५५	११००-११५०	७००-७५०
१३.	पडवळ	जून-जुलै	१८०-२००	६००-७००	२००-२५०
		जानेवारी-फेब्रुवारी	-	९००-११००	८५०-११००
१४.	टरबुज	जानेवारी-फेब्रुवारी	९०-१२०	६५०-७००	६००-७००
१५.	खरबुज	जानेवारी-फेब्रुवारी	९०-१२०	५००-६००	४५०-६००
१६.	काकडी	मार्च	११०-१२०	७००-८००	७००-८००
१७.	दुधी	जून-जुलै	१८०-२००	७००-७५०	२५०-३००
	भोपळा	जानेवारी-फेब्रुवारी	-	९००-१०००	८५०-१०००
१८.	वाटाणा	सप्टेंबर-ऑक्टोबर	९०	४००-४५०	३५०-४००
१९.	घेवडा	जून-जुलै	९०-१२०	४००-४५०	१००-१५०
		सप्टेंबर-ऑक्टोबर	-	४००-४५०	३००-४५०
		जानेवारी-फेब्रुवारी	-	५५०-६००	५००-६००
२०.	मुळा	सप्टेंबर-नोव्हेंबर	६०	२००-३००	१५०-३००
२१.	मेथी	सप्टेंबर-मार्च	३५-४५	१७५-२००	१५०-२००
२२.	पालक	जून-जुलै	९०-१२०	५००-५५०	२००-२५०
		सप्टेंबर-डिसेंबर	-	६००-७००	५५०-७००
२३.	कारले	जून-जुलै	१८०-२००	६००-७००	२००-२५०
		जानेवारी-फेब्रुवारी	-	९००-११००	८५०-११००
२४.	दोडका	जून-जुलै	१४०-१५०	५००-५५०	१५०-२५०
		जानेवारी-फेब्रुवारी	-	८००-८५०	७५०-८५०

तक्ता क्र. १ : चारा पिकांची पाण्याची व सिंचनाची गरज (मि.मि. मुळा जवळ)

पिके	पेरणीची वेळ	कालावधी (दिवस)	पाण्याची गरज (मि.मि.)	सिंचनाची गरज (मि.मि.)
मका	जून-जुलै ऑक्टोबर-नोव्हेंबर फेब्रुवारी	९०	४५०-५०० ४५०-५०० ६००-६५०	१५०-२०० ४००-५०० ६००-६५०
ज्वारी **	जून-जुलै ऑक्टोबर-नोव्हेंबर फेब्रुवारी	१५०	७००-८०० ७५०-८५० १०००-११००	३५०-५०० ७००-८५० ९५०-१०००
बाजरी *	जून-जुलै फेब्रुवारी	१००	४००-४५० ५००-६५०	१००-१५० ५००-६००
ओट *	नोव्हेंबर	१२०	५५०-६००	५००-५५०
चवळी *	जून-जुलै फेब्रुवारी-मार्च	१३०	६००-६५० ८५०-९००	२००-२५० ८००-९००
बरसीम *	नोव्हेंबर	९०	५००-६००	५००-५५०
गजराज	जून-जुलै फेब्रुवारी-मार्च	बहूवर्षायू- १ वर्षासाठी	१८००-२००० १८००-२०००	१५००-१६०० १५००-१६००
लसूर्णघास	डिसेंबर-जानेवारी	बहूवर्षायू- १ वर्षासाठी	१९००-२०००	१६००-१६५०

* दोन कापण्या, ** तीन कापण्या

WATER AND LAND MANAGEMENT INSTITUTE, AURANGABAD
LIST OF IMPORTANT WALMI PUBLICATIONS [Available for sale]

Pub. No.	Title of Publication
1.	History & Practice of Management of Irrigation water in Maharashtra by Shri. P. R. Gandhi
4.	Table of Hydraulic Design of Field Channels
11.	Special Course on D. A. of Minor Irrigation schemes Sept. 85
12.	On-farm Development Works Including Micro Distribution net work & Land Shaping for Irrigation.
14	सिंचन संदेश
15.	Irrigation Gravity Methods and Efficiencies
20.	Operation & Management of Irrigation Systems in Maharashtra State
21.	Application of Soil Survey in Irrigation Water Management
22.	Water Distribution Practice in Maharashtra State Nov. 87
26.	पीक उत्पादन वाढीसाठी जमीन व पाण्याचे व्यवस्थापन
28.	Ready Reckoner for obtaining Earth work Quantities of Cuts & Fills for Square grids in Land Development works.
32.	Hydrophysical Properties and Management of Vertisoils
33.	Water Management of Low Land Rice.
34.	Drip Irrigation
36.	Flow Measurement In Irrigation Canals
38.	Sprinkler Irrigation
39.	Farmers Training in Irrigation Water Managenent
41.	सिंचन व्यवस्थापनेत वापरले जाणारे फॉर्म
44.	Irrigated Crops (Part - 1)
45.	National Workshop on Phad System
47.	Agro-Technology for Irrigated Agriculture
48.	Statistical Techniques in Irrigation Water Management
49.	सहकारी पाणी वाटप संस्थेच्या पाटकऱ्यांसाठी मार्गदर्शिका
51.	Economics for Irrigation Water Management.
52.	Social & Organisational Aspects of Irrigation Management
53.	Training Techniques
27.	Dams in Maharashtra

तक्ता - १ अ : पुढे चालू

१	२	३	४	५	६	७	८	९	१०
१०.	सुर्यफुल (रब्बी)	१ नोव्हेंबर	१०५	४००-५००	४००-५००	४००-४५०	४००-४५०	-	-
११.	मिरची	जानेवारी	१५०	८००-९००	८००-८५०	८५०-९००	८००-८५०	७७५-८००	७००-७२५
१२.	टोमॅटो	डिसेंबर	१२०	६००-७००	६००-६५०	६००-७००	६००-६५०	६००-७००	६००-६५०
१३.	कलिंगड	नोव्हेंबर	११०	५००-५५०	४५०-५००	५००-५५०	४५०-५००	-	-
१४.	आंबा	जून	-	१५००-१६००	१०००-११००	१४००-१६००	१०००-११००	१४००-१६००	१०००-११००
१५.	नारळ	जून	-	१६००-१८००	१०००-१३००	१५००-१८००	१०००-१३००	१५००-१६००	१२००-१४००
१६.	सुपारी	जून	-	१६००-१८००	१०००-१३००	१६००-१८००	१०००-१३००	-	-
१७.	चिकू	जून	-	१६००-१८००	१०००-१४००	१६००-१८००	१०००-१३००	-	-
१८.	काजू	जून	-	१५००-१६००	१०००-११००	१५००-१६००	१०००-११००	-	-
१९.	केळी	जुले	४५०	११००-२२००	११००-१३००	-	-	-	-

टीप : १. बारमाही पिकाची पाण्याची / सिंचनाची गरज एक वर्षासाठी दिली आहे.

तक्ता - १ ब : कृषि - हवामान विभाग निहाय प्रमुख पिकांची पाण्याची व सिंचनाची गरज (मिमी)

अ.क्र.	पिके	पेरणीची वेळ	कालावधी (दिवस)	संक्रमण विभाग १ लाल ते लालसर तपकिरी रंगाच्या जमिनीचा विभाग		संक्रमण विभाग २ करड्या रंगाच्या जमिनीचा विभाग	
				सह्याद्रीचा पूर्व भाग, सातारा पुणे, नाशिक, अहमदनगरचा अति पश्चिम भाग, कोल्हापूरचा मध्य भाग		धुळे, नाशिक, अहमदनगर, पुणे, सातारा जिल्ह्याचा पश्चिम भाग कोल्हापूरचा इशान्य भाग	
				पाण्याची गरज	सिंचनाची गरज	पाण्याची गरज	सिंचनाची गरज
१	२	३	३	५	६	७	८
१.	खरीप सं. ज्वारी	१ जुलै	१२०	४००-४५०	१००-१५०	४००-४५०	१५०-२००
२.	रब्बी ज्वारी	१ ऑक्टोबर	१३५	४५०-५००	३००-३५०	४५०-५००	३००-३५०
३.	गहू	१ नोव्हेंबर	१२०	५५०-६००	५००-५५०	५००-५५०	५००-५५०
४.	पेरसाळ	जून-जुलै	१२०	६००-६५०	२००-२५०	६००-६२५	२५०-३००
५.	सं. बाजरी	जूलै	९०	३००-३२५	०-१००	२५०-३००	०-१००
६.	तूर	जूलै	१६५	६००-६५०	२५०-३००	६००-६५०	३००-३५०
७.	हरभरा	१ नोव्हेंबर	१०५	३५०-४५०	३५०-४००	३००-४५०	३००-४५०
८.	खरीप भूईमुग	जुलै	१२०	४५०-५००	१५०-२००	४५०-५००	२००-२५०
९.	उन्हाळी भूईमुग	फेब्रुवारी	१२०	७५०-८००	७००-७५०	७५०-८००	७५०-८००
१०.	करडई	१ ऑक्टोबर	१२०	४५०-४७५	२७५-३२५	४००-४५०	३००-३५०
११.	सोयाबीन	जुलै	१०५	३००-४००	७५-१२५	३५०-४००	१००-१५०

तक्ता - १ ब : पुढे चालू

१	२	३	४	५	६	७	८
१२.	सुर्यफूल (रब्बी)	१ नोव्हेंबर	१०५	४५०-५००	४००-४५०	४००-४५०	४००-४५०
१३.	सूर्यफुल (खरीप)	जुलै	१०५	-	-	३५०-४००	१००-१५०
१४.	सुर्यफुल (उन्हाळी)	१ मार्च	१०५	७५०-८००	६५०-७००	७००-८००	६५०-७००
१५.	मिरची	जानेवारी	१०५	८५०-९००	८००-८५०	८५०-९००	८५०-९००
१६.	हळद/आले	जून	२४०	१२००-१३००	७००-८००	११००-१२००	८००-८५०
१७.	लिंबू वर्गीय फळझाडे (संत्रा, मोसंबी, लिंबू)	जून	-	-	-	१३००-१५००	१०००-१२००
१८.	पेरू	जूलै	-	१४००-१५००	१०००-१२००	१४००-१५००	१०००-१२००
१९.	सुरू ऊस	जानेवारी	३६५	२०००-२१००	१३००-१४००	२०००-२१००	१६००-१७००
२०.	पूर्वहंगामी ऊस	ऑक्टोबर	४५०	२५००-२६००	१९००-२०००	२५००-२६००	१९००-२०००
२१.	आडसाली ऊस	जूलै	५४०	२८००-२९००	२०००-२१००	२८००-२९००	२०००-२१००

तक्ता - १ (क) : कृषि - हवामान विभाग निहाय प्रमुख पिकांची पाण्याची व सिंचनाची गरज (मिमी)

अ.क्र.	पिके	पेरणीची वेळ	कालावधी (दिवस)	अवर्षण (कमी पावसाचा) विभाग		निश्चित पावसाचा मुख्यत: खरीप पिकाचा विभाग	
				पुणे, नाशिक, अहमदनगरचा पूर्व भाग सातारा, सांगलीचा अतिपूर्व भाग औरंगाबाद, सोलापूर, बीड, उस्मानाबादचा पश्चिम भाग (सविस्तर माहितीसाठी आ.२ पहावे)		जळगाव, सोलापूर (अक्कलकोट) औरंगाबादचा पूर्व व उत्तर भाग जालना, परभणी, बीड, (गेवराई, केज, अंबाजोगाई व माजलगांव), उस्मानाबाद (पूर्व भाग), लातूर, नांदेड, बुलढाणा, अकोला, अमरावती, हिंगोली (पश्चिमभाग)	
				पाण्याची गरज	सिंचनाची गरज	पाण्याची गरज	सिंचनाची गरज
१	२	३	४	५	६	७	८
१.	खरीप सं. ज्वारी	१ जुलै	१२०	४००-४५०	१५०-२००	४००-४५०	७५-१००
२.	रब्बी ज्वारी	१ ऑक्टोबर	१३५	४००-४५०	३००-३५०	४००-४५०	३००-३५०
३.	गहू	१ नोव्हेंबर	१२०	५००-५२५	४००-५००	५००-५५०	४७५-५२५
४.	सं. बाजरी	जुलै	९०	३००-३२५	५०-१००	३००-३२५	०-५०
५.	पेरसाळ	जून-जुलै	१२०	-	-	६००-६५०	१७५-२२५
६.	तूर	जुलै	१६५	५७५-६२५	३००-३५०	६००-६५०	२५०-३००
७.	हरभरा	१ नोव्हेंबर	१०५	३००-४२५	३५०-४००	३००-४५०	३००-४००
८.	मूग	जून	६०	२५०-३००	०-५०	२५०-३००	०-५०
९.	उडिद	जून	७५-९०	३००-३५०	०-५०	२५०-३००	०-५०

तक्ता - १ (क) : पुढे चालू

१	२	३	४	५	६	७	८
१०.	खरीप भूईमुग	जुलै	१२०	-	-	४५०-५००	१००-१५०
११.	उन्हाळी भूईमुग	फेब्रुवारी	१२०	७५०-८००	७५०-८००	८००-८५०	७५०-८००
१२.	करडई	१ ऑक्टोबर	१२०	४००-४५०	३००-३५०	४००-४५०	२७५-३२५
१३.	सोयाबीन	जुलै	१०५	३५०-४००	१००-१५०	३५०-४००	०-५०
१४.	सूर्यफुल (खरीप)	जुलै	१०५	३५०-४००	१००-१५०	३७५-४२५	०-७५
१५.	सुर्यफुल (रब्बी)	नोव्हेंबर	१०५	४००-४५०	३७५-४२५	४००-४५०	४००-४५०
१६.	सुर्यफूल ((उन्हाळी)	१ मार्च	१०५	७००-७५०	६५०-७००	७००-७५०	६५०-७००
१७.	तीळ	जून	१०५	३००-३५०	०-५०	३००-३५०	०-५०
१८.	हळद/आले	जून	२४०	११००-१२००	७२५-७७५	१२००-१३००	७००-७५०
१९.	मिरची	जानेवारी	१५०	८५०-९००	८५०-९००	९००-९५०	८५०-९००
२०.	कापूस	१६ मे	१७०-१९०	७००-८००	२२५-३२५	७५०-८५०	२००-३००
२१.	सुरू ऊस	जानेवारी	३६५	२०००-२२००	१६००-१७००	२१००-२२००	१४००-१५००
२२.	पूर्वहंगामी ऊस	ऑक्टोबर	४५०	२५००-२६००	२०००-२१००	२७००-२८००	२०००-२२००
२३.	आडसाली ऊस	जुलै	५४०	२८००-२९००	२२००-२३००	३२००-३३००	२२००-२५००
२४.	लिंबू वर्गीय फळझाडे (संत्रा,मोसंबी,लिंबू)	जून	-	१३००-१५००	१०००-१२००	१४००-१६००	९००-११००
२५.	द्राक्षे	जून	-	१७००-१८००	१३००-१४००	-	-
२६.	केळी	जुलै	४५०	-	-	२०००-२१००	१२००-१४००
२७.	बोर	जुलै	-	१२००-१५००	९००-१०००	१२००-१५००	९००-११००
२८.	डाळिंब	जुलै	-	१२००-१५००	१०००-११००	-	-
२९.	लसूण	जानेवारी	३६५	१९००-२०००	१५००-१६००	२०००-२१००	१४००-१४५०

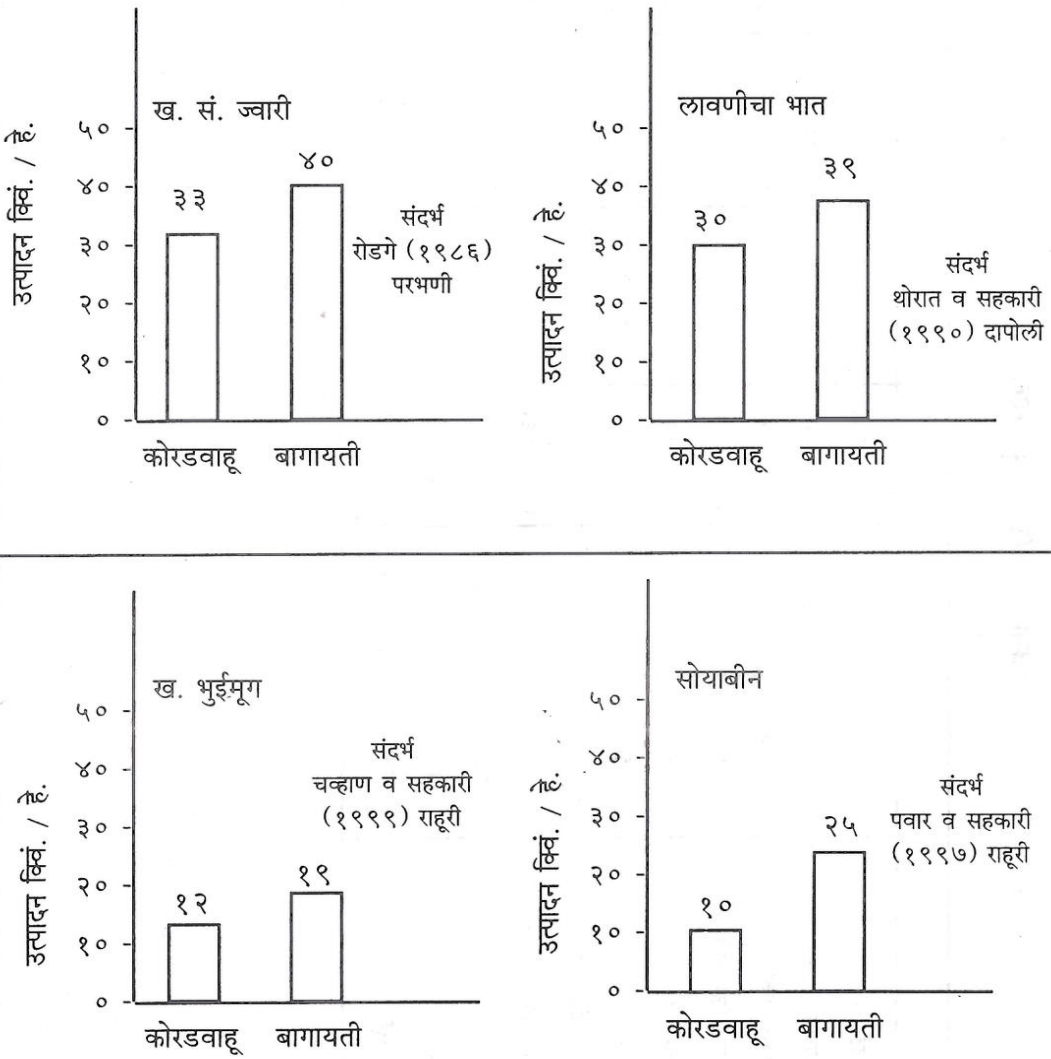
तक्ता - १ (ड) : कृषि - हवामान विभाग निहाय प्रमुख पिकांची पाण्याची व सिंचनाची गरज (मिमी)

अ.क्र.	पिके	पेरणीची वेळ	कालावधी (दिवस)	मध्यम ते साधारण जास्त पावसाचा, कार खडकापासून बनलेला जमिनीचा विभाग हिंगोली व नांदेडचा उत्तर व पूर्व भाग, यवतमाळ, वर्धा, नागपूर, चंद्रपूर (पश्चिम)		जास्त पावसाचा, मिश्र खडकापासून बनलेल्या जमिनीचा विभाग भंडारा, गोंदिया, चंद्रपूर (पूर्व), गडचिरोली	
				पाण्याची गरज	सिंचनाची गरज	पाण्याची गरज	सिंचनाची गरज
१	२	३	४	५	६	७	८
१.	खरीप सं. ज्वारी	१ जुलै	१२०	४००-४५०	७५-१००	-	-
२.	रब्बी ज्वारी	१ ऑक्टोबर	१३५	४२५-४७५	३००-३५०	४००-४५०	३००-३५०
३.	गहू	१ नोव्हेंबर	१२०	५००-५५०	४७५-५२५	४७५-५२५	४५०-५००
४.	पेरसाळ	जून-जुलै	१२०	६००-६५०	१५०-२००	-	-
५.	खरीप भात (लावणीचा)	जुलै	१२०-१३५	-	-	१७००-१९००	०-२५०
६.	रब्बी उन्हाळी भात (लावणीचा)	डिसेंबर	१२०-१३५	-	-	१७००-१९००	१६००-१८००
७.	तूर	जुलै	१६५	६००-६५०	२००-२५०	६००-६५०	१५०-२००
८.	हरभरा	नोव्हेंबर	१०५	३००-४५०	३५०-४००	३००-४००	३००-४००
९.	खरीप भूईमुग	जुलै	१२०	४५०-५००	१००-१५०	-	-
१०.	उन्हाळी भूईमुग	फेब्रुवारी	१२०	८००-८५०	७५०-८००	७५०-८२५	७५०-८००

तक्ता - १ (ड) : पुढे चालू

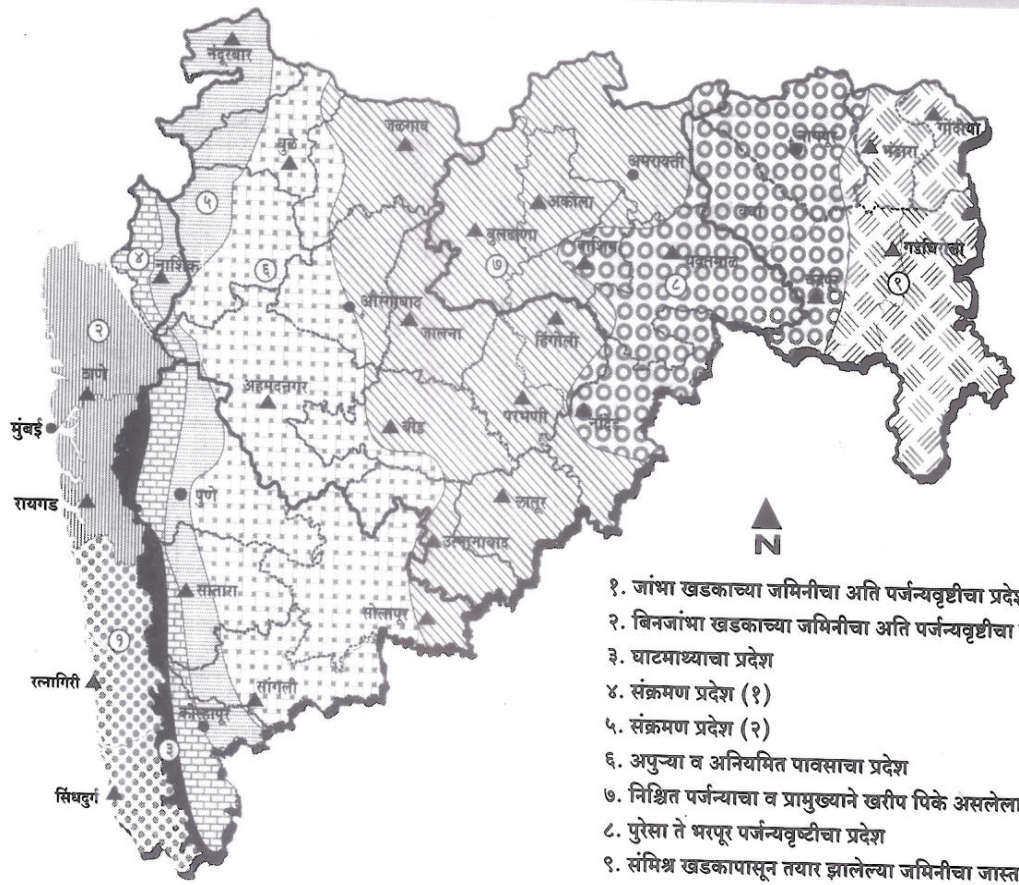
१	२	३	४	५	६	७	८
११.	करडई	१ ऑक्टोबर	१२०	४००-४५०	२७५-३२५	४००-४५०	२५०-३००
१२.	सोयाबीन	जुलै	१०५	३५०-४००	०-५०	३७५-४२५	-
१३.	सुर्यफुल (रब्बी)	१ नोव्हेंबर	१०५	४००-४५०	४००-४५०	४००-४५०	३७५-४२५
१४.	सूर्यफुल (उन्हाळी)	१ मार्च	१०५	७००-७५०	६५०-७००	७००-७५०	६५०-७००
१५.	हळद/आले	जून	२४०	११५०-१२५०	६००-७००	११५०-१२५०	६००-६२५
१६.	मिरची	जानेवारी	१५०	९००-९५०	८५०-९००	८५०-९००	८००-८५०
१७.	लिंबू वर्गीय फळझाडे (संत्रा, मोसंबी, लिंबू)	जून	३६५	१४००-१६००	९००-११००	१४००-१६००	९००-११००
१८.	लसूण	जानेवारी	३६५	२०००-२१००	१४००-१४५०	-	-
१९.	कापूस	१६ मे	१७०-१९०	७५०-८५०	२००-३००	-	-
२०.	ऊस सुरू	जानेवारी	३६५	२१००-२२००	१४००-१५००	२१००-२२००	१२००-१३००

खरीप हंगामात संरक्षणात्मक सिंचनामुळे पिकांचे उत्पादन वाढते.



आकृती १ : खरीप हंगामात अवर्षण परिस्थितीत संरक्षणात्मक सिंचनामुळे वेगवेगळ्या पिकांच्या उत्पादनात वाढ होते हे अनेक प्रयोगावरून सिद्ध झालेले आहे.

महाराष्ट्र राज्याचे कृषि हवामान विभाग



१. जांभा खडकाच्या जमिनीचा अति पर्जन्यवृष्टीचा प्रदेश ⑨
२. बिनजांभा खडकाच्या जमिनीचा अति पर्जन्यवृष्टीचा प्रदेश ②
३. घाटमाथ्याचा प्रदेश ③
४. संक्रमण प्रदेश (१) ④
५. संक्रमण प्रदेश (२) ⑤
६. अपुऱ्या व अनियमित पावसाचा प्रदेश ⑥
७. निश्चित पर्जन्याचा व प्रामुख्याने खरीप पिके असलेला प्रदेश ⑦
८. पुरेसा ते भरपूर पर्जन्यवृष्टीचा प्रदेश ⑧
९. संमिश्र खडकापासून तयार झालेल्या जमिनीचा जास्त पर्जन्यवृष्टीचा प्रदेश ①

तक्ता क्र. ३ : पुढे चालू

अ. क्र.	हवामान विभागाचे नांव	पर्जन्याधारीत पीक रचना		साठवलेल्या पाण्याची उपलब्धता					
		खरीप	रब्बी	३००० घमी प्रति हेक्टर		७००० घमी प्रति हेक्टर		१०,००० घमी प्रति हेक्टर पेक्षा जास्त	
				खरीप	रब्बी-उन्हाळी (कोकण हंगाम)	खरीप	रब्बी-उन्हाळी (कोकण हंगाम)	खरीप	रब्बी-उन्हाळी (कोकण हंगाम)
२.	जास्त पावसाळी प्रदेश (जांभ्या जमिनी विरहीत) हंगामी / द्विहंगामी पिके	भात नागली वरई सावा कारळ		भात भात भात भात भात	घेवडा मोहरी वाल/पावटा नागली/चवळी/ हरभरा/सुर्यफूल	भात भात भात भात भात भात	टोमॅटो/मिरची भेंडी कलिंगड वांगी भुईमूग तोंडली/वेलवर्गीय भाज्या	भात भात भात भात भात भात भात भात भात भात	मिरची टोमॅटो-मुग टोमॅटो-काकडी ढोबळी मिरची कलिंगड-काकडी टोमॅटो-कोथिंबीर कलिंगड-मुग भुईमुग भात (तळाकडील भाग)
	बारमाही पिके	आंबा काजू कोकम फणस		आंबा काजू कोकम फणस		आंबा काजू कोकम फणस		ऊस केळी नारळ + मसाला पिके चिकू रबर सुपारी + मसाला पिके	

तक्ता क्र. ३ : पुढे चालू

अ. क्र.	हवामान विभागाचे नांव	पर्जन्याधारीत पीक रचना		साठवलेल्या पाण्याची उपलब्धता								
		खरीप	रब्बी	३००० घमी प्रति हेक्टर			७००० घमी प्रति हेक्टर			१०,००० घमी प्रति हेक्टर पेक्षा जास्त		
				खरीप	रब्बी	उन्हाळी	खरीप	रब्बी	उन्हाळी	खरीप	रब्बी	उन्हाळी
३.	घाटमाथ्याचा प्रदेश हंगामी/द्विहंगामी पिके	भात नागली वरई सावा कारळ मका		भात भात भात भात भात	घेवडा चवळी वाल नागली हरभरा		भात भात भात भात	बटाटा रताळी मिरची टोमॅटो/ वांगे/ भाज्या		भात भात भात भात	-- बटाटा टोमॅटो मिरची	उ.भुईमुग भुईमुग
	बारमाही पिके	आंबा काजू		आंबा काजू			आंबा काजू			ऊस नारळ		

तक्ता क्र. ३ : पुढे चालू

अ. क्र.	हवामान विभागाचे नांव	पर्जन्याधारीत पीक रचना		साठवलेल्या पाण्याची उपलब्धता								
				३००० घमी प्रति हेक्टर			७००० घमी प्रति हेक्टर			१०,००० घमी प्रति हेक्टर पेक्षा जास्त		
		खरीप	रब्बी	खरीप	रब्बी	उन्हाळी	खरीप	रब्बी	उन्हाळी	खरीप	रब्बी	उन्हाळी
४.	संक्रमण विभाग-१ तांबूस तपकिरी मातीचा प्रदेश हंगामी / द्विहंगामी पिके	भात ज्वारी भूईमुग नागली तूर सूर्यफूल कारळ वरई बाजरी		भात ज्वारी बाजरी/ नागली सावा/ वरई तूर	हरभरा/ वाटाणा मोहरी/ वाल हरभरा/ मोहरी हरभरा/ सूर्यफूल ---		भात भात हळद आले सावा/ वरई	गहू/ बटाटा कोबी/ हरभरा/ वांगे -- -- कांदे		भात नागली ज्वारी भूईमुग भूईमुग सुर्यफूल सुर्यफूल	गहू टोमॅटो बटाटा कांदे बटाटा गहू वांगे	मका चारापिके भूईमुग चारापिके भुईमुग मुग
	बारमाही पिके	बोर आंबा		बोर आंबा			आवळा सिताफळ आंबा			सिताफळ पेरू ऊस अंजीर चिकू आंबा घास (लुसर्न)		

तक्ता क्र. ३ : पुढे चालू

अ. क्र.	हवामान विभागाचे नांव	पर्जन्याधारीत पीक रचना		साठवलेल्या पाण्याची उपलब्धता								
				३००० घमी प्रति हेक्टर			७००० घमी प्रति हेक्टर			१०,००० घमी प्रति हेक्टर पेक्षा जास्त		
		खरीप	रब्बी	खरीप	रब्बी	उन्हाळी	खरीप	रब्बी	उन्हाळी	खरीप	रब्बी	उन्हाळी
४.	संक्रमण विभाग-१ तांबूस तपकिरी मातीचा प्रदेश हंगामी / द्विहंगामी पिके	भात ज्वारी भूईमुग नागली तूर सूर्यफूल कारळ वरई बाजरी		भात ज्वारी बाजरी/ नागली सावा/ वरई तूर	हरभरा/ वाटाणा मोहरी/ वाल हरभरा/ मोहरी हरभरा/ सूर्यफूल ---		भात भात हळद आले सावा/ वरई	गहू/ बटाटा कोबी/ हरभरा/ वांगे -- -- कांदे		भात नागली ज्वारी भूईमुग भूईमुग सुर्यफूल सुर्यफूल	गहू टोमॅटो बटाटा कांदे बटाटा गहू वांगे	मका चारापिके भूईमुग चारापिके भुईमुग मुग
	बारमाही पिके	बोर आंबा		बोर आंबा			आवळा सिताफळ आंबा			सिताफळ पेरू ऊस अंजीर चिकू आंबा घास (लुसर्न)		

तक्ता क्र. ३ : पुढे चालू

अ. क्र.	हवामान विभागाचे नांव	पर्जन्याधारीत पीक रचना		साठवलेल्या पाण्याची उपलब्धता								
				३००० घमी प्रति हेक्टर			७००० घमी प्रति हेक्टर			१०,००० घमी प्रति हेक्टर पेक्षा जास्त		
		खरीप	रब्बी	खरीप	रब्बी	उन्हाळी	खरीप	रब्बी	उन्हाळी	खरीप	रब्बी	उन्हाळी
५.	संक्रमण प्रदेश विभाग - २ (करडी व काळी जमीन असलेला प्रदेश) हंगामी/द्विहंगामी पिके	ज्वारी बाजरी मुग/ उडीद तूर भुईमुग	-- -- ज्वारी/ करडई -- --	ज्वारी बाजरी मुग/ उडीद तूर	हरभरा सुर्यफूल ज्वारी --		ज्वारी बाजरी ज्वारी/ बाजरी आले हळद बाजरी	गहू बटाटा कांदे -- -- हरभरा		ज्वारी भात नागली कापूस	गहू हरभरा गहू --	भुईमुग/ मका भेंडी/ मिरची भुईमुग भुईमुग
	बारमाही पिके	बोर आवळा आंबा सिताफळ		बोर आवळा आंबा सिताफळ			बोर आवळा आंबा सिताफळ			ऊस अंजिर पेरू द्राक्षे केळी बोर आवळा आंबा सिताफळ घास (लुसर्न)		

			(लुसर्न)

तक्ता क्र. ३ : पुढे चालू

अ. क्र.	हवामान विभागाचे नांव	पर्जन्याधारीत पीक रचना		साठवलेल्या पाण्याची उपलब्धता								
		खरीप	रब्बी	३००० घमी प्रति हेक्टर			७००० घमी प्रति हेक्टर			१०,००० घमी प्रति हेक्टर पेक्षा जास्त		
				खरीप	रब्बी	उन्हाळी	खरीप	रब्बी	उन्हाळी	खरीप	रब्बी	उन्हाळी
६.	अवर्षणप्रवण विभाग हंगामी/द्विहंगामी पिके	बाजरी ज्वारी हुलगा मटकी सुर्यफूल एरंडी कापूस मुग/ उडीद	-- -- -- -- रब्बी ज्वारी ज्वारी/ करडई	बाजरी तूर कापूस मुग ज्वारी सुर्यफूल	करडई हरभरा -- ज्वारी मोहरी/ हरभरा हरभरा		बाजरी/ज्वारी ज्वारी/सुर्यफूल बाजरी तूर मिरची हळद/आले बाजरी ज्वारी	कांदा गहू गहू बटाटा -- हरभरा/ टोमॅटो मोहरी		ज्वारी सुर्यफूल भुईमुग तूर मुग/उडीद हळद आले बाजरी/ ज्वारी	गहू/ बटाटा कांदे गहू -- टोमॅटो -- -- टोमॅटो	भुईमुग भुईमुग मका भेंडी भेंडी भेंडी
	बारमाही पिके	आंबा चिंच बोर सिताफळ आवळा		आंबा चिंच बोर सिताफळ आवळा			आंबा चिंच बोर सिताफळ आवळा			ऊस डाळींब बोर पेरू मोसंबी लिंबू / पपया द्राक्षे / सिताफळ घास (लुसर्न)		

तक्ता क्र. ३ : पुढे चालू

अ. क्र.	हवामान विभागाचे नांव	पर्जन्याधारीत पीक रचना		साठवलेल्या पाण्याची उपलब्धता								
		खरीप	रब्बी	३००० घमी प्रति हेक्टर			७००० घमी प्रति हेक्टर			१०,००० घमी प्रति हेक्टर पेक्षा जास्त		
				खरीप	रब्बी	उन्हाळी	खरीप	रब्बी	उन्हाळी	खरीप	रब्बी	उन्हाळी
७.	निश्चित पावसाळी प्रदेश (प्रमुखत: खरीप पिकांचा) हंगामी / द्विहंगामी पिके	कापुस भुईमुग ज्वारी तूर सोयाबीन पेरसाळ मुग उडीद तीळ सुर्यफूल -- -- --	ज्वारी करडई हरभरा	कापूस ज्वारी ज्वारी मुग/ उडीद सोयाबीन सोयाबीन सोयाबीन पेरसाळ सोयाबीन/ तीळ ज्वारी/ सुर्यफूल/ मका भात	-- हरभरा करडई ज्वारी करडई ज्वारी मोहरी हरभरा सुर्यफूल चवळी जवस		भूईमुग भुईमुग ज्वारी कापूस सोयाबीन तूर सोयाबीन भात हळद आले कापूस	कांदा गहू गहू मका गहू गहू भुईमुग गहू -- -- कांदा		कापूस ज्वारी कापूस भुईमुग/ तीळ ज्वारी सोयाबीन तूर ज्वारी उडीद मिरची ज्वारी/ भात कापूस हळद आले	- सुर्यफूल - सुर्यफूल सुर्यफूल सुर्यफूल -- -- कांदा -- गहू	भुईमुग भुईमुग मिरची तीळ/ भुईमुग भेंडी तीळ भुईमुग मका/ मुग चवळी भुईमुग भुईमुग
	बारमाही पिके	आंबा / चिंच / सिताफळ बोर / आवळा		आंबा / चिंच / सिताफळ बोर / आवळा			आंबा / चिंच / सिताफळ बोर / आवळा			ऊस, केळी, संत्रा, चिकू, पेरू, लिंब, मोसंबी, घास (लूसर्न)		

तक्ता क्र. ३ : पुढे चालू

अ. क्र.	हवामान विभागाचे नांव	पर्जन्याधारीत पीक रचना		साठवलेल्या पाण्याची उपलब्धता								
				३००० घमी प्रति हेक्टर			७००० घमी प्रति हेक्टर			१०,००० घमी प्रति हेक्टर पेक्षा जास्त		
		खरीप	रब्बी	खरीप	रब्बी	उन्हाळी	खरीप	रब्बी	उन्हाळी	खरीप	रब्बी	उन्हाळी
८.	अधिक पावसाचा प्रदेश : हंगामी/ द्विहंगामी पिके	कापुस भुईमुग ज्वारी भात तूर उडीद सोयाबीन पेरसाळ	-- -- करडई/ हरभरा जवस -- करडई/ हरभरा -- --	कापूस भुईमुग भुईमुग भुईमुग सोयाबीन	-- हरभरा सुर्यफूल मोहरी ज्वारी		कापूस भुईमुग ज्वारी हळद आले	-- गहू गहू		कापूस भुईमुग/ ज्वारी सोयाबीन हळद आले सोयाबीन भात मिरची ज्वारी	-- गहू मोहरी -- -- गहू राजमा	भुईमुग भुईमुग मुग भुईमुग मुग भुईमुग भुईमुग भुईमुग
	बारमाही पिके	आंबा		आंबा			आंबा			ऊस संत्रा चिकू कागदी लिंबू पेरू केळी घास (लूसर्न)		

तक्ता क्र. ३ : पुढे चालू

अ. क्र.	हवामान विभागाचे नांव	पर्जन्याधारीत पीक रचना		साठवलेल्या पाण्याची उपलब्धता								
				३००० घमी प्रति हेक्टर			७००० घमी प्रति हेक्टर			१०,००० घमी प्रति हेक्टर पेक्षा जास्त		
		खरीप	रब्बी	खरीप	रब्बी	उन्हाळी	खरीप	रब्बी	उन्हाळी	खरीप	रब्बी	उन्हाळी
९.	जास्त पावसाचा प्रदेश हंगामी / द्विहंगामी पिके	भात भात भात सोयाबीन	पावटा करडई -- जवस	भात भात भात सोयाबीन सोयाबीन भात	पावटा हरभरा करडई सुर्यफूल ज्वारी जवस		भात भात भात सोयाबीन हळद	-- -- गहू गहू	भुईमुग सोयाबीन	भात भात भात भात भात भात सोयाबीन सोयाबीन	राजमा -- -- मका गहू/ मका सुर्यफूल गहू गहू	भुईमुग भुईमुग भात चवळी मुग चवळी मुग चवळी
	बारमाही पिके	आंबा		आंबा			आंबा			ऊस चिकू संत्री पेरू		

टीप : कोकणात हिवाळा अत्यल्प असल्यामुळे फक्त दोन हंगाम असतात. खरीप व कोकण हंगाम

आधार : कृषि विद्यापीठाकडून प्राप्त टिपण्यातून संकलित माहिती

संदर्भ : महाराष्ट्र जल व सिंचन आयोगाचा (१९९९) अहवाल.

तक्ता क्र. ४ : पाणी वापर सहकारी संस्थेला व शेतकऱ्यांना फायदेशीर पिके :

अ. क्र.	हंगाम व पिकाचे नांव	पाण्याच्या पाळ्या	पिकांच्या मुळाजवळ लागणारे पाणी (मिमी)	मायनरच्या मुखाजवळ सोडावे लागणारे पाणी (घनमीटर/हे)	पाटबंधारे विभागाला द्यावी लागणारी पाणीपट्टी (रू/हे)	शेतकऱ्यां कडून संस्थेला मिळणारी पाणीपट्टी (रू/हेक्टर)	संस्थेला फायदा/ तोटा (रू./हे.)
खरीप पिके							
१.	ज्वारी, बाजरी	१	१००	१६६७	७९.३५	२३८	१५८.६५
	मका, सोयाबीन	२	१७५	२९१७	१३८.८५	२३८	९९.१५
	सूर्यफुल	३	२५०	४१६७	१९८.३५	२३८	३९.६५
२.	भुईमूग	१	१००	१६६७	७९.३५	४७६	३९६.६५
	सं. बियाणे	२	१७५	२९१७	१३८.८५	४७६	३३७.१५
		३	२५०	४१६७	१९८.३५	४७६	२७७.६५
रब्बी पिके							
३.	ज्वारी, करडई	१	१००	१६६७	११९.०२	३५८	२३८.९८
	हरभरा, मोहरी	२	१७५	२९१७	२२८.२७	३५८	१३९.७३
	सुर्यफूल	३	२५०	४१६७	२९७.५२	३५८	६०.४८
४.	गहू	४	३२५	५४१७	३८७.८६	४७६	८८.१४
		५	४००	६६६७	४७६.००	४७६	०.००
५.	सं. बियाणे	६	४७५	७९१९	५६५.२७	७२४	१५८.७३
उन्हाळी पिके							
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पाणीपट्टीचे दर १.७.२००३ पासूनचे धरावेत.
मायनरच्या मुखापासून पिकाच्या मुळापर्यंतची पाणी वापर क्षमता ६० टक्के.

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वापरलेले पाणी (मिमि)	हलक्या व उथळ जमीनीवर मिळालेले गव्हाचे उत्पादन (क्विंटल/हेक्टर)	एक द.ल.घ.मी. पाण्यामध्ये भिजणारे क्षेत्र (हेक्टर)	एक द.ल.घ.मी पाण्यातून मिळणारे एकूण उत्पादन (क्विंटल)	शेरा
४००	२८	१५०	४२००.००	
३५०	२५	१७१.४३	४२८५.७५	यात ५० मिमी पाणी कमी वापरल्यानंतर सुद्धा एकूण उत्पादन जास्त मिळत असल्याचे दिसून येते.
३००	२१	२००.००	४२००.००	
२५०	१५	२४०	३६००.००	

मायनर मुख्यापासून पिकाच्या मुळापर्यंतची पाणी वापर क्षमता ६० टक्के

तक्ता क्र. ६ : प्रमुख पिकांची पाण्याची व सिंचनाची गरज (पिकांच्या मुळा भोवती)

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अ. क्र.	पीक	पेरणीची वेळ	पिकांचा कालावधी (दिवस)	पाण्याची गरज	सिंचनाची गरज	गृहीत धरलेली सिंचनाची गरज	पिकाला पाण्याच्या पाळ्या		दोन पाळ्यातील अंतर
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तक्ता क्र. ६ : प्रमुख पिकांची पाण्याची व सिंचनाची गरज (पिकांच्या मुळा भोवती)

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टीप : पाण्याची व सिंचनाची गरज प्रवाही पद्धतीसाठी आहे व ही गरज पिकांच्या मुळा भोवतालची आहे.

आधार : हवामानाची आकडेवारी / भारत मोसम विज्ञान विभाग व संदर्भिय पिक बाष्पपर्णोत्सर्जन, वाल्मी औरंगाबाद.

का.पा.ठ. : कार्यसाधक पावसावरून ठरवावे.

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IRRIGATED CROPS

(PART I)

(Fifth Edition)

Water And Land Management Institute
Aurangabad (Maharashtra) - 431005

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FOREWARD

The information on irrigation water management of different crops is essential not only to agricultural scientists but also to the irrigation engineers, agricultural engineers, agricultural extension workers and land development officers. In response to that, the book entitled "Irrigated Crops" is prepared with an objective to present a brief review of current research work done on irrigation water management of major crops grown in Maharashtra. This publication will be useful to the teachers, research workers and extension officers engaged in irrigation management.

Efforts taken for preparation of this book by Shri. V. G. Musande under the guidance of Dr. S.S. Bhalerao Professor and Head, Faculty of Agriculture, Dr. S. B. Varade, Joint Director (Trg.) and Dr. D. H. Pawar, Associate Professor are appreciated.

Date : 23-4-90

N. R. Joshi
Director

PREFACE TO THE FIFTH EDITION

It is a great pleasure for WALMI to publish FIFTH EDITION of the publication on "IRRIGATED CROPS"

The response to the previous Four editions was overwhelming. This indicates the utility of this publication to the engineers of Water Resources Department, Agriculture Department and all others involved in Irrigation Water Management.

Fifth edition is revised after incorporating the correction and changes suggested by readers, Shri G. R. Tekale, Asstt. Prof. and Dr. D. H. Pawar, Prof. & Head, Faculty of Agriculture.

We are indebted to the readers who have suggested improvements. The suggestions for further improvements are always welcome.

Aurangabad
March 2013

H. T. MENDHEGIRI
Director General, WALMI

CONTENTS

List of Abbreviations

^0C	Centigrade
mm	Millimeter
pH	Logaritham of the reciprocal of hydrogen ion concentration
cm	Centimeter
Kg	Kilogram
ha	Hectare
N	Nitrogen
P_2O_5	Phosphorus
K_2O	Potash
Kc	Crop coefficient
P	Fraction (P) of total available water
m	meter
fig.	Figure
IW/CPE	Ratio of Irrigation water and cumulative pan evaporation
gm	Grams
ml	milliliter
Lit.	Litre
EC	Emulsifiable concentrate
WP	Wettable powder
%	Percentage
q	Quintals
@	at the rate of
ASM	Available soil moisture
AV	Average
O_2	Oxygen
HW	Hot Weather
L	Length
B	Breadth
H	Height
FYM	Farm yard Manure
ETc	Crop evapotranspiration
WR	Water requirement
GM	Green Manure
OM	Organic matter
WUE	Water use efficiency
t	tons
DAT	days after transplanting
LS	Long Stapple cotton
a.i.	active ingredient

SORGHUM

Sorghum is one of the major food grain crops of Maharashtra. It is a staple food of the people and also grown as a fodder crop in the relatively dry tracts of central and southern parts of India.

Climate :

Sorghum requires warm climate but can be grown under a wide range of climatic conditions. Suitable temperature for optimum growth is 26°C to 30° C. For germination, minimum temperature requirement is 10°C. If mean daily temperature is greater than 20°C the duration decreases and if the mean temperature is less than 20°C. the duration increases. At low temperature (below 10° C.) seed setting is poor and there will be only fodder. While under very high temperature (above 45°C.) pollination fails. It grows well in 600 to 1000 mm rainfall zone.

This crop can tolerate high temperature, drought condition and water logging for certain period.

Soil :

Soils with clay loam or loamy texture, having good water retention capacity are best suited for sorghum cultivation. But it is cultivated on variety of soils in India. It performs well on a soil having 6.0 to 8.5 p^H range as it tolerates saline and alkaline soil conditions to some extent.

Field Preparation :

Soil should be loose up to 20 cm, therefore one light ploughing with 2-3 harrowings are required. In rabi season border strips should be prepared for irrigation.

Seed and Sowing

Seed rate should be 10 Kg/ha to ensure good stand of 1,50,000 to 1,80,000 plant population per ha. Spacing should be 45 cm x 15 cm and the depth of sowing should be 3 to 5 cm. Sowing should done by seed cum fertilizer drill. Recommended time of sowing in Maharashtra is as below :

Kharif	-	15 June to 10 July
Rabi	-	15 September to 15 October
Summer	-	15 January to 15 February

Varieties / Hybrids :

Now the improved hybrid varieties having higher yield potential are available. These hybrid varieties are dwarf therefore plant population per unit area can be increased. Its duration is only 100 to 120 days due to which this crop can be included in multiple cropping system. The hybrid cultivars are giving good response to irrigation and fertilizers as compared to local varieties. Cultivars for Kharrif and Rabi season are as below :

Recommended Cultivars for Kharif season

CSH - 5, CSH - 9, CSH - 14, CSH - 17, CSH - 18, CSH - 25, SPV - 462, SPV 475 and Phule Amrita

In addition to above SPV - 297 and SPV - 346 varieties are also recommended in Kharif season.

Recommended cultivars for Rabi season.

CSH - 13 - R, CSH - 15 - R, CSH-19 R, M - 35 - 1, SPV 839, Selection 3, Phule Yashoda and Phule Mauli

Manures and Fertilizers :

The quantity of manures and fertilizers to be applied varies according to the fertility status of the soil. The application of farm yard manure or compost at the rate of 10-15 tons/ha improves the water holding capacity and microbial activities in soil. It is essential to add organic manures for sustainable yields. Sorghum requires 100 - 120 kg N, 50 to 60 Kg P_2O_5 and 50-60 kg K_2O per ha for hybrids and for improved varieties under irrigated condition, 80 kg N + 40 Kg P_2o_5 / ha is recommended.

Half dose of N and total amount of P_2O_5 and K_2O should be applied at the time of sowing by drilling method. The fertilizer should be placed 3-5 cm below the soil. The remaining quantity of nitrogen should be applied as top dressing 30 days after sowing. In light soil the top dressing may be done in two split applications. Sorghum is most sensitive to iron and zinc deficiency.

Intercultural Operations :

After thinning and gap filling operation, one or two hoeings and one hand weeding are enough to remove the weeds. Besides this spraying with 1 Kg a.i. of Propazine or 0.5 kg a.i. of Atrazine per ha should be used as pre-emergence to control the weeds.

Rotation and Mixed Cropping :

Most of the improved varieties and hybrids mature in about 95-120 days and they fit very well in multiple cropping system. Some of the rotations with sorghum are given below :

Sorghum	-	Gram	Groundnut	-	Sorghum
Sorghum	-	Wheat	Moong	-	Sorghum
Sorghum	-	Safflower	Urid	-	Sorghum
Sorghum	-	Cotton	Sorghum	-	Potato
Sorghum	-	Groundnut	soybean	-	Sorghum

Mixed cropping of sorghum + Arhar, Sorghum + Moong, Sorghum + Urid, Sorghum + Soybean have been found to be more profitable.

Water Management :

Sorghum is relatively drought tolerant crop because

1) Extensive root system.

2) Effective control on opening and closing of stomata.

3) Ability to recover rapidly after periods of water stress.

4) Ability to withstand desiccation.

5) Flexibility in frequency and depth of irrigation

6) Osmo-regulatory process

7) Blume formation.

1. Water Requirement :

For high production crop water requirement of sorghum is between 400 to 500 mm depending on the climate and duration of variety.

Irrigation Requirement :

Kharif Season : 150 to 200 mm

Rabi Season : 300 to 350 mm

Kc Values :

	Stage	Duration	Kc
1.	Initial stage	20	0.40
2.	Crop development stage	30	0.70 - 0.75
3.	Mid season stage	45	1.00 - 1.15
4.	Late season stage	25	0.75 - 0.80
5.	At harvest	-	0.50 - 0.55

Kc value throughout the growth period is 0.8

Allowable Soil Moisture Depletion of Sorghum is 55 to 60 percent of the total available water (P = 0.55 to 0.60)

Critical Stages :

There are four critical stages.

Table 1 : Critical stages.

	Critical stage	No. of days from sowing	Effect of water deficit.
1.	Seedling stage (Fig. 1)	25	Reduces the height of plant. Severe water defecit will cause no earhead.
2.	Flower primordia to flag leaf stage (Fig. 2)	35-45	Reduces the size of earhead.
3.	Flowering (Fig. 3)	55-65	Reduces the No. of grains per plant.
4.	Grain filling stage (Fig. 4)	70-85	Reduces the size of grains.

Water Uptake :

The total root depth of sorghum is about 1.5 m. However, effective root depth is 1.2 m.

Fig. 1 Seedling stage of Sorghum

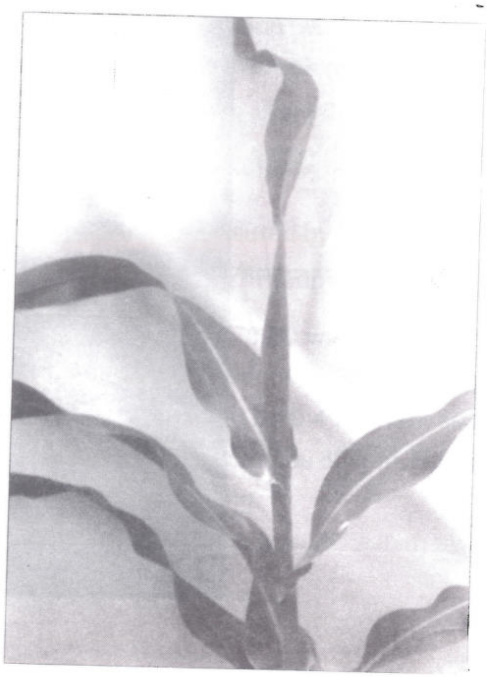

Fig. 2 Flag leaf stage of Sorghum

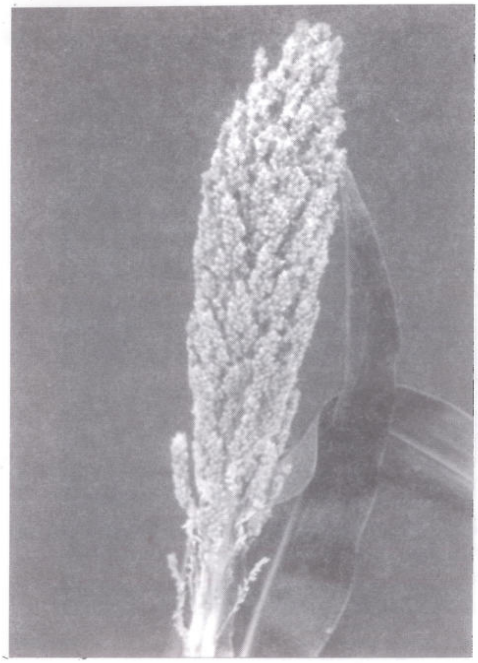

Fig. 3 Flowering stage in sorghum

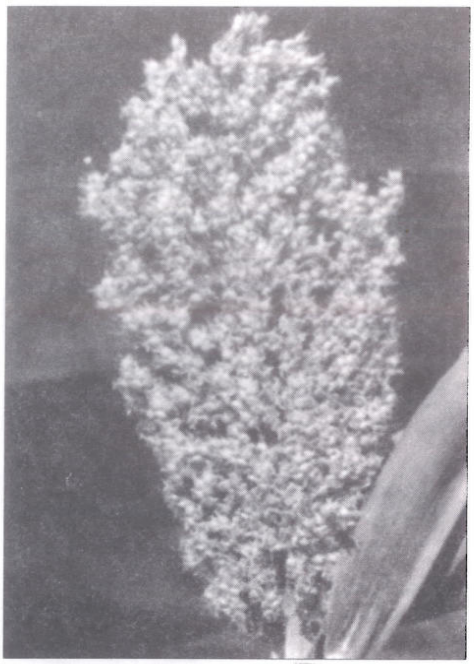

Fig. 4 Grain filling stage in sorghum

Scheduling of irrigation :

Various scheduling approaches have been studied such as soil moisture depletion, critical growth stage approach, climatological approach, integrated approach etc.

1) Soil moisture depletion approach :

At Rahuri the grain yield of sorghum was maximum when irrigation was applied at 50 percent depletion of available soil moisture (Magar et. al. 1984). Patil et. al. (1969) reported that irrigation at 25 per cent available water (75 per cent depletion) in heavy clay soils was adequate for sorghum sown in Kharif season whereas in summer, irrigation should be given at 50 percent available water. Depth of irrigation is depends on soil type.

ii) Critical growth stage approach :

In this method irrigation are scheduled at critical stage of crop growth. When grown on deep, medium to fine textured soil. Singh et. al. (1972) identified four critical stages in sorghum and he harvested maximum yield by irrigating at all the four stages. The critical stages are seedling (2-4 weeks), flower primordia (6 weeks), flowering (8-10 weeks) and grain filling stage (10-12 weeks). Singh et. al. (1972) observed that seedling and flowering stages were most critical in water demands. Depth of irrigation will depend on soil type. Rodge (1986) harvested maximum yield by supplying two irrigations one at primordia initiation and second at boot stage (Table 2)

iii) Climatological Approach

in this method evaporation is measured by USWB class A pan evaporimeter and IW/CPE ratio (irrigation water / cumulative pan evaporation) is suggested.

Out of several IW/CPE ratio tried, 0.60 was found to be optimum involving 3 irrigations (Magar et. al. 1984). The depth of irrigation was 80 mm. Rajput (1983) suggested that the IW/CPE ratio for irrigation scheduling should be 0.4 in kharif season whereas in summer the ratio should be 1.05. The depth of irrigation should be 80 mm. Rodge (1986) reported that the IW/CPE ratio should be 0.8 for irrigation scheduling.

Table 2 Grain yield of rabi sorghum as influenced by irrigation.

(Rodge, 1986)

	Treatment	Grain yield (kg/ha)			Pooled Mean
		1981-82	1982-83	1983-84	
1.	No irrigation	4171	2771	2543	3272
2.	One Irrigation at Primordia initiation	4371	3433	3398	3733
3.	One irrigation at boot	4688	3889	3001	3852
4.	Two irrigation at primordia initiation and boot	4826	4560	3715	4365
	CD at 5%	144	394	323	562

iv) Integrated Approach :

Irrigation scheduling is dependent on rate of water uptake and how much amount of water can be stored in crop root zone. The rate of water uptake depends on type of crop and climate whereas storage of water in crop root zone on type of soil (texture), depth of soil and rooting depth of crop. Therefore crop, climate and soil influence the irrigation scheduling. Hence data base of soil, climate and crop are considered for scheduling of irrigation. The interval and depth of irrigation is decided as below :

Interval :

$$I = \frac{AW \times D \times P}{ETc} + Ts$$

where,

I = Irrigation interval in days.

AW = Available water (mm/m)

D = Effective root depth (m)

P = Fraction of available water (Management Allowable depletion)

ETc = Crop Evapotranspiration (mm/day)

Ts = Time required from saturation to field capacity (days)

Depth :

Depth can be calculated as below :

$$dn = AW \times D \times P - (ER + Ge)$$

$$d = \frac{dn}{Ea}$$

dn = net depth (mm)

ER = Effective rainfall (mm)

Ge = Groundwater effective (mm)

d = Gross depth (mm)

Ea = application efficiency.

A Study to suggest a irrigation schedule under different situations of water availability in the command area of sina medium irrigation project where rabi jowar was a main crop was undertaken based on four years study a irrigation schedule was propared (Fig 4 A) Depending upon the availability number of irrigations and crop mix different Irrigation schdules are suggested.

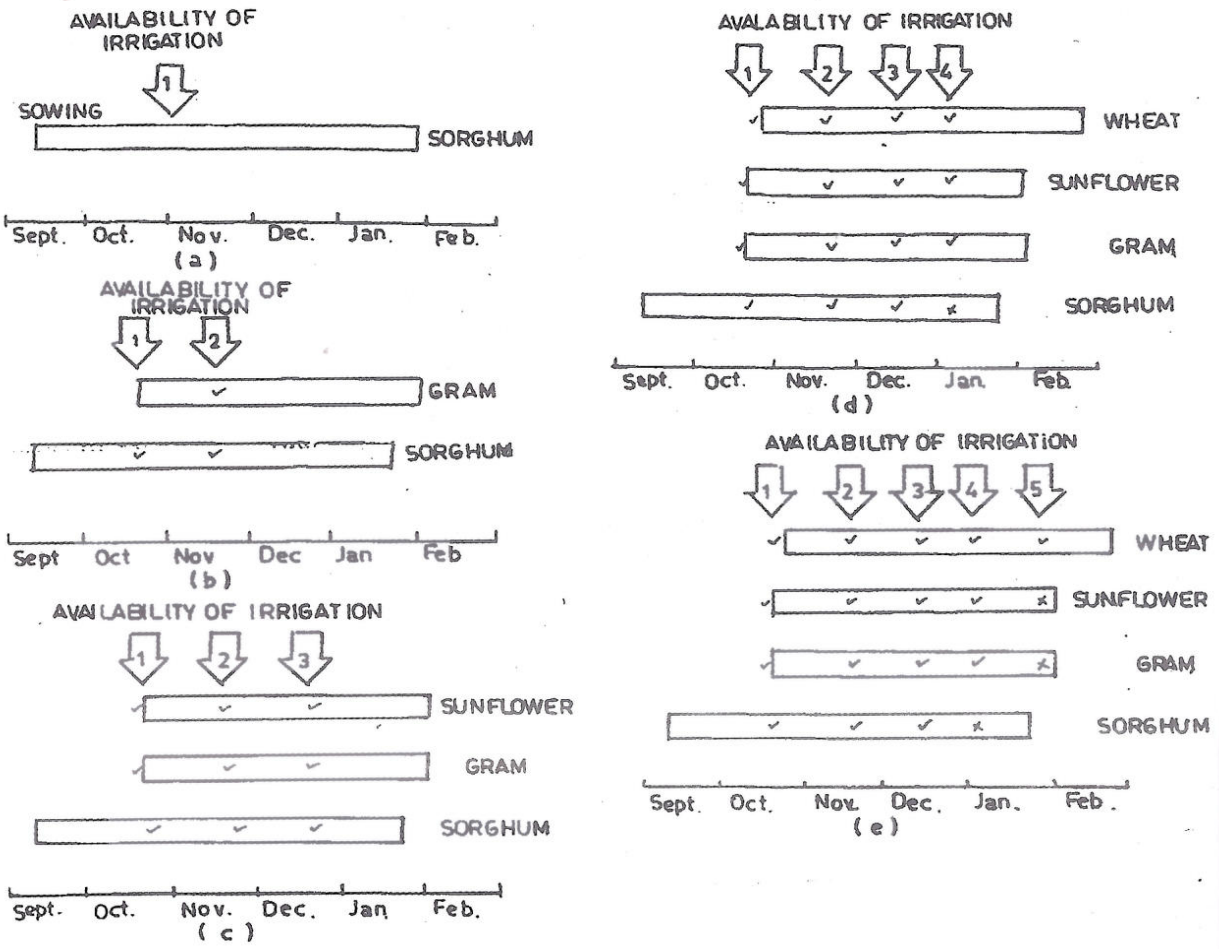

Fig. 4 A : Irrigation scheduling and crop planning

Method of irrigation :

Border(Fig. 5), Corrugated furrow, sprinkler (Fig. 6)

Table 3 : Grain yield of rabi sorghum hybrid as influenced by irrigation interval and depth

(Rodge, 1986)

Treatment	Grain yield Kg/ha			Pooled Mean	No. of irrigation
	1980-81	1981-82	1982-83		
Moisture Regimes :					
1. 0.40 IW/CPE	7143	5958	4844	5992	2
2. 0.60 IW/CPE	7730	6088	5726	6502	3
3. 0.80 IW/CPE	7722	6534	6267	6877	4
4. 1.00 IW/CPE	7442	6677	6511	6877	5
CD at 5%	NS	98	726	316	-
Depth of Irrigation :					
1. 60 mm	7641	6255	6001	6626	4
2. 80 mm	7378	6389	5674	6480	3
CD at 5%	NS	69	NS	NS	-

Table 4 Grain yield of Kharif sorghum hybrid as influenced by irrigation at Prabhani.

(Rodge, 1986)

	Irrigation Treatment	Grain yield (Kg/ha)
1.	No Irrigation	3662
2.	Irrigation at 0.4 IW/CPE (150 mm CPE)	4412
3.	Irrigation at 0.8 IW/CPE (75 mm CPE)	4543
	CD at 5%	614

Depth of irrigation = 60 mm.

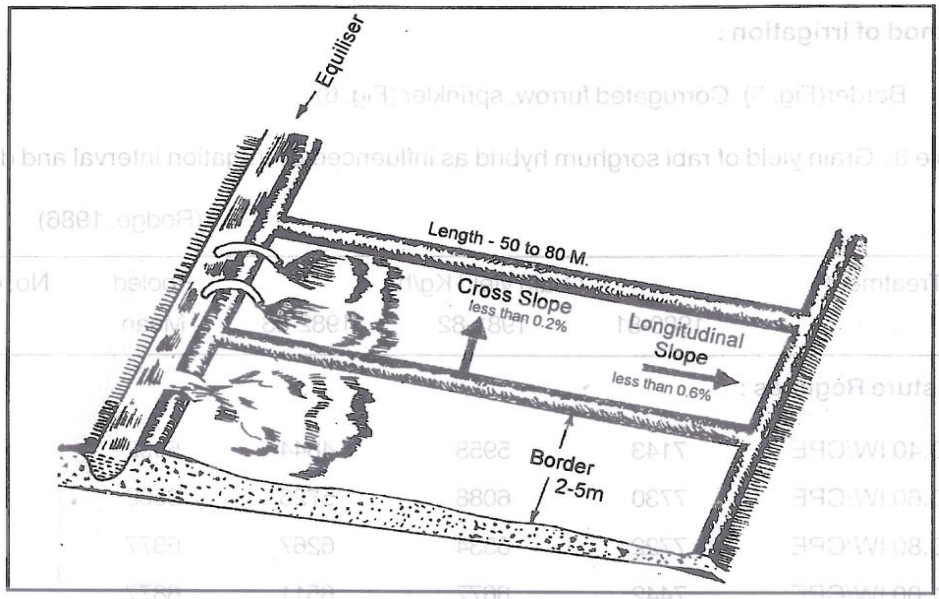

Fig 5 Border method of irrigation

Fig. 6 Sprinkler method of irrigation

Important pest and their control :

	Pest	Control
1.	Shoot fly :	Soil application of Carbofuron (3%G) @ 25 Kg/ha before sowing. Spraying of chloropyriphos (20EC) @ 1000 ml/500 lit of water.
2.	Stem borer :	Spraying of chloropyriphos (20EC) @ 1000 ml/500 lit of water.
3.	Midge fly :	Dusting of carbaryl (10% Dust) @ 20 - 25 Kg/ha.
4.	Grain smut :	Seed treatment of 300 mesh sulphur @ 3 gm/kg of seed.

Yield :

40 to 50 q/ha irrigated hybrid varieties, 30 to 35 q/ha irrigated high yielding improved varieties.

WHEAT

Wheat is the world's widely cultivated food grain crop. It is consumed in various forms by more than thousand million human beings in the world.

In India it is second important staple food crop, rice being the first. Besides staple food for human beings, wheat straw is good source of fodder for a large population of cattle in our country.

The length of total growing period of wheat in India ranges form 100 to 135 days. Temperature and day length are the key factors for variation in duration of this crop. Haward (1924) pointed out that wheat growing in India is a gamble with temperature. The wheat season in India shorter in the direction of north to south in correspondence with the duration of winter which decreases in the same direction. The yield per unit area and the area of the crop are lower in southern region than in the northern parts of the country.

Climate :

Wheat crop requires cool weather during the major portion of the growing period followed by dry warm weather to enable the grain to ripen properly. It has wide adaptability. It can successfully be grown in tropical and subtropical zones though temperate climate favours its production. Wheat can tolerate sever cold and snow and resume growth with the setting in of warm weather in spring. The optimum temperature (mean) for wheat is 14 to 25°C. The temperature above 25°C decreases grain weight. When the temperature is high, too much energy is required for transpiration and reduced residual energy results in poor grain formation and lower yield. Increase in temperature result in hastening maturity with poor yield.

Soil :

Soil with clay loam to loam texture having moderate water holding capacity are ideal for wheat cultivation. Heavy soils with good drainage are suitable for wheat cultivation under dry conditions. Soil should be neutral in its reaction. pH - 6.5 to 7.5.

Field Preparation :

Wheat requires a well- pulverised but compact seed bed for good and uniform germination. One ploughing and 2-3 harrowings are required. Land should be levelled and clean. Methyl parathion (2%DP) @ 25-40 Kg/ha or phorate (10 G) @ 10 Kg/ha should be used to control the termites and white grub. Border strips should be prepared before sowing.

Seed and sowing :

1. Time of sowing

1st November to 15 November for irrigated condition.

2. Seed rate and spacing :

Seed rate should be 100-125 kg/ha depending on seed size, germination percentage, tillering ability, moisture content, method of sowing. Spacing should be 20 to 22.5 cm between two rows. If sowing is delayed, closer spacing (15cm) should be adapted with higher seed rate.

3. Depth of sowing :

Less than 5.0 cm

4. Method of sowing :

Drilling by seed cum fertilizer drill is a good method of sowing.

5. Seed treatment :

Seed should be treated with Vitavex/Thirum or Agresan @ 2.5 g/kg seed.

Varieties : (For Maharashtra)

Irrigated area (For timely sowing)	:	HD (M) 2189, MACS - 2496, G-496, NIAW - 301 (Trimbak), HD - 2501, NIDW-295 (Godavari), NIAW-917 (Tapovan)
For late sowing	:	NIW - 34, HD (M) 2189, PBN - 142

Interculture Operations :

One or two hand weedings are required to control weeds. 2, 4-D weedicide is also useful for controlling broad leaved weeds.

Manures and Fertilizers :

100 to 120 kg N + 50 to 60 kg P_2O_5 + 40 to 50 kg K_2O/ha. Half dose of Nitrogen and full dose of P_2O_5 and K_2O should be given at the time of sowing and remaining half dose of nitrogen should be given 25 to 30 days after sowing.

About 10 tonnes of FYM per hectare should be mixed with the soil before sowing.

Rotation and Mixed Cropping :

Rotation should be as below :

Soybean	-	Wheat
Groundnut	-	Wheat
Jowar	-	Wheat
Maize	-	Wheat
Moong / Urd	-	Wheat
Paddy	-	Wheat
Sunflower	-	Wheat

Mixed cropping of wheat with mustard, is recommended.

Water Requirement :

Water requirement of wheat depends upon climate, variety and its duration. According to the research findings it is observed that the water requirement of wheat crop is ranging from 360 mm to 550 mm for good yield at various locations. Among the various factors, climate plays dominant role in deciding the crop water requirement.

Water supply and crop yield :

Several scientists (Sharma et. al. 1977; Agarwal 1977; Singh et. al. 1975 a; Singh et.. al. 1975 b; Patil and Bathkal 1975; Potdar and Pawar, 1979; Jana and Sen, 1978; Atar Singh 1979; Dastane et. al. 1971 and Garge and Saraswat 1972) have studied and identified the critical stage of wheat crop. The term critical stage is commonly used to define the stage of growth when plants are most sensitive to shortage of water and each crop has certain critical stages at which if there is shortage of water, Yield will reduce drastically. The identified critical stages of wheat crop are given below. (Table 5)

Table 5 : Critical stages of wheat and the effect of moisture stress.

Sr. No.	Critical stages	Days after Sowing	Effect of moisture stress
1.	Crown root initiation (CRI) (fig. 7)	20-25	Moisture stress reduces root growth and number of tillers, hasten maturity and reduces the yield.
2.	Tillering (T) (Fig. 8)	40-45	Reduces height of plant and number of effective tillers.
3.	Late Jointing (LT) (fig. 9)	55-60	Reduces length of spike and number of grains per spike and yield.
4.	Flowering (F)	70-80	Pollen formation and fertilization will be seriously affected.
5.	Milk stage (M) (Fig. 11)	90-100	Low moisture in soil reduces size of grains.
6.	Dough stage (D) (Fig. 12)	110-120	Reduces test weight poor quality and shrivelled grains.

Fig. 7 Crown root initiation stage in wheat

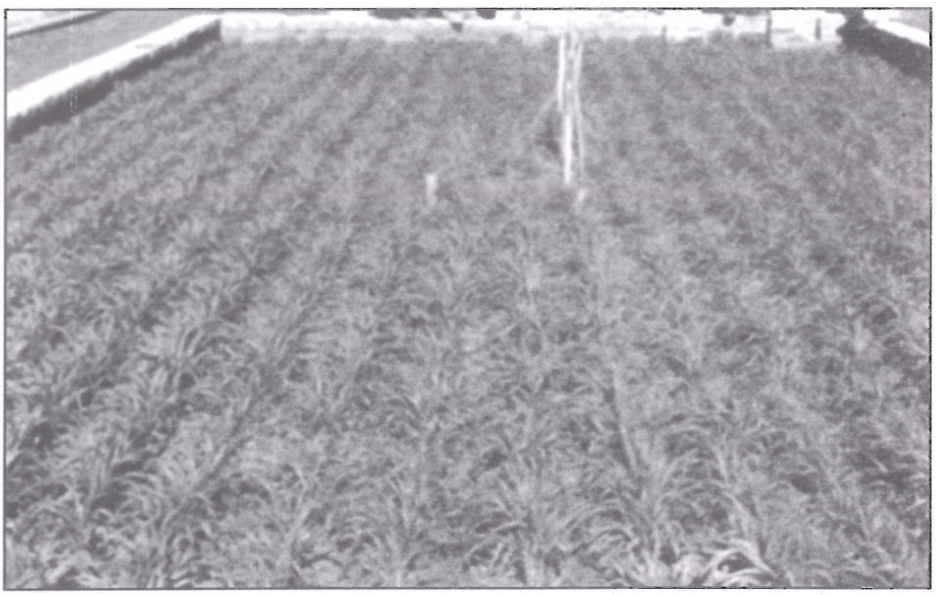

Fig. 8 Tillering stage in wheat

Fig. 9 Late jointing stage in wheat

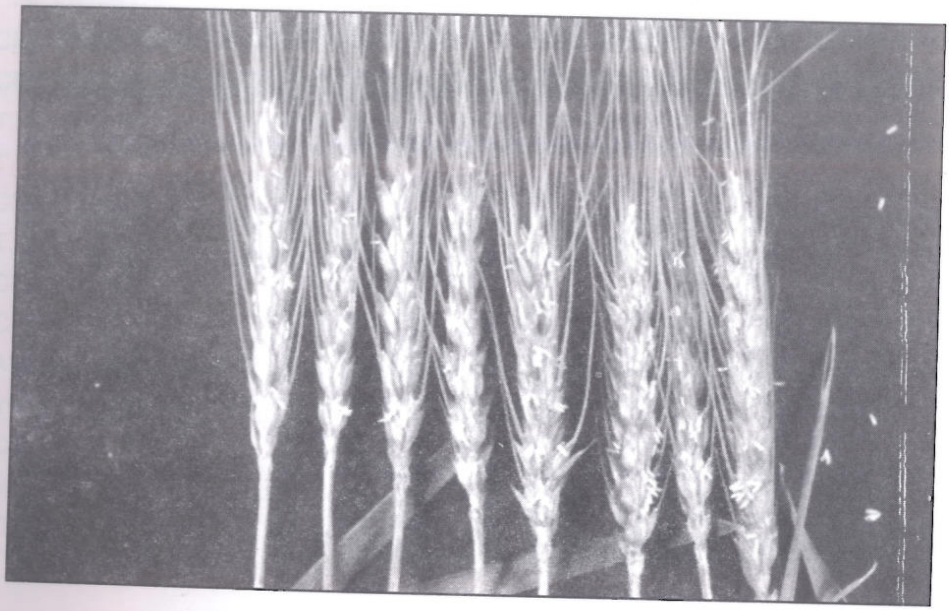

Fig. 10 Flowering stage in wheat

Fig. 11 Milk stage in wheat

Fig. 12 Dough Stage

Singh et. al. (1975 b) suggested that if only one irrigation is available, wheat crop should be irrigated at crown root initiation stage, if two irrigations are available, irrigation should be given at crown root initiation and late jointing stage, if three irrigations are available irrigate at crown root initiation, late jointing and flowering stage, If four irrigations are available, irrigate at crown root initiation, tillering, jointing and milk stage, if five irrigations are available, irrigate at crown root initiation, tillering., late jointing, flowering and milk stage and if six irrigations are available irrigate at all 6 critical stages, for maximum yield.

Singh et. al. (1975 a) after two years study at Nawabganj (Bareilly) obtained the yield of wheat by scheduling of irrigation by critical stage approach is given below (Table 6)

Table 6 : Critical stages of wheat and yield.

Critical stages	No. of irrigations	Yield obtained (q/ha)		
		1970-71	1971-72	Mean
Control	0	33.0	23.1	28.1
CRI (crown root initiation)	1	42.7	35.7	39.0
T (Tillering)	1	39.4	32.8	35.6
LJ (Late jointing)	1	33.7	23.6	28.7
F (Flowering)	1	36.1	26.9	31.5
CRI, LJ	2	41.5	33.5	37.5
CRI, F	2	45.4	33.2	39.3
CRI, M	2	46.9	36.4	41.7
T, F	2	42.4	33.6	38.0
T, M	2	43.0	34.6	38.8
CRI, T, M	3	44.1	32.8	38.2
T, F, D	3	42.7	33.8	38.3
CRI, T, F, M	4	47.8	38.3	43.1
CRI, T, LJ, M, D	5	46.0	37.9	42.0
All stages	6	46.0	37.7	41.6
Irrigation at 50% ASM		46.1	35.6	40.9
CD at 5%		3.8	3.1	-

M (Milk stage)
D (Dough Stage)

Readily available water ;

Readily available water is the portion of available water which the crop can use without affecting its evapotranspiration and the growth. This portion is often indicated as a fraction of available water (p) which is dependent primarily on the type of crop and evaporative demand. Readily available water equals soil water depletion.

As reported by Sondge et. al.(1980) the allowable soil water depletion of wheat crop is 50 percent (p=0.5) of available water (Table - 7)

Table - 7 : Allowable soil water depletion for wheat.

Soil moisture regime in ASM per cent	Fraction (p)	Yield obtained (q/ha)	Relative yield (%)
80	0.2	42.7	95.5
65	0.35	38.0	85.01
50	0.50	44.7	100
35	0.65	35.1	78.5

Scheduling of Irrigation :

1. Critical growth stage approach is good if soil is medium to fine texture and depth of soil is more than one meter. Six irrigations at 6 critical stages and 100 mm depth at each irrigation are required.

2. **Integrated approach :**

Interval and depth can be calculated as below :

$$I = \frac{AW \times D \times P}{ETC} + Ts$$

In medium to heavy soil (Available water 200 mm/m)

$$I = \frac{200 \times 0.9 \times 0.5}{5} + 2 = 20 \text{ days Interval}$$

dn (net depth) = 200 x 0.9 x 0.5 = 90 mm.

Number of irrigations will be 5 - 6.

In coarse textured soil (Available water 120 mm/m)

$$I = \frac{120 \times 0.9 \times 0.5}{5} + 1 = 12 \text{ days}$$

dn = 60 mm

Number of irrigations 6 - 8.

In shallow soils number of irrigations will be increased and net depth will be decreased.

In an experiment conducted at Mahatma Phule Krishi Vidyapeeth Rahuri from 1977 - 78 to 1979 - 80, maximum yield of 41.00 q/ha was obtained with 1.00 IW/CPE [Total five irrigations] The irrigations depth applied was 60 mm at each irrigation. Rodge [1986] suggested that IW/CPE ratio should be 1.2 for highest yield [Table 8]. Further he suggested that number of irrigations should be eight [Table 9].

Table 8 : Effect of irrigation treatments on grain yield and consumptive use if wheat.

[Rodge, 1986]

Treatment	Grain yield (q/ha)			Consumptive use (mm)	
	1979-80	1981 : 82	Pooled	1979 - 80	1981-82
IW/CPE VALUES :					
0.6	30.63	31.22	30.94	363	335
0.8	37.27	37.76	37.52	408	376
1.0	39.12	41.87	40.54	436	411
1.2	40.02	54.60	42.50	482	466
CD at 5%	2.21	3.04	1.87	-	-
Depth of Irrigation					
60 mm	38.62	41.46	40.05	460	426
80 mm	34.90	36.32	35.60	384	369
CD at 5%	1.56	2.20	1.25	-	-

Table 9 : Grain yield and consumptive use of wheat HD (M) 1593 as influenced by irrigation schedule.

Treatment	No. of Irrigation			Grain yield q/ha			Mean consumptive use (mm)
	1975 - 76	1976-77	mean	1975-76	1976-77	Mean	
IW/CPE ratio							
0.50	4	3	3.5	33.90	28.05	30.97	334
0.65	5	4	4.5	38.14	31.84	34.99	375
0.80	6	5	5.5	46.32	35.16	40.74	438
0.95	8	6	7.0	48.99	40.99	44.72	473
1.10	9	7	8.0	52.78	42.69	47.79	509
CD at 5%	-	-	-	4.28	3.39	3.70	-

Irrigation Method :

1. Border strip method (Fig. 12)
2. Sprinkler can be used

Use syphon tubes for efficient utilization of water (Fig. 13)

Important pest :

Pest	Control
1. Rust	1. Use rust - resistant varieties 2. Avoid late sowing 3. Avoid excess N application 4. Spraying zineb or Dithane M - 45 or Dithane Z - 78, 2 - 3 spraying from boot stage with 10 - 12 days interval.
2. Loose smut	Seed treatment, with vitavax 2.5 g/kg seed.

Yield :

35 to 40 q/ha under irrigation condition

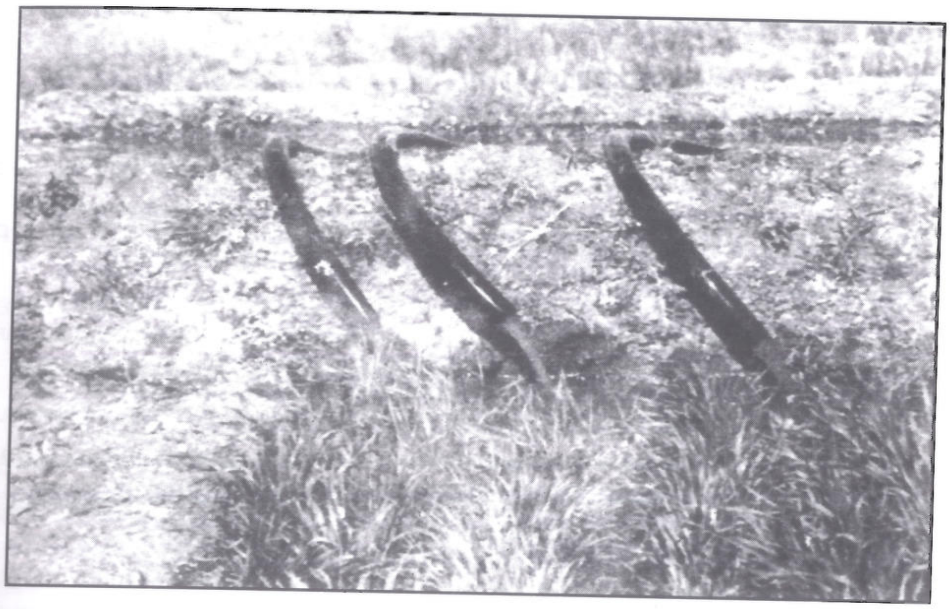

Fig. 13 Use of syphon tubes for irrigation

If syphon tubes are used in the border, the irrigation water will spread uniformely and also reduce the soil erosion. Such type of syphon tubes can also be used for furrow irrigation. The size of syphon tubes should be 40 - 50 mm in diameter and 1.5 to 2.0 m in length.

RICE

DISTRIBUTION OF RICE IN INDIA :-

I. **North Eastern Zone :-** Comprises state of Assam, W. Bengal, Orissa, Southern districts of Bihar i. e. basins of Bramhaputra, Ganga, and Mahanadi, Highest intensity of Rice cultivation in the Country.

II. **Southern Zone :-** Deltatic regions of Godavari, Krishna Kaveri & Tambropani rivers and rainfed areas of A.P.,Tamil Nadu & parts of Karnataka.

III. **West Coast Zone :-** Kerla, Coastal districts of Karnataka, Maharashtra & Gujrat States.

IV. **Central Zone :-** Madhya Pradeh, parts of Andhra Pradesh (Telangana) Eastern parts of Maharashtra & Gujrat States.

V. **Northern Zone :** North Bihar, Uttar Pradesh, Punjab, Himachal Pradesh, Jammu & Kashmir & Haryana.
In Maharashtra State :- Coastal district i.e.Thane, Raigad, Ratnagiri, Sindhudurga, Chandrapur, Bhandara, Gondia, Gadchiroli, eastern parts of Nagpur, Nasik, Nanded & Osmanabad.

CLIMATIC REQUIREMENT:

1. **Water :-** Requires adequate water. 53% more yields under flooded conditions, Rainfall decides the distribution of crop.

2. **Temperature :-** Crop of sub-tropics & tropics. Average temperature of 20° C to 38° c, suitable. Below 15°c retards growth & development of plant. Below 10°C limits the germination. Above 38°C detrimental to plant growth.

3. **Solar Radiation :-** Pronounced effect on growth and yield. Amount of Sunlight a plant receives depends on solar radiation, intensity, day length and cloud cover. Yields during H.W. are always higher than yields in wet seaon.

4. **Humidity :-** High humidic conditions favours the Growth. (Av. 70 to 90 percent).

5. Under flooded conditions Aerenchyma in roots linked through aerenchymatic tissues o leaves & steam. Through Aerenchyma of leaves O_2 is transferred from Ambien atmosphere to roots known as "Plant Aeration".

SOIL :- Rice is grown best on Loam to Clay-loam soils. Soil-depth - 40 to 50cm. Rice is tolerant to salinity- Optimlim PH- 5.5 to 7.5 soils should have percolation rate less than 10 mm/day (D = 0.35m.).

RICE CULTIVATION :-

NURSARY :- Raised beds. (1.20 L. x 5.0 B. X 0.15 H.m) For transplanting one hectare area nursery on 0.10 ha. should be prepared. (Fig. 14)

TRANSPLANTING :- Seedings on 6th leaf stage i.e. 21, 25 and 30 days after sowing for early, middle & late varieties respectively.

Transplanting at 20 x 15 cm. or 15 x 15 cm. 2 to 3 seedlings/hill, straight and shallow. Plant population 3,33,333, /ha.

SEED RATE :- 35 To 45 Kg/ha.

SEED TREATMENT :- 3% Brine solution, followed by Thirum or Emison @ 2 gms. /kg of seed.

PUDDLING :- Before puddling mix about 10 tonnes/ha of F.Y.M. or Green manure (Sunnhemp or Glyricidia). Then puddle the field for 2-3 days. (Fig. 15)

1. Puddling creates impervious layer by decreasing Macro-porosity & increasing Microporosity thereby reduces percolation rate-better moistue conservation.
2. Creates favourable physical, chemical and hydraulic environment in Rhizoshpere.
3. Facilitates transplanting - Rapid root penetration / seeding establishment at new place.
4. Thorough mixing of organic manures.
5. Reduces weed population.
6. Puddling often accompanies sumbergence of water, which increases availability of nutrients particularly N, P, K, Ca, Si, & Fe (Poonnam), 1972). In porous soil structure nutrients will leach away.

Water Requirement of puddling :

1. Initial moisture content of soil	.....	20%
2. Moisture content of soil on saturation	.....	48%
3. Bulk density of soil	.....	1.37 g/cm3
4. Depth of puddling	.....	30 cm.
5. Deep percolation losses during puddling @ 7.0 mm/day (3 days)	.....	21.0 mm
6. Standing water above soil surface	.....	7.5 cm.

SOLUTION :-

1. Water reequired for saturation of soil -

$$= \frac{48 - 20 \times 1.37}{100} = 0.38 \text{ cm / cm of soil depth}$$

2. Water required for 30 cm. dept = 0.38 x 30 = 11.40 cm.

3. Add deep percolation loses & standing water

= 11.40 + 2.1 x 7.5 = 21.0 cm.
say 210 mm.

FERTILIZER :-

100 kg N + 50 kg. $P_2 O_5$ + 50 kg K_2O/ha.

1. **First dose :-** 40 kg N+ 50 kg $P_2 0_5$ +x 50 kg K_2O/ha at puddling.

2. Second dose :- 40 kg N/ha at 25 days after transplanting.

3. Third dose :- 20 kg N/ha before flowering. (Fig. 16)

Water Requirement :- Upland Rice is grown in assured rainfall zone (up to 1000 mm.) Sowing by drilling method. Rice field is kept at field capacity to saturation.

Under lowland, crop is kept under submergence. Depending on climate, soil and duration of variety, total W.R. of rice ranges from 1500 to 2000 mm.

Table - 10 - Components of W.R. of lowland Rice:

Sr. No	Particulars	W.R.(mm)
1.	Actual ETc in field	400 to 700
2.	Nursery (ETc)	50 to 80
3.	Puddling requirement	200 to 300
4.	Maintaining water above soil surface	150 to 200
5.	Deep percolation losses	700 to 800
	Total :	1500 to 2080

Considerable amount of water in lowland Rice is lost through deep percolation. Hence it must be considered for deciding total W.R. of crop.

Dastane & Vamdevan (1968) observed that out of 1680 mm water about 1200 mm (about 72%) water was lost through deep percolation and 480 mm. was used consumptively.

Yadav (1972) at Sirugappa also observed 62% loss of water in kharif season. However, these losses were 52% during summer due to increased ET.

Table :- 11 Evapo-transpiration in flooded Rice at Tirupati, Ram Reddy (1983) :

Sr. No.	Component	Summer Season		Rainy season	
		Daily (mm)	Total (mm)	Daily (mm)	Total (mm)
1.	Evaporation	3.0	279.0	2.13	210.7
2.	Transpiration	6.0	554.0	4.37	433.0
3.	Total	9.0	883.0	6.50	643.7

Duration of variety, 95 to 100 days.

Table 12 :- Growth stages of Rice Crop.

Sr. No.	Growth stages		Days after sowing	Kc values
1.	Seedling in nursery	Vegetative	0-21	0.85
2	Tillering		21-45	1.0
3	Stem elongation & primordia initiation		45-60	1.15
4.	Panicle initiation	Reproductive	60-70	1.30
5.	Panicle development		70-80	1.30
6.	Flowering		80.90	1.30
7.	Grain development & milk grain.	Ripening	90-100	1.25
8.	Dough grain		110-118	1.10
9.	Mature grain		118-125	0.9

Table 13 : Effect of water shortage on Rice yield on loamy soil (Dastane, 1970)

Sr. No.	Period of water shortage (days after transplasting)	Growth stages	Rice yield	
			q/ha	Relative%
1.	Control (no water shortage)	Throghout	70.2	100
2.	0-20	Tiller initiation	58.9	84
3.	20-40	Maximum tillering	67.2	96
4.	40-60	Primordia growth to flowering	58.9	84
5.	60-80	Late flowering to grain formation.	63.6	91
6.	80-100	Grain maturity	68.1	96
			CD @ 5%	2.85

Water Management in Rice :

1. Efficient management of irrigation water results in higher yields with less water.
2. Water control is essential if crop is to be provided adequate water as needed.
3. Yield is seriously affected if water supply is inadequate especially at earhead and flowering stages.
4. Yamada (1965) reported that submergence benefits rice crop by providing nutrients, fresh clay particles, O.M. which enriches the soil with Nitrogen, increases availability of Phosphorus, Iron & Manganese and control of weeds.
5. Successful paddy cultivation depends on impounding rice fields adequately during greater part of vegetative growth period of crop.

Water requirement of Rice depend on --

a. Manuring - Lowers the W.R.(F.Y.M./G.M.) Paddy plant under submergence take no more water than dryland crop. But submerged conditions provide silica- Not in dry soil.

b. Main factors influencing W.R. are field evaporation seepage, percolation, land preparation, climate, length of irrigation Period, soil type, ground water table, planting method.

Poorly constructed bunds will increase W.R. through seepage - wastage of water.

DEPTH OF WATER :

Deep flooding affects development of plant, reduces no. of tillers, panicles & yield is adversely affected.

If crop is subjected to deep water, seedlings will be closely planted & No. of seedlings per hill be increased.

IRRI (1967) reported high yields & high W.U.E. with continuous flow of shallow water depth of 2.5 cm, in clay soil.

Matsushima (1982) suggested that shallow water depth results in higher temp. by day and lower temp. by night, which encourages more tillering.

Extreme of Diurnal temp. promotes more dry matter accumulation & this may well contribute to the advantages of shallow water.

Shallow water also favours decomposition of O.M. in soil resulting better root development of plants.

In California Mikkelsen (1963) reported that Japonica varieties grown under continuous shallow flooding produced better vegetative growth and 50% more grain yield compared to intermittently irrigated conditions.

IWM under adequate availability of water :

1. Transplanting is done at shallow water level (2-3 cm.)
2. Maintain 3-5 cm. depth of water from 5th -8th days after transplanting (Rootings)
3. From 8th day after transplanting to 40-45th day shallow water level (2-3 cm) be maintained (tillering stage) (Fig. 17)
4. From 45th to 50th day drained out the field completely for 3 to 5 days, as per soil type.
5. Water is kept ponded to a depth of 7-10 cm. during 55 to 70 days. (Panicle initiation stage)
6. Similarly, during 80 to 90 days 7-10 cm. depth be maintained. (Flowering to grain filling).
7. From 90 days onwards water depth should be reduced gradually to 5-3 cm. till the physiological maturity of grain.
8. Water is drained out completely 10-15 days before harvesting to facilitate even ripening of grains (of late tillers) and harvesting.

Drainage Needs in Rice Field

Small quantities of water given at frequent intervals are more conducive to high yields. However, under static water or prolonged submergence it is essential to drain the rice fields atleast 2 to 3 times during the crop growth period.

It has been observed that a shallow continuous flow of water over the fields gives better yields than static water on the field & changed at some intervals. But it increases water consumption.

As water consumption increases, yields also incease but on diminishing scale. Irrigation

implies not only adequate and controlled water supply, but also efficient drainage of excess water whenever desirable.

Deep & prolonged submergence has adverse effect on growth & yield. Continuous inundation depletes free & combined oxygen from sub soil and leads to accumulation of various organic acids, formation of toxic substances like sulfides (H_2S) & methane (CH4) under reduced condition in rootzone.

This inhibits nutrient absorption and normal aerobic respiration, retards root development and cause root rot. Stagnant water may lead rise in water table (water logging), which brings toxic salts to surface as so often happens, it must have detrimental effect on paddy growth.

Hence at many places (flat terrain) it is essential to drain the paddy lands atleast 2 to 3 times during crop growth period to remove toxic material and supply of oxygen to root system.

Rice fields may be drained out during later stage of tillering - when reduction increases and another at late flowering stage for 3-5 days.

Table 14 : Effect of different depths & drainage on rice yield in Rabi season at Cuttack (q/ha.)

Depth of Drainage	Drainage once during growth	Twice during growth period	Mean grain yield (q/ha)
0 cm	55.5	59.9	57.7
25 cm	59.4	62.2	60.8
30 cm	62.6	63.2	62.9
45 cm	67.9	68.3	68.1

Table 15 : Effect of Water Management Practices on yield and nutrient uptake in dry seaso

Rice

Sr. No.	Treatment	Grain yield (t/ha)	Total W.R. (mm)	Nutrient uptake (kg/ha)			W.U.E.
				N	P	K	
T1	7cm. Irrig. One day after disappearance of ponded water.	4.11	1220	85.51	45.28	130.6	33.7
T2	7cm. Irrig. Two days after disappearance of water.	3.85	1092	78.58	39.68	120.21	35.2
T3	7cm Irrig. Four day after disappeance of ponded water.	3.60	937	73.56	37.57	112.76	38.5
T4	Submergence 5 cm. at tillering (20-45 DAT) + rest as T-1	3.84	1349	80.31	41.88	125.36	28.5
T5	Submergence of 5+2 cm. at Reproductive stage (panicle initiation)	4.23	1409	96.39	49.13	146.80	30.1
T6	Submergence of 5+ cm. at tillering & Reproductive stages plus rest as T-1.	4.30	1549	99.27	50.68	152.55	27.8

dry season

W.U.E.
33.7
35.2
38.5
28.5
30.1
27.8

Table 16 : Grain yield and weed biomass production as influenced by water regimes

(M- Nageswar Reddy & Raju, K.A. 1987)

Sr. No.	Treatments	Grain yield (q/ha)	Weed Biomass (g/m2)
1.	Continuous saturation	42.8	43.1
2.	Continuous flooding (3 to 5 cm. depth	55.1	22.7
3.	Flooding (5cm.) 1 day after diappearance.	53.1	25.2
4.	Flooding (5 cm.) 2 days after diappearance.	50.6	28.5
5.	Flooding (5 cm.) 3 days after diappearance.	45.6	31.0
6.	Flooding (5 cm.) 4 days after diappearance.	41.0	34.6
7.	Flooding (5 cm.) 5 days after diappearance.	33.6	37.8
	C.D. at 5%	7.4	16.4

BROAD CONCLUSIONS

1. Submergence has direct effect on development of plant characteristics and crop yield.
2. Percolation plays major role in deciding crop water requirement of paddy.
3. Measures like land levelling, selection of proper soils, thorough puddling, addition of organic manures, compacting etc. should be taken to reduce the percolation losses.
4. Drain out the paddy fields twice during the growth period (especially fields at flat topography).
5. Intermittent submergence during initial tillering, primordia and flowering stages and maintenance of saturation to field capacity at rest of the stages gives better yields of rice (kharif).
6. Continuous shallow submergence (3 to 5 cm) throughout saves 30-40 percent water. It is possible when water supply is adequate and assured.

Table 17 : Recommended varities of paddy.

	For konkan region		For Vidarbha region
I.	**Early varieties (90 to 115 days)**		**Early varieties (90 to 115 days)**
1.	Ratnagiri - 73	1.	Ratna
2.	Ratnagiri - 24	2.	Sakoli -6
3.	Karjat -184	3.	Sindewahi-1
4.	Ratnagiri -1	4.	Tel Hansa
5.	Ratna	5.	Kalinga-1
6.	Karjat-1	6.	Kalinga-2
7.	Karjat- 3	7.	HMT sona
8.	Karjat- 4		
9.	Phondaghat-1		
10.	Ratnagiri - 771		
II.	**Midlate Varieties (120-135 days)**		**Midlate Varieties (120-135 days)**
11.	Palghar - 1	8.	Jaya
12.	Jaya	9.	Sindewahi-75
13.	Vikram	10.	Safed luchai
14.	RP-4-14	11.	RF-4-14
15.	Karjat - 5	12.	Sahyadri - 1, 2 (Hybrid)
16.	Karjat - 6		
17.	PHB - 71 (Hybrid)		
III.	**Late varieties (140-155 days)**		**Late varieties (140-155 days)**
18.	Ratnagiri - 3	13.	Pankaj
19.	Karjat 14-7	14.	Sindewahi - 5
20.	Sahyadri (Hybrid)	15.	Sakoli-7 (Scented)
21.	Ratnagiri-68		

For Western Maharashtra

1. Phule Maval
2. Ambemohar - 157
3. Indrayani
4. Kundalika
5. Basumati - 370
6. Jaya
7. Phule Samrudhi

Pest :

Table 18 : Insect pest and diseases on paddy, Their symptoms and control measures :

Pests and diseases	Symptoms	Control measures
Stemborer	Larvae bore and feed inside the stem	i) Destroy stubbles of previous crop.(2) Use 25 kg. 3% carbophuron per hectare at 20 days interval.
Swarming caterpillar	Larvae appear in big swarms and eat young plants, cause complete defoliation.	ii) Dust 20 kg. 2 per cent Methyl Parathion per hectare if caterpillars are fully grown, spary Nuvacron 40 EC @ 12.5 ml in 10 litre water.
Paddy gall Fly.	Maggtots attack at growing points & tillers are tranformed into tabular galls, resembling the leaf of onion.	i) Burn grass and wild rice. ii) Use 10 Kg. (10 percent) Thimet granules per ha. in 3-4 cm standing water in the field at 20 and 50 days after transplanting iii) Remove affected plants.
Blast	Brown spots on leaves, spots on stem, rotting of neck and dropping of ears, affected grains partially filled.	i) Treat the seed with Ceresan, or Agresan before sowing at the rate of 2 gm per kg of seed. ii) Spray the crop with 2 kg zineb in 1500 litres of water at an interval of 10 to 12 days.

Yield :

A well managed crop of Mid Late duration varieties. like Jaya, IR-8, IR-20 etc., yields about 60 to 70 quintals grain per hechare, short duration varieties yield about 45 to 55 q/ha. (Fig. 18)

Fig. 14 Nursery

Fig. 15 Puddling

Fig. 16 Fertilizer Application

Fig. 17 Shallow submergence during tillering stage

Fig. 18 : Paddy at Harvesting Stage

GROUNDNUT

Among the oilseed crops, groundnut has first place in India , which accounts to more than 40% area and 60% production in the country. Groundnut oil is primarily used as edible oil and in manufacture of vegetable oil. Groundnut seed contains about 45% oil and 26% protein. The oilcake obtained after the extraction of the oil is a valuable organic manure and animal feed. It contains 7-8% N. 15.% P_2O_5 and 1.5% K_2O. It is a good rotational crop and efficient cover crop for land exposed to soil erosion.

Climate :

Groundnut is a tropical crop. It requires a long and warm growing season. The most favourable climatic conditions for groundnut are a well distributed 500-700 mm rainfall, abundance sunshine and relatively warm temperature. It grows well in a mean temperature range of 22 to 28°C. Germination is delayed at temperature below 20 C. It is a day-neutral crop.

Soil :

Groundnut thrives best in well drained, loose, friable sandy loam soils, as light textured soil helps in easy penetration of pegs and development of pods, and also harvesting. Clayey or heavy texture soils are not suitable for this crop as they interfere in penetration of pegs and make harvesting quite difficult. Groundnut gives good yields in the soil with PH between 6.0 - 8.0 The crop is moderately sensitive to salinity.

Varieties :

There are three types of varieties in groundnut, viz; bunch with erect plant habit, spreading and semi-spreading. Its growing period is 85 to 145 days.

I. Bunch type :

1) JL-24 (Phule pragati) : Duration 85 days, test weight 45 g. yield 18-23 q/ha, oil 50.7%, shelling 72% grown in kharif.

2) SB-XI: Duration 105-115 days, 49% oil, 12-15 q/ha yield, 76% shelling grown in kharif and summer.

3) TAG-24

4) TG-26

5) JL-220 (Phule Vyas)

6) Phule unap (JL 286)

7) TPG - 41

II. Spreading type :

1) Karad 4-11 : Spreading veriety matures in 145 days, recommended for rainfed, 41% 66% shelling, 20-25 q/ha yield.

2) M-13: Duration 130-135 days, 25 q/ha yield, grown in kharif and summer.

3) U.F. 70103: Duration 130-135 days, 25 q/ha yield recommended for summer seasor

III. Semi-spreading :

1) ICGS-76 : Semi-spreading matures in 125 days, 48% oil, 66% shelling, 15-20 q/ha yie

2) TMV-10: Duration 125 days, 20-22 q/ha yield, for kharif and summer.

3) T.G.17: Recommended in summer, duration 125 days, yield 20-22 q/ha.

4) Konkangourav : Recommended in summer for Konkan region.

For ICRISAT method: FDRS-4 and FDRS-10 in kharif and ICGS-11 and ICGS-44 for l weather season are suggested.

Field Preparation :

One light ploughing followed by two harrowings would be sufficient to achieve a go surface tilth upto 12-18 cm depth. Border strips should be prepared. Remove the stubbles previous crop and keep the field clean. Use heptaclor or chlorodane 5%, 50 kg per hectare control white grub and white ants. Borders should be prepared. For ICRISAT method broad b furrow with 150 cm spacing is suggested.

Seed and Sowing :

Seed treatment : Seed should be treated with 5 g of Thirum, or 2.5 g Captan or Ceres per kg seed to check various seed borne, and soil borne diseases. Seed should be innoculat with proper strain of Rhizobium culture.

Time of sowing :

This crop is grown in three seasons in Maharashtra, in kharif, it should be sown betwe 15 June to 15th July and in summer it should be sown from 15th January to 15th February. Konkan area groundnut is also cultivated in rabi season and is sown between 15th November 31 st December.

Spacing :

Bunch or erect	.....	30 x 10 cm
Semi - Spreading	.....	30 x 15 cm
Spreading	.....	45 x 15 cm

Seed rate :

Bunch or erect	.....	100 kg/ha
Semi - Spreading	.....	80-100 kg/ha
Spreading	.....	80 kg /ha

Depth of sowing :

4 - 5 cm deep.

Method of sowing :

i) Drilling

ii) Dibbling.

Manures and Fertilizers :

Being a legume, groundnut can fix nitrogen from the air, treatment of Rhizobium culture will increase the yield. The total requirement of manures and fertilizers are as follows:

Manures		7.5	–	10	tons/ha.	
N	-	20	–	40	kg./ha	through Ammonium sulphate or Urea.
P_2O_5	-	50	–	80	kg/ha	through Super phosphate
K2O	-	30	–	40	kg/ha	through Muriate of potash

The above manures and fertilizers should be applied at the time of sowing. Fertilizers should be applied by drilling method. Zinc (10 kg/ha) and boron 0.5 kg/ha) should be applied according to need. Gypsum should be applied to Hot weather crop @ 250 Kg/ha after 25-30 days after sowing.

Intercultural Operation :

Normally one or two hand weeding or hoeings are required First at 3rd week from sowing and second at 3 weeks after first weeding i.e. before flowering. Earthing up should be carried out before pegging.

Soil should not be disturbed at pod formation stage.

Weeds can be controlled by TOK E-25 @ 4 Lit / 600 Lit. water as pre-emegence or basalin 1 kg a. i. per ha dissolved in 800 / 1000 Lit. water.

Earthing up is essential to promote easy penetration of pegs. It is reported that drum rolling at peg formation increases the yield due to more number of peg penetration.

Crop rotation :

This crop is grown in rotation with cotton, jowar, wheat, bajra maize etc.

Mixed cropping :

It is grown as mixed crop with cotton, tur, jowar, bajra, sugarcane etc.

Water Management :

The water requirement of groundnut crop depends on climate, season, and the duration of variety. Doorenbos and Kassam (1979) reported that the water requirement (ETc) ranges from 500-700 mm for the total growing period. In summer it increases upto 900 mm. Daily evapotranspiration of kharif groundnut was measured by weighing type lysimeters at Rahuri and it was reported that the ET was between 355 to 412 mm in three years (1981-83) In summer the consumptive use was 650-960 mm by soil moisture depletion method at Parbhani (Bharambe and Varade, 1982; Shinde and Pawar 1984). In rabi ET was 608 to 693 mm at Chiplima (orissa) calculated by lysimeter (Rajput 1981-83).

Table 19 : Evapotranspiration/Consumptive use (mm) of groundnut in different season.

Season	ET/Cu (mm)
Kariff	355 to 412
Rabi	608 to 693
Summer	650 to 960

The water requirement of long duration spreading varieties is more as compared. to short duration varieties.

Water supply and crop yield :

For maximum yield adequate moisture is required. Low moisture causes reduction in yield of pods. There are four critical stages in groundnut. If the soil moisture is low at critical

stages there will be drastic reduction in yield (Table 20)

Excessive soil moisture is also harmful because lack of oxygen in the soil limits the activities of the N fixing bacteria. This is noted by unhealthy growth and yellowing of leaves.

Allowable soil moisture depletion :

Readily available water is the portion of total available water at which the crop can use without affecting its evapotranspiration and growth which is indicated by fraction (P)

Table 20 : Critical growth stages of groundnut.

	Stage	Days after sowing	Effect of moisture stress
1.	Seedling stage (Fig 19)	20-25	Reduces number of branches and delayed flowering.
2.	Flowering (Fig 20)	30-45	Severe moisture deficit causes flower drop and reduces no. of pods.
3.	Pegging (Fig 21)	50-55	Reduces the number of pods, Peg penetration becomes difficult.
4.	Pod formation (Fig 22)	65-85	Reduces pod size and test weight.

Readily available water is equal to allowable soil water. The allowable soil water depletion in groundnut is 0.4 (40%).

Root growth and moisture extraction :

It is observed that roots of groundnut can penetrate deep upto 80 cm (D = 0.8m) in soil and can extract moisture and nutrient from deeper soil layer. The rooting depth, and root weight is given.

The crop has well developed tap root with many laterals. Normally 80% water they extract from first half of the effective root depth and remaining 20% from lower half of the effective root depth.

Irrigation scheduling :

In summer season the interval should be 11 days and at each irrigation the gross depth should be 90 mm. The total number of irrigation should be 8 (Table-21) for medium textured deep soil (Bharambe and Varade 1982).

Table 21 : Irrigation scheduling in summer groundnut.

Interval of irrigation(days)	Depth of irrigation (mm)	No.of irri-gations.	Yield obtained (q/ha)
18	140	5	35.41
15	115	6	42.70
11	90	8	75.20
9	70	10	56.45
5	50	14	37.70

On coarse textured soil interval should be reduced. Number of irrigation should be increased and the depth should be decreased.

In kharif the number of irrigations should be reduced according to rainfall. Dhonde et. al. (1985) suggested that the number of irrigations should be 5 and depth should be 65 mm, on medium textured soil. The experiment was conducted at Bilaspur and it was observed that four irrigations at four critical stages were sufficient to harvest maximum yield in the kharif season.

It is suggested that the IW/CPE ratio should be 0.95 for scheduling of irrigation CPRMW 1981-83. The depth should be 50 mm. IW/CPE ratio is suggested as 1.25 at Parbhani in summe season (Table 22) and the depth should be 60 mm. Irrigation scheduling can also be done o the basis of soil moisture depletion method and it is suggested that irrigation should be applie when soil moisture is depleted upto 40%. Rodge (1986) suggested that the CPE should be 12 mm in summer for irrigation scheduling.

Studies in Irrigation scheduling based on soil crop climate data for hot weather groundnu grown on large area in Jayakwadi project command was undertaken based on these studies, th suitable irrigation intervals were suggested in project command under different sowing datas an duration of Varieties (Fig. 19 A) (Musande & Plaskar 1997)

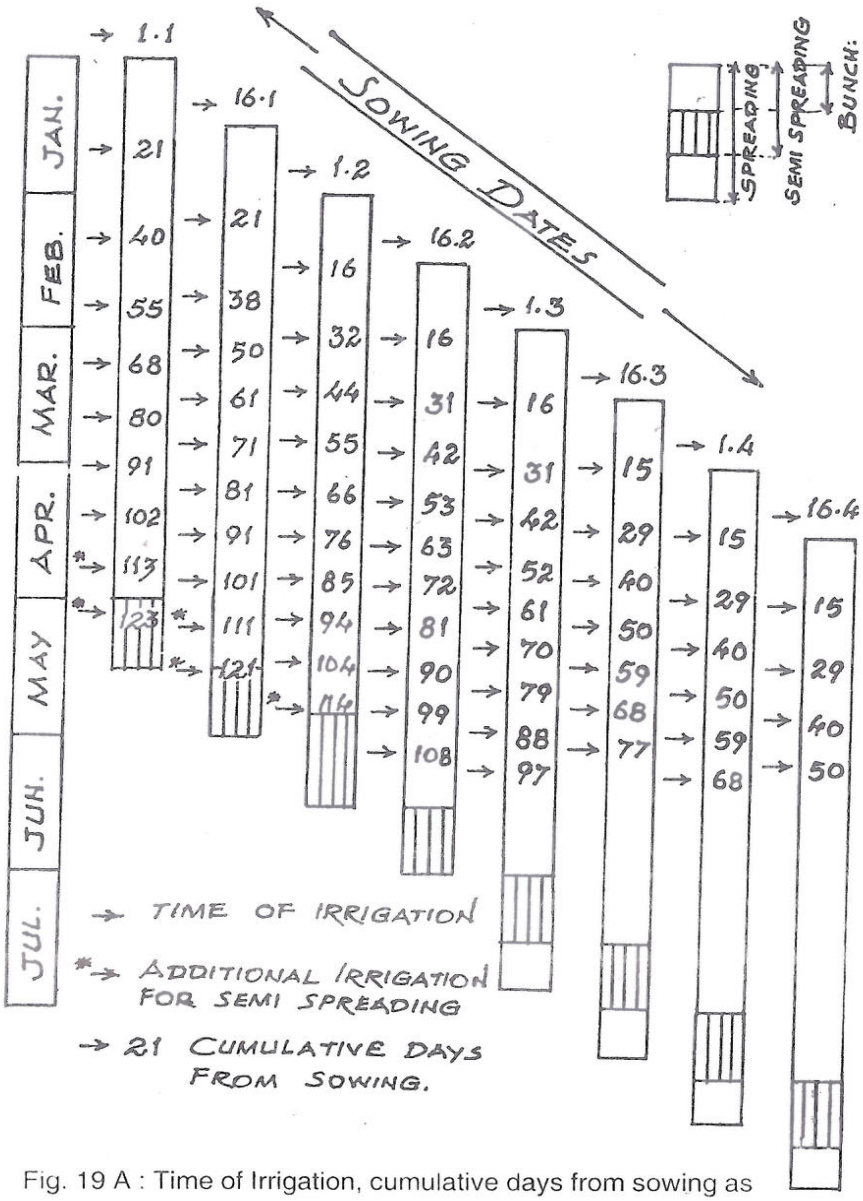

Fig. 19 A : Time of Irrigation, cumulative days from sowing as influenced by sowing dates and varieties of HW Groundnut.

Method of Irrigation :

Irrigation method for groundnut should be border strip (Fig.23) or broad bed furrow or sprinkler. It is reported that the yield of groundnut pods was increased by 36.9% by sprinkler method as compared to border. Further the water saving was upto 22.9% (Table 23).

Fig. 19 : Seedling stage in groundnut

Fig. 20 : Flowering stage in groundnut

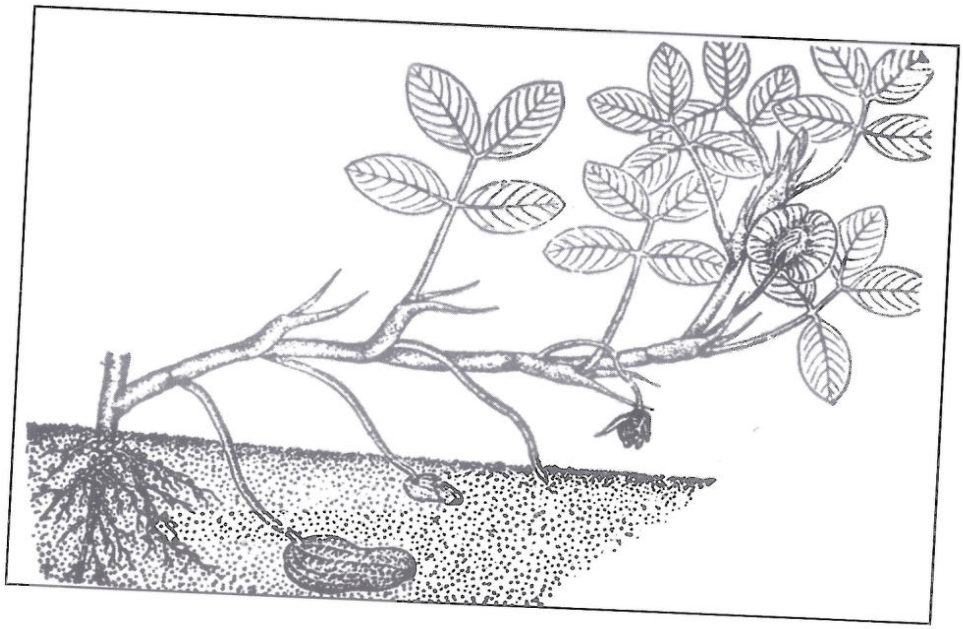

Fig.21 : Pegging stage in groundnut

Fig. 22 : Pod formation stage in groundnut

Table 22 : Yield of dry pods (groundnut) as influenced by levels of irrigation.

(Rodge, 1986)

	Treatments	Yield of dry pod (kg/ha)		
		1982-83	1984-85	Mean
1.	Irrigation at 6 critical stages.	929	340	634
2.	Irrigation at 10 days interval.	1168	958	1063
3.	Irrigation at 0.50 IW/CPE	1040	1126	1033
4.	Irrigation at 0.75 IW/CPE	1429	1878	1653
5.	Irrigation at 1.00 IW/CPE	1636	1995	1815
6.	Irrigation at 1.25 IW/CPE	1722	2010	1866
	SE ±	29	57	–
	CD at 5%	80	159	–

Table 23 : Effect of method of irrigation on yield.

Method	Crop yield (q/ha)	Water saving (%)
Border	14.9	--
Sprinkler	20.4	22.9

An experiment was conducted to findont suitable irrigation menthod and irrigation layout for summer groundnut at Rahuri (Firake and shinde 2000). The results indicated that broad bed furrow coupled with micro-sprinkler irrigation to summer groundnut was found suitable for higher productivity.

Pest Control :

Pest	Control
1. Seedling rot	Seed treatment of thirum 3 gm per kg seed.
2. Tikka	sprayings of Zineb 2 kg/1000 l. Four or two sprayings of Bavistin 0.05% or 300 mesh Sulphur dusting,
3. Aphids & Jassids	Spraying of Acephate (75%sp) 1.0 lit in 500 liter of water.
4. Termites/white ants / White grub	Soil application of methyl parathion (2% dust) @ 25 Kg/ha or Thimet (10 G) @ 10 Kg/ha.

Yield :

The yield of groundnut dry pods can be obtained to the extent of 25 q/ha by adopting a recommended practices. By ICRISAT method it is reported that the yield can increase upto tons per hectare.

Fig. 23 : Border method of irrigation

SUGARCANE

Sugarcane is the main source of sugar in India, and holds a prominent position as a cas crop. India has the largest area under sugarcane in the world and also ranks first in suga production. Juice is used for making white sugar, khandsari, and jaggery (gur) The main by products of the sugarcane industry are bagasse and molasses. . Bagasse is mainly used as fuel. It is also used for the production of compressed fibre board, paper, plastic. Molasses used in distilleries for the manufacture of ethyl alcohol, butyl, alcohol, acid etc.

Climate :

Sugarcane is a tropical crop but it can be grown in subtropics. Under warm and humi conditions, it can continue its growth, unless terminated by flowering. Temperature above 50 arrest its growth, those below 20°C slow it down. Low temperature reduces tillering. An averag mean temperature of 26 to 32°C is best suited for the growth of sugarcane. The crop does we in the tropical regions receiving rainfall of 750 to 1200 mm per annum.

Under bright sunshine conditions the stem becomes thick but length is reduced and leave become broad and more green. While under low sunshine, the stems are slender and long wi narrow and yellowish leaves. Day length considerably influences tillering. Short day leng decreases number of tillers per plant and ultimately the tonnage. The plants grown under lon day conditions produce more dry matter, Day length also influences flowering.

Soil :

Most suitable soil is deep well drained loamy soil with high organic matter. It can also b raised successfully on light soils provided there is adequate water supply and on heavy claye soil where there is good drainage. Saline alkali and acidic soils are not suitable for this crop.

Recommended varieties

1. CoM -- 0265
2. Co -- 86032
3. Co -- 94012
4. CoM -- 88121
5. VSI -- 434
6. COC -- 671

Field Preparation :

1. Two Deep ploughings criss-cross are essential because shallow ploughing limits root growth results into lodging.
2. 2 - 3 cross harrowings and then planking is given.
3. Clean the field.
4. Prepare straight ridges and furrows (90 cm to 120 cm spacing) in the field.

Seed and sowing :

(1) Seed selection :

1. Healthy seed material, free from pests and diseases like red rot, wilt, smut, etc. should be selected for seed purpose.

2. The top portion of the cane being comparatively immature has buds of high viability and is best for planting. Bottom portion of cane is rich in sugar and takes a long time for germination.

3. Seed cane should be selected from well manured healthy crop of not more than 10-11 months age.

(2) Seed preparation and treatment :

1. The dry leaves of the cane stalks are removed by hand in order to avoid any possible damage to buds.

2. There after cane is cut in to two eye budded setts.

3. About 25000 setts are required per ha.

4. Distance of 22.5 m between two sets should be maintained. End to end planting is not advisible.

5. Single eye budded setts are also used which save about 40 - 60 per cent seed material compared to two and three eye budded setts and increase in yield because of uniform growth and increased no. of tillers.

6. To prevent the attack of fungal diseases and also to improve germination, the seed setts are dipped in to Bavistin solution before planting.

Hot water treatment is also recommended for setts. Setts should be treated with 50° C for 2-3 hrs to control grassy shoots and other virus diseases.

Hot water treatment is also recommended for setts. Setts should be treated with 50 C for 2-3 hrs to control grassy shoots and other virus diseases.

(3) Time of planting :

In India, sugarcane is planted at three different times in a year as shown below.

	Planting season	Planting time	Harvesting time	Duration
1)	Seasonal	Jan-Feb.	Feb.	12 months
2)	Pre-seasonal	Oct-Nov.	Jan-Feb.	15 --,,--
3)	Adsali	July-August	Jan-Feb.	18 --,,--

4) Method of planting :

i) Furrows are prepared with a ridger about 30 cm deep. Setts are planted in the furrows (Fig. 24) and covered with soil. In heavy soil Irrigation is suggested after planting while in light soil, planting is suggested in wet soil. In well drained soil, planting of cane setts should be done at bottom of furrow where as under water stangated conditions, setts should be planted to the side of furrow.

ii) Paired Row system : (Fig. 26)

5) Spacing :

Row to row spacing should be 90 to 120 cm which depends on soil type. Spacing between two buds (single budded planting) should be 30 to 45 cm.

Manures and Fertilizers :

Twenty to twenty five tons of well decomposed FYM should be mixed in the soil. Green manuring is also suggested. Organic manures improves physical condition of soil, & water holding capacity of soil. Sugarcane requires N, P_2O_5 and K_2O as given in Table 24.

Weed Control :

If weeds are not controlled, 60-80% yield will be reduced in sugarcane. Integrated approach of weed control will be more useful. During pre-monsoon period mechanical weed control is suggested. Several weedicides are suggested as 2 4-D for broad leaved weeds (1 kg a, i./ha), 2 kg a. i. of Simazine or Atrazine after planting is suggested.

Table 24 : Fertilizer requirement of sugarcane (kg/ha)

Time of fertilizer application	N	P_2O_3	K_2O
ADSALI :			
Planting	50	100	100
After 6-8 weeks	200	–	–
After 12-16 weeks	50	–	–
After 20-24 weeks (Earthing up)	200	100	100
Total	**500**	**200**	**200**
PRE-SEASONAL :			
Planting	40	85	85
After 6-8 weeks	160	–	–
After 12-16 weeks	40	–	–
After 20-24 weeks	160	85	85
Total	**400**	**170**	**170**
SEASONAL / RATOON			
Planting	35	70	70
After 6-8 weeks	140	–	–
After 12-16 weeks	35	–	–
After 20-24 weeks	140	70	70
Total	**350**	**140**	**140**

Earthing and tying :

Earthing should be done at 20-24 weeks from planting. This prevents lodging of cane and further tillering.

Tying should be done when cane reaches about 2m height, Semidry leaves are used for this purpose. Tying also prevents lodging of cane.

Rotation :

This crop can be rotated with maize, potato, wheat, paddy, cotton, jowar, gram groundnut etc.

Intercropping :

Intercropping with potato, onion, legume (moong, urid, groundnut, cowpea) is suggested and it is observed that intercropping is more remunerative.

Water Requirements :

Adequate water throughout the growth period is essential for obtaining maximum yields. Depending on climate, duration of variety and planting season, water requirements of sugarcane is 1500 to 3000 mm. Magar et. al (1984) reported that the water requirement of adsali (18 month crop) and suru (seasonal) was 2800 mm and 2300 mm respectively. Irrigation requirement may be different according to rainfall at that location. The crop coefficient values for different growth stages (Doorenbos and Kassam 1979) are :

Stages	Days	Kc values
Planting to 0.25 full canopy	30	0.4 – 0.6
0.25 to 0.50 full canopy	30	0.75 – 0.85
0.50 to 0.75 full canopy	15	0.90 – 1.00
0.75 to full canopy	45	1.00 – 1.20
Peak Use	180	1.05 – 1.30
Early senescence	30	0.80 – 1.05
Ripening	30	0.60 – 0.80

Allowable soil water depletion :

The depletion of 50 per cent of the available soil moisture from 0 to 60 cm depth of clay loan soil was found optimum in Andhra Pradesh and Tamil Nadu (Srinivasan and Mariakulandi 1969, Rao et. al. 1972)(P=0.65).

Critical Growth stages :

Sugarcane crop can not be irrigated by critical stage approach because of its high water requirement and long duration but there are five critical stages (sensitive stages) in this crop. There fore moisture should be adequate during critical stages, except ripening period. The critical stages of seasonal cane are as below.

Table 25 : Effect of water stress on sugarcane crop.

Critical stages	Days form planting	Effect of water stress
1. Establishment	25	Less sprouting and tillering
2. Tillering or early vegetative stage	75	Less number of effective tillers,
3. Stem elongation (Fig.28)	150	Lowers rate of internode elongation.
4. Early yield formation	180	Lower rate of stem elongation, early ripening.
5. Ripening period	310	Low moisture is essential for maintaining sugar content.

Water uptake :

The root system of sugarcane is fibrous and consists of two types of roots viz: sett roots and shoot roots. The roots which are developed from the root primordia of planted sett are called as "sett roots" and are mostly temporary. After the emergence of primary shoot from the bud, other roots are produced from lower rings of the lower nodes of the shoot called 'shoot roots' which are permanent and thick. Roots of sugarcane can penetrate deep in soil upto 2 m or more but effective root depth is 1.0 m. Normally 100 per cent water is extracted from 0.90 to 1.0 m, (D= 1.0m.).

Irrigation scheduling :

Frequency and depth of irrigation depends on type of soil, stage of crop and climate. In medium to heavy textured soil at initial stage (upto 4 months) the interval should be 15- 20 days and the depth of irrigation should be 100-120 mm.

After 4 months, the interval should be increased i.e, 20-25 days and the depth should be 120 - 150 mm.

In coarse textured soil at initial stage the irrigation interval should be 10-15 days and the depth of irrigation should be 80 to 100 mm. In Later stages (after 4 months) the interval should be 15-20 days and depth of irrigation should be 100-120 mm.

In fine textured soil, number of irrigations for seasonal crop will be about 18-20 where as in light textured soil the number of irrigations will be about 22-25. Number of irrigations can be reduced depending on rainfall at that location. In adsali more number of irrigation will be required.

Fig.24 : Single Budded Sets

Fig. 25 : Drip Irrigation

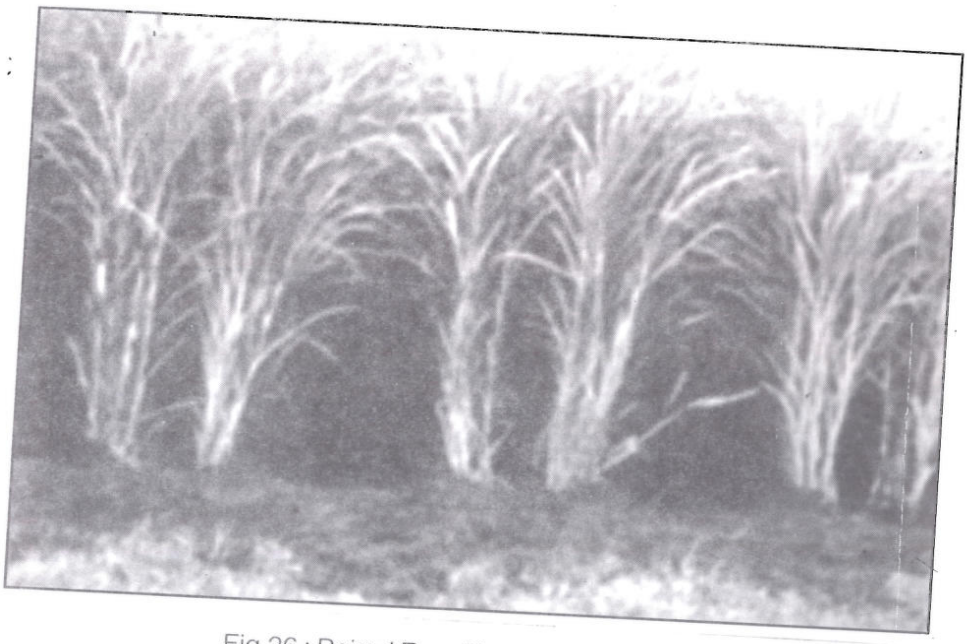

Fig.26 : Paired Row Planting Technique

Fig. 27 : Mulching

Fig.28 : Stem elongation

Table 26 : Effect of irrigation timing on cane yield of adsali sugarcane at Rahuri.

Treatment	Cane yield (t/ha)		Irri.requirement (mm)	
	1982-83	1983-84	1982-83	1983-84
CPE (mm)				
75	137.0	120.0	2700(29)*	2600 (29)
125	116.9	94.0	1740. (19)	1740 (19)
175	100.6	94.1	1480 (16)	1280 (14)
CD at 5%	8.7	10.7	–	–

*Figures in parenthesis are number of irrigations.

Irrigation interval and irrigation depth can be calculated by given formula.

$$I = \frac{AW \times D \times P}{ETc} + Ts$$

$$dn = AW \times D \times P - (ER + Ge)$$

$$d = \frac{dn}{Ea}$$

Irrigation scheduling by IW/CPE ratio of 1.2 was also suggested on medium textured soils Rodge (1986) reported on the basis of experiment conducted at Parbani that C.P.E. for irrigation scheduling should be 75 mm. Highest yield was recorded by supplying 2800 mm of water (Table 27).

Table 27 : Effect of irrigation schedules on yield of sugarcane at Parbhani.

Treatment	Cane yield (t/ha)	Irrigation requirement (mm)
IW/CPE ratio		
0.6	60.3	1540 (16)*
0.8	73.2	1960 (24)
1.0	87.1	2380 (30)
1.2	92.0	2800 (36)

*Figures in parenthesis are number of irrigations.

Studies on the effect of Irrigation scheduling on growth and yield of seasonal sugarcane were conducted for three years at Rahuri (Pawar and More 1993). The results indicated that scheduling Irrigation at 50 mm CPE with Irrigation depth of 8 cm upto earthing up and 10 cm there after gave maximum cane yield. The mean consumptive use of 2227 mm was recorded in this treatment.

Method of irrigation :

Sugarcane crop can be irrigated by 1. Straight furrow irrigation method (Fig 29), 2. Furrow cum basin 3. Contour furrow, 4. Sprinkler irrigation method or 5. Drip irrigation method (Fig. 25) Serpentine furrow method of irrigation should be discouraged as it consumes more water.

In an experiment conducted at Rahuri (Rajput 1983-85), observed that yield of cane was significantly higher when it was irrigated by ridges and furrow (Fig. 29) as compared to check basin. It is also observed that there was considerable water saving to the extent of 30 and 60 per cent when water was applied through sprinkler and drip irrigation system (Magar et. al. 1984) Mulching ((Fig. 27) also helps to reduce evaporation of water theirby increasing irrigation interval. In the periods of water shortage, alternate furrow irrigation (irrigating odd and even furrows in rotation) is recommended. Alternate furrow irrigation saves about 35-40% water with 10% reduction in crop yields compared to irrigating all furrows.

Pests and their control :

Pest	Control
1. Stem borer	Soil application of carbaryl 4% granules @ 25 Kg/ha at the time of planting.
2. Top shoot borer	Methyl parathion (50%) spray 60 ml./100 l water
3. Pyrilla (white Jassids)	3 % Linden @ 25 kg/ha dusting or Dimethioate (30%) spray 120 ml/100 lit water.
4. White fly	Malathion (50%) spraying 150 ml/100 l water
5. Whip smut and red rot	Seed treatment with bavistin solution
6. Rust	Spraying of 0.5% Dithane -Z-78 (Zineb)

Yield :

Seasonal	100-120 tons/ha
Preseasonal	120-150 tons/ha
Adsali	150-170 tons/ha

Ratoon :

1) Only one two ratoons of the crop are advised as ratoons beyond two are likely to be affected by pests and diseases.

2) For ratoon crop, main crop should be harvested before the menth of February. Ratoon kept of the crop harvested in the month of March onwards, heavely infested by shootfly.

3) Harvesting should be done close to the ground. This will increase sprouting and no. of tillers.

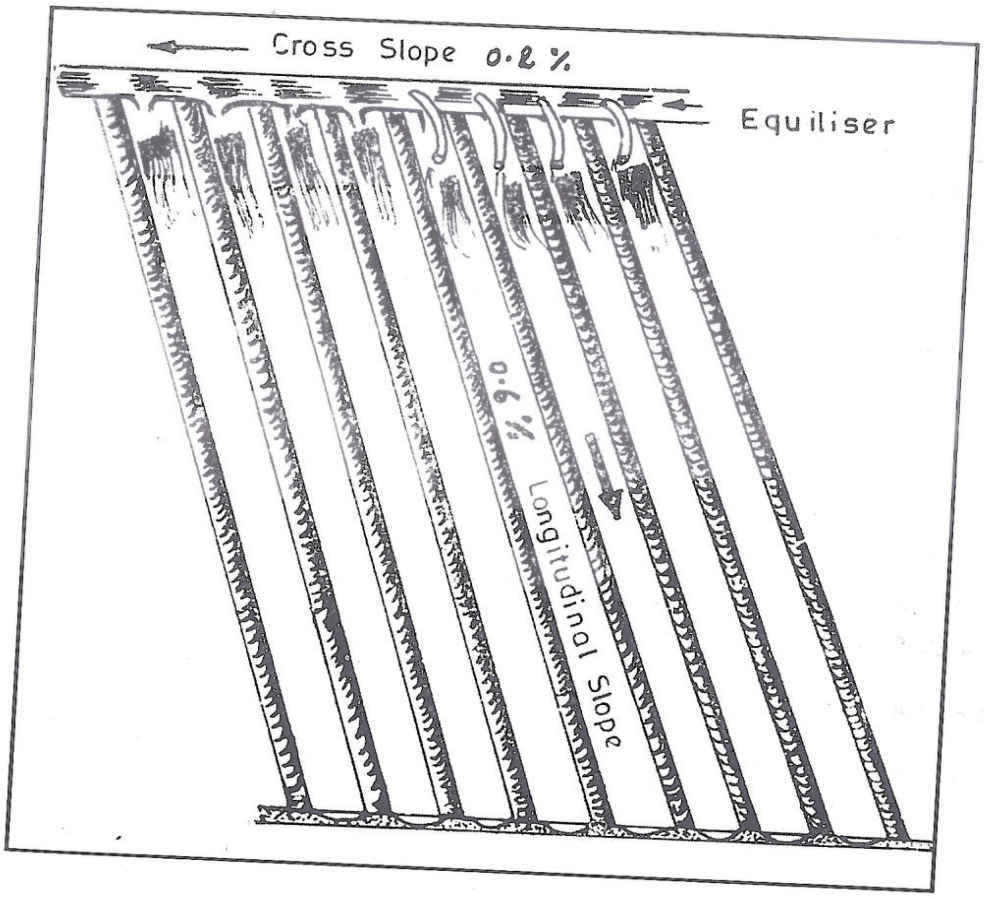

Fig.29 : Straight Ridges and furrows for sugarcane

COTTON

Cotton is one of the most important fibre crops in Maharashtra. cotton is grown for fibre, c (20-25% in seed) and cotton seedcake for animals and as a manure (6% N,3% P_2O_5 ar K_2O).

Climate :

Optimum temperature range for the growth of the crop is 21°C -27°C and, for fruiting ar boll development 21-31°C followed by cool nights. It can not tolerate continuous rains or lo spell of dry weather particularly at flowering and fruiting stages as it may cause heavy sheddi of buds and bolls. Humid or cloudy weather and poor sunshine conditions are equally harmful they reduce the yield, promote the attack of pests and diseases and lowers the quality of t produce.

Soil :

Deep, fine textured soil, with good water holding capacity, high fertility and good draina is essential for this crop clay loam, loam or alluvial soils are ideal for this crop. Avoid coa textured, shallow and water logged soils.

Varieties :

1. H-6
2. H-10
3. Savitri
4. Phule-492
5. LR-5166
6. PHH-316 (Ganga)
7. AHH 468 (PKV H-2)
8. NHH-44
9. JLH-168
10. Phule - JNA - 494
11. PKV-Rajat
12. NH-545
13. PKV-Hy. I.
14. AKAH-081
15. PKV-H-2,3,4,5

16. BT Hybrids : MRC-7326, MRC-7301, MECH-12, Ajit - 11 & 155, Rashi-2, KDCHH Tulsi-4, Banni, Mallika, Varun and Durga.

Field Preparation :

Cotton being a deep rooted crop requires well prepared seedbed. The field shoul ploughed upto 20 cm deep. Thereafter 3 to 4 horrowings are required. Planking is essentia levelling the land. Irrigated cotton is sown on ridges and furrows.

Seed and Sowing :

i) **Seed treatment**

Delinting of seed with sulphuric acid and seed treatment with organomercurial fungicides @ 3 gm/kg seed to minimise the incidence of seed borne diseases is essential.

ii) **Seed rate :**

Seed rate varies according to the variety, its growth behaviour and production practices. Seed rate of hybrid cotton under irrigated condition is 2.5 to 3 kg/ha. The seed rate of other American varieties in assured rainfall zone is 8-9 kg/ha and in case of Deshi cotton, it is ranging from 10-12 kg/ha.

iii) **Spacing :**

For L.S. cotton under irrigated condition
120 cm x 90 cm or 120 x 120 cm.
Rainfed cotton (American varieties)
60 cm x 45 cm
Deshi cotton (Rainfed)
45-60 cm x 30 cm.

iv) **Plant population :**

L.S. cotton under irrigated condition: 18,000 to 20,000 plants /ha Rainfed Cotton : 50,000 to 80,000 plants/ha.

v) **Sowing time :**

Timely sowing of cotton is the key factor to influence the cotton yields, hence sowing should be done at proper time. Late sowing results in considerable reduction in cotton yields. The crop is very suceptible to delay in sowing. The optimum time of sowing of irrigated cotton in Maharashtra starts from March to 1st fortnight of May. Sowing period of irrigated cotton is decided on the basis of late rains received in the area and temperature during sowing period. In Western Maharashtra, crop is sown in March / April while in Marathwada and Vidarbha in May. Rainfed cotton is sown in 2nd or 3rd week of June depending upon onset of monsoon.

vi) Sowing method :

1. Drilling – Rainfed deshi cotton crop is sown by seed drill.
2. Dibbling – Irrigated hybrid, high yielding cotton is sown by dibbling on ridges.

vii) Depth of sowing :

4 - 5 cm depth.

Gap filling and thinning is essential. At every place or hill one to two plants shou maintained. If there are some gaps, fill the gaps by dibbling the water soaked seeds. Irri cotton is sown on ridges after giving pre-soaking irrigation. However one light irrigation (chimb is required 4-5 days after sowing for proper emergence of the seed.

Rotation and mixed cropping :

Many rotations of crops involving cotton are feasible. Crops like wheat, pea, sor gram, sunflower and groundnut can be grown after harvest of cotton.

Intercropping or mixed cropping with arhar, green gram, black gram, soybean, sesa ragi etc. is common. Intercropping and mixed cropping under rainfed conditions serves insurance against crop failures.

Manures and Fertilizers :

About 15 to 20 tonnes of well decomposed FYM/ha is required. The cotton crop re following major nutrients.

N-100 to 120 kg./ha

P_2O_5 - 50 to 60 kg/ha.

K_2O - 50 to 60 kg/ha.

Half dose of the nitrogen and full dose of P_2O_5 and K_2O should be applied at sow remaining half quantity of nitrogen should be applied at square formation stage.

Water requirement :

Depending on climate and length of total growing period, cotton needs about 70 mm to meet its water requirements (ETm). Crop water requirements are low in the early ve period, they are high during flowering period, the requirement decline after boll developm crop coefficient (kc) for different growth stages of cotton is for the initial stage 0.4 to days), the development stage 0.7 to 0.8 (50 days). The mid-season stage 1.05 to 1.25 (6 the late-season stage 0.8 to 0.9 (55) days and at harvest 0.65 to 0.7. Irrigation require hybrid cotton is 200 to 350 mm. Irrigation requirement of cotton sown in March / April i 550 mm.

The consumptive use of water for cotton was 713 mm (Magar et al. 1984) and the irrigation requirement was 640 mm at Rahuri (prihar and Sandhu, 1987).

Water supply and plant growth

Cotton requires adequate water, excess water in early growth stage results in (1) restriction root growth and crop development (2) prolong and an excessive vegetative growth which causes boll shedding and (3) Delay in flowering and decrease in reproductive growth.

Allowable depletion for cotton is 65 per cent i.e. P=0.65 (Doorenbos and Kassam 1979). The experiment conducted at Rahuri shows that the allowable depletion should be 50 per cent (Table 29) for maximum yield (Prihar and Sandhu. 1987). In Tamil Nadu, irrigation at 50 per cent depletion of available soil moisture was found optimum for winter cambodia cotton grown on red sandy loam soils at Bhavanisagar (Ali et. al. 1974).

In cotton there are five critical growth stages. If moisture is low during critical stages there will be drastic reduction in yield.

Table 28 : Critical growth stages :

	Stages	Duration from sowing (days)	Effect of moisture stress
1.	Vegetative stage	25-35	Reduces branching and plant height
2.	Square formation (Fig. 30)	45-60	Reduction in squares and flowers
3.	Flowering (Fig. 31)	85-90	Affect further square formation, flower opening and cause flower and boll shedding
4.	Boll development (Fig. 32)	105-120	Affect boll opening & staple length.
5.	Ripening	130-140	Affect quality of cotton.

Rooting depth and moisture extraction pattern :

Cotton has a single tap root with extensive lateral branching. The tap root may extend in deep soils to a depth of 1.8m. The effective root depth of cotton is considered as 1.35 m (D=1.35 m.). About 70 to 80 per cent of the total water uptake by the crop occurs from the first 0.9m soil depth.

The current Literature on maximum allowable soil moisture depletion levels of cotton for optimum crop production was reviewed (Musande and Palaskar 1997) and it is suggested that the maximum allowable soil maisture depletion should be 50 percent for cotton.

Irrigation scheduling :

If cotton is planted in summer, frequent irrigation (i. e. 8-10 days interval) is required up to onset of monsoon. In rainy season frequency of irrigation depends on rainfall. Irrigation interval and depth of irrigation can be calculated by given formula.

Table 29 : Effect of soil moisture depletion on the yield of cotton.

(Prihar and Sandhu, 1987)

Place	Soil type	Duration of study (years)	Parameter	Seed cotton yield (kg/ha) & no. of irrigation		
				Available soil moisture depletion		
				25%	50%	75%
Siruguppa (Karnataka)	Medium clay	3	Yield	3750	3270	3210
			No.of irrigations	14	11	8
Rahuri (Maharashtra)	clay	3	Yield	1910	1950	1890
			No.of irrigations	4	3	2

$$I = \frac{AW \times D \times P}{ETc} + Ts$$

$$dn = AW \times D \times P - (ER = Ge)$$

$$d = \frac{dn}{Ea}$$

If cotton is planted in June, irrigation scheduling can be done on the basis of critica stage approach. In this approach, depth of irrigation depends on soil type and its depth, and interval of irrigation is dependant on critical stages at which Irrigation is to be given. Irrigatio

scheduling can be done on the basis of soil moisture depletion approach. Allowable depletion in cotton is 50 to 65 per cent. Full grown crop can allow to deplete the moisture upto 65 per cent.

Irrigation methods :

Cotton is grown under a variety of irrigation systems in which ridges and furrow irrigation system is the most common. In the regions where water resources are less and demand is more, drip Irrigation should be used.

Integrated pest management :

1) Before sowing, seed treatment of Emidacloprid (70 wp) @ 10 gm/kg of seed. Planting of trap crops like Maize, Cowpea, Sorghum as a mix or intercrop.

2) After 21-30 days after sowing, release eggs of Crysopa @ 50,000 eggs/ha. If crop is infested with Jassids or Aphids spraying of Dimethoet (30 EC) @ 400 ml/500 Lit. of water.

3) During 50-80 days after sowing, if attak of White fly noticed, spraying of Acetamiprid (20 sp@150 gm/500 Lit of water)

4) In the initial stage of the crop (15-21 days) if attack of Heliothis is observed on the crop release eggs of Tricograma @ 1.5 Lac/ha. spraying of Kurastki @ 1 kg/500 lit of water.

5) For the control of all types of Bollworms, spraying of HNPV 500 LE/ha or Lambda Cypermethrin (5 Ec) @ 1000 ml/500 lit water or profenophos (50 EC) @ 2000 ml/500 Lit of water.

Yield :

A well managed irrigated crop may yield about 25 to 30 q per hectare. (Fig. 33)

Fig.30 : Square Formation

Fig. 31 : Flowering

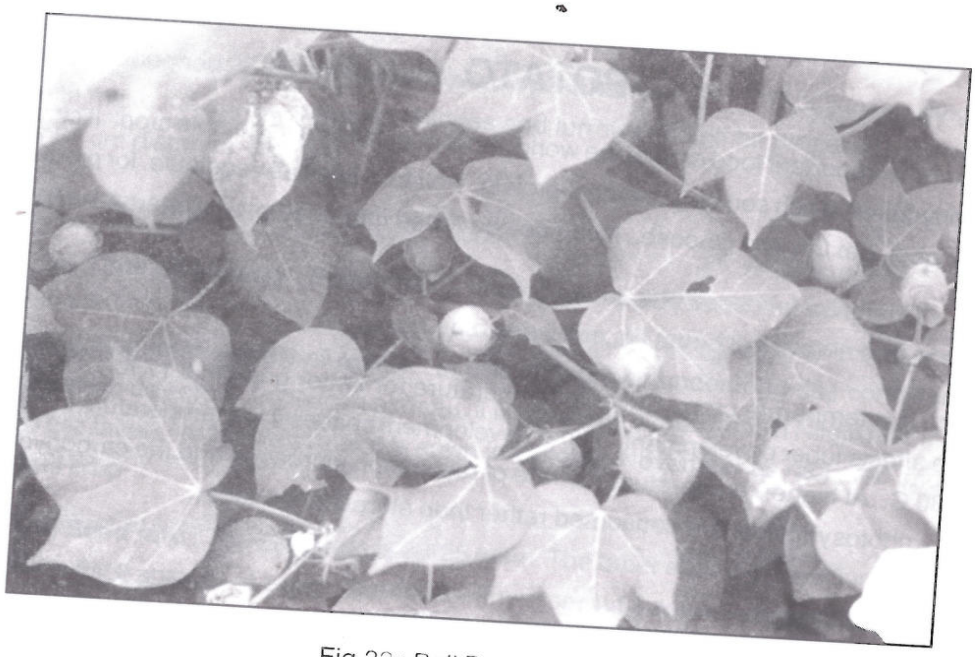

Fig.32 : Boll Devlopment

Fig.33 : Cotton at Harvesting

POTATO

Potato is an important food crop of the world, most popular as a vegetable crop. It contains 21.6% carbohydrates, a rich source of starch & protein. Potato is used as vegetable, for production of starch, alcohol, dextrin and glucose. It can be converted into dried products such as "potato chips".

Climate:

Potato is a temperate crop. Suitable temperature for better growth is 17 to 19 C Higher temperature affects tuber development. Tuber development ceases if the temperature increases more than 30 C. At higher temperature the rate of respiration increases and the carbohydrates produced by photosynthesis are consumed rather than stored in the tuber.

Soil :

Potato needs loose and friable soil with good drainage and aeration. Sandy loam and loam soils, rich in organic matter are most suitable for potato. Potato should not be grown on the alkaline and saline soils.

Preparation of Land :

Preparation of field should be done after giving one pre-sowing irrigation. Thereafter field

Fig.34 : Potato

should be ploughed 20-25 cm deep followed by 2-3 harrowings. One or two plankings should be given to make the surface smooth. Ridges and furrows should be prepared for planting potato at 45-60 cm distance. (fig. 34)

Seed and Sowing:

a) Time of sowing : Potato has a wide regional and seasonal adaptability. It is grown from sea level to areas extending right upto snow line, all round the year in one or other part of India ensuring fresh supply of potato. In hills, it is grown under long day condition and in the plains a short day crop. In deccan plateau, it is grown as a rabi crop, in Nilgiri hills three crops of potato are taken. In Maharashtra it is sown in October-November as rabi crop and June - July as kharif crop.

b) Seed rate : The seed rate is 20-25 q/ha. The tuber should be medium in size (30 to 50 gms) with thick sprouts of 1 cm. The seed without sprout if sown, it delays the germination and too long sprouts may be damaged at the time of planting. The potato seed obtained from the cold storage is not fit for immediate planting. The seed is kept in ventilated boxes for 10-15 days in a cool shady place exposed to diffuse sunlight. This treatment helps in development of good sprouts.

c) Spacing : Row to row 45 cm to 60 cm
Plant to plant 15 cm to 20 cm.

d) Seed treatment : The whole tubers or cut tubers (30 to 40 g, weight, having atleast 3 eyebuds) should be treated with Aretan or Tafasan (6%) solution for 2 minutes to control black arm diseases and rooting of seed potato. Dipping in Dithane M 45 for 10 minutes is also useful to avoid rottening.

Method of Planting :

There are three methods of planting potato.

1) Planting potato on flat surface: Planting of potato is done on flat surface in shallow furrows. After germination when plants attain about 12-15 cm height, small ridges are made. Later 2-3 earthings are given at an interval of 15-20 days.

2) Planting potatoes on flat surface followed by ridges : In this method shallow furrows are opened and sprouted potatoes are planted in furrows. Immediately after planting, small ridges are made on the furrows. These ridges are made thick lateron.

3) Planting potatoes on ridges: After preparation of land, ridges are made at suitable distance and planting of potato is done on the ridges.

Manures and Fertilizers :

Well decomposed compot or FYM about 7-10 tonnes/ha is applied. In addition, following fertilizer dose is required.

N	--	80--100	kg/ha.
P_2O_5	–	60--80	kg/ha.
K_2O	–	60--80	kg/ha.

Full quantity of P & K and half quantity of N should be applied at planting and 50% N should be applied at earthing up.

Varieties :

A large number of high yielding varieties of potato suited to different agro-climatic conditions have been evolved at Central Potato Research Institute, Simla.

Table 30 : Varieties.

Groups	Plain	Hills.
Early maturing group	70-80 days	125 - 135 days
Mid duration group	90-110 days	135 - 150 days
Late duration group	110-130 days	150 - 165 days

Table 31 : Recommended Varieties.

	Variety	Duration	Yield
Early maturing group :			
1)	Kufri Chandramukhi	80 - 90 days	250 q/ha
2)	Kufri Navtal	75 - 85 days	150 - 200 q/ha.
3)	Kufri Lavkar	85 - 90 days	250 q/ha
4)	Kufri Badshaw	80 - 90 days	200 - 250 q./ha.
Mid duration group :-			
1)	Kufri Jyoti	90-100 days	200-225 q/ha.
2)	Kufri Navjot	100-110 days	200-250 q/ha.
3)	Kufri chamatkar	110-135 days	250-300 q/ha.
4)	Kufri Jawahar	90-100 days	200-225 q/ha.
Late duration group :-			
1)	Kufri Sinduri	120-140 days	300-350 q/ha.
2)	Kufri Deva	125-135 days	300-400 q/ha.

Earthing up :-

Two to three earthings should be done at an interval of 15-20 days. First earthing up should be given when the plants attain 15-20 cm height.

Weed Control :-

Earthing up helps in controlling weeds. One or two hand weedings are required.

Simazine @ 0.75 a.i. in 400-500 l. water can be used as pre-emergence treatment. Post emergence application of stam F-34 @ 1000 ml mixed in 500 liters water also gives effective control.

Water Requirements

For high yields, the crop water requirements (ETm) are 500 to 700 mm depending on

Table - 32 : The crop coefficient (kc) values for different growth stages of potato

	Stages	Duration of stage (days)	Kc values
1.	Initial stage	20	0.4 - 0.5
2.	Crop development stage	30	0.7 - 0.8
3.	Mid season stage	30	1.05 - 1.2
4.	Late season stage	20	0.85 - 0.95
	At harvest	--	0.7 - 0.75

Water supply and crop yield

Potato is relatively sensitive to soil water deficits. For maximum yields the total available soil water should not be depleted more than 40 per cent. There are four critical stage in potato.

Table - 33 : Critical growth stages of Potato.

Critical stages	Days from Planting (days)	Effect of moisturs deficit
1. Early vegetative stage	20 - 25	Reduction in root growth and branching.
2. Stolonization /Tuber Initiation	45 - 50	Reduction in number of tubers.
3. Yield formation (tuber enlargement)	70 - 75	Reduction in size of tubers.
4. Ripening	80 - 85	Reduces the size and quality of potato.

Root depth and moisture extraction :

The root of potato is adventitious, arising from the base of a sprout. The root growth is usually restricted to top soil layers at a depth of about 0.5 m (D= 0.5 m). Normally 70 per cent of the total water uptake occurs from the upper 0.3 m and 100 per cent from 0.40 to 0.60 m soil layer.

Irrigation Scheduling :

Potato is a relatively sensitive crop. Allowable soil water depletion is very low and it is shallow rooted crop, therefore frequent irrigations are required. (P= 0.30)

Irrigation interval (I) and irrigation depth (d) can be calculated by given formula.

$$I = \frac{AW \times D \times P}{ETc} + Ts$$

$$dn = AW \times D \times P - (ER + Ge)$$

$$d = \frac{dn}{Ea}$$

In this crop, irrigation scheduling can be done by CPE or IW/CPE method, Highest yield of potato was recorded at Parbhani when this crop was irrigated at 1.35 IW/CPE ratio (Table - 34) Similar results are also reported by Rodge (1986) at Parbhani (Table 35). In temperate region this crop can be irrigated by critical stage approach.

In generai, the interval should be 6-8 days and the depth of each irrigation should be 50-60 mm. The total number of irrigation will be about 10-12 depending on duration of variety.

Table -34: Effect of irrigation schedules on tuber yield of Potato at Parbhani.

(Rajput, 1981-82)

IW/CPE ratio IW= 60 mm.	Tuber yield (q/ha)	Irrigation requirement (mm)
0.60	125.6	360
0.75	156.5	420
0.90	160.2	480
1.05	169.1	540
1.20	170.4	600
1.35	183.9	660
CD at 5%	20.1	–

Table - 35 : Tuber yield of potato variety Kufri Chandramukhi as influenced by irrigation levels.

	Treatment	No. of irrigations	Tuber yield (q/ha) 1978-79	1979-80	Pooled
1.	Irrigation scheduled at 0.80 IW/CPE	7	166	153	157
2.	Irrigation scheduled at 1.00 IW/CPE	8	135	166	172
3.	Irrigation scheduled at 1.20 IW/CPE	9	226	203	211
4.	Irrigation scheduled at 1.40 IW/CPE	10	249	226	233
	SE +		3.6	2.5	2.0
	CD at 5%		10.4	7.2	5.9

Irrigation methods :

Most common irrigation method in potato is ridges and furrows. When water is inadequate, sprinkler irrigation method can be used.

Pest	Control
1) Late blight	1) Grow resistant variety as Kufri Navtal
	2) Spray Dithane M-45 @ 2.5 kg/1000 l/ha.
2) Early blight	1) Use clean field for potato
	2) Spray Dithane M-45 or Dithane Z-78 @ 2.5 kg/ha in 1000 Lit of water
3) Black scurf	1) seed treatment 0.5% Aretan/Agallol for 10 min
4) Cut worms	1) Use Phorate (10 G) @ 10 kg/ha at sowing 2) Use savin dust @ 25 kg/ha.
5) Potato tuber moth	1) Soil application of Carbaryl 10% dust @ 20 kg/ha.
6) White grub	1) soil application of phorate (10G) @ 10kg per hectare before planting.
7) Leaf hoppers	1) Use Phorate (10 G) @ 10kg Per ha or Carbofuron (3 G) @ 25 kg/ha.

Yield :

With recommended package of practices, yield of 300 to 400 quintal per hectare can be obtained.

GRAM

Gram is commonly known as 'Chick pea' or Bengal gram. Gram is the most important pulse crop of India. India alone has nearly 75% of the world acerage and production of gram. In the world, it is cultivated over an area of 10.4 million hectares. In India it is cultivated on 7.87 million ha with production of 5.83 million tons.

Climate :

Gram is a Rabi season crop but severe cold and frost are injurious to it. Frost at flowering results in the failure of seed setting. Excessive rains soon after sowing or at flowering and fruiting cause heavy loss. It is best suited to areas having moderate rainfall of 600 to 900 mm per annum.

Soil :

Though gram is grown on all kinds of soils, loam to clay loam soil is considered the most suitable. On light soils, the plants remain short while on heavy soils having high water retention capacity, the vegetative growth is abundant, sunshine becomes limiting and fruiting is retarded. The soil pH should be nutral in reaction.

Varieties:

1. Phule G-5
2. BDN-9-3
3. Phule G-12
4. Vijay
5. PKV-Kabuli-2
6. Vishal
7. Virat (Kabuli cv.)
8. Gulak-1
9. Vihar (Kabuli cv.)
10. BDNG-797
11. AKGS-1 (Green Coloured grains)
12. AKG-46
13. D-8
14. PKV - 4-1
15. ICCV - 2
16. Digvijay (Kabuli cv)

Rotation and Mixed Cropping :

Gram can be rotated with jowar, bajra, maize, paddy, etc.

Gram is mixed with rabi jowar, wheat, barley, linseed, mustard etc.

Field Preparation :

Gram is highly sensitive to soil aeration. This impreses a restriction for its cultivation of heavy soils. A rough seed bed is required for gram. One deep ploughing and two harrowings are required. Border strips should be prepared.

Seed and Sowing :

Time of sowing : 15th Octomber to 15th November is suitable. Early sowing of gram results in excessive vegetative growth and poor setting of pods. Early sowing also suffers due to wilt because of high temperature. Delay in sowing results in decrease in yield.

Spacing	:	30 cm x 15 cm
Seed rate	:	60 to 70 kg/ha
Depth of sowing	:	8 cm by drilling, shallow sown crop damages due to wilt.

Manures and Fertilizers :

Being legume crop it can fix atmospheric nitrogen. But small dose of nitrogen at initial stage will be required. For optimum yield 25:50:25 kg/ha NPK at sowing by drilling method is recommended.

Weed control :

One hand weeding at 30 days and if required second weeding at 60 days should be done. Basalin 1 kg. a.i. per ha in 800 to 1000 liters of water as pre-sowing spray will be useful.

Water Requirement :

The evapotranspiration or consumptive use of water of gram depends on climate and duration. The results of experiments conducted at various places are given below.

Table - 36 : Consumptive use of gram.

Location	Year	Consumptive use (mm)	Yield q/ha	References
Rahuri (M.S.)	1980	268	28.73	Shinde et, at. (1985)
	1981	248	27.29	
	1982	246	19.36	
Hissar (Haryana)	1975-77	221	37.30	Singh et.al. (1980)
	1976-77	221	23.95	
	Mean	216	30.62	

The total water requirement of crop ranges from 220 to 300 mm a indicated in Table 37.

Table - 37 : Total quantity of water applied for highest yield of gram.

Location	Soil Type	Total qty. of water applied (mm)	Yield obtained q/ha	References
Badnapur (M.S.)	Clayey	300	23.59	Raikhelkar et al (1977)
New Delhi	Sandy loan	240	38.40	Dastane et. al. (1971)
Rahuri (M.S.)	Clayey	220	25.12	Shinde et. al.(1985)
New Delhi	Loam	240	38.60	Mohd. Yusuf et.al. (1980)

Water supply and crop growth:

For high yield adequate water supply is required for gram. Reduction in water supply at pre-flowering stage, flowering and early pod formation stage in general has an adverse effect on growth and yield. The researchers (Table 38 and Table 39) have identified the critical stages of gram and reported that the irrigation should be given during those growth stages.

Table - 38 : Critical growth stagers of gram.

Researchers	Location	Soil Type	Critical stages identified	Days after sowing	Effect of moisture stress.
Dastane et. al (1971)	New Delhi	Sandy Loam	1. Branching (Fig. 34)	45	Reduces branches, pods flowers and yield.
			2. Pod formation	75	Reduces size of grain.
Singh et al. (1980)	Hissar	Sandy Loam	1. Preflowering	45	--do--
			2.Early pod formation	75	
Mohd Yusuf et.al. (1980)	New Delhi	Loam	1. Branching	45-50	--do--
			2. Grain develop-ment.	80	
Shinde et. al. (1985)	Rahuri	Clayey	1.Branching	45	--do--
			2. Pod development	75	--do--
Rodge (1986)	Parbhani	Clay	1. Flowering (Fig.35)	50	--do--
			2. Pod development (Fig. 36)	70-75	

60% of Available water (P=0.60)

Table - 39 : Grain yield of gram as influenced by irrigation.

Treatment	No.of irrigations	Grain yield (kg/ha) 1981-82	1982-83	1983-84	Pooled
1. No irrigation	0	354	625	238	406
2. Irrigation at flowering (40 + 5 days)	1	774	1000	637	804
3. Irrigation at pod development stage (70+5 days)	1	563	980	620	721
4. Irrigation at flowering and pod development stage	2	842	1270	838	983
5. Irrigation at 0.75 IW/CPE	6	800	1206	934	980
6. Irrigation at 0.50/IW/CPE	4	848	913	848	870
SE +	--	33	78	53	38
CD at 5%	--	96	243	153	106

Water uptake and moisture extraction pattern :

Gram has well developed strong tap root system, and can penetrate deep into the soil and can absorb water and nutrients from deeper soil layer. It is reported that the rooting depth of gram in monolith is 115 cm (Musande et.al. 1987). The results of moisture extraction patter upto 90 cm is given in Table 40 on the basis of experiments conducted by Singh et.al. (1980).

Table - 40 : Moisture extraction pattern of gram at optimum moisture level.

Location	Year	Soil layer (cm)	Moisture extraction in (%)
Hissar	1975-76	0-30	47.2
		30-60	34.2
		60-90	18.3
	1976-77	0-30	51.0
		30-60	25.2
		60-90	23.8

It is also reported by Singh et.al. (1980) that when moisture is low in soil, the moisture extraction by gram was more from deeper soil layer.

Irrigation scheduling :

Raikhelkar, et. al., 1977; Shinde et.al., 1985; Mandal et. al., 1979; Dastane et. al., 1971; Mohd. Yusuf et.al., 1980 and Singh et. al., (1980) in the field of water management have recommended critical stage approach for gram, if the soil is medium to fine textured (water holding capacity/available water should be more than 200 mm/m depth) and deep (atleast 1 m). The identified critical stages are branching stage at 35 days after sowing and early pod development stage i.e. 75 days after sowing.

Number of irrigations:

As per the results (Table 41) of the experiments conducted at various locations and on medium to heavy textured soils 2-3 irrigations are sufficient for maximum yield.

Depth of irrigation :

Depth of irrigation at each irrigation should be 120 mm (Dastane et.al.1971) in medium textured soils for gram. Shinde et.al. (1985) obtained highest yield when depth of irrigation was 73 mm at Rahuri.

Table - 41 : Effect of irrigation frequency on yield of gram.

Location	Soil Type	Frequency of Irrigation.	Maximum yield obtained (q/ha)	Reference
Rahuri (M.S.)	Clayey	3	25.12	Shinde et.al. (1985).
Sabour (Bihar)	Sandy Loam	2	24.90	Mandal et.al. (1979).
Badnapur (M.S.)	Clayey	2	23.59	Raikhelkar et.al. (1979).
New Delhi Loam	Sandy	2	38.40	Dastane et.al. (1971).
New Delhi	Loam	2	38.60	Mohd.Yusuf et.al.(1980).
Hissar (Haryana)	Sandy Loam	2	30.62	Singh et. al. (1980).

Pest :

Wilt : 1) Treat the seed with Benlate T or a mixture of Benlate and Thirum 1:1 @ 2 g/kg seed.

2) Grow resistant variety

Cutworm : This pest can be controlled by the application of 5% Aldrin dust @ 20-25 kg/ha mixed in soil.

pod borer : 1) Spray monocrotophos (Nuvacron 40 EC) at pod formation 10 ml in 10 liters water or;

2) Spray 5% Neemark or HNPV 250 LE

Yield :

Average yield of well managed gram crop is about 20 to 25 q/ha.

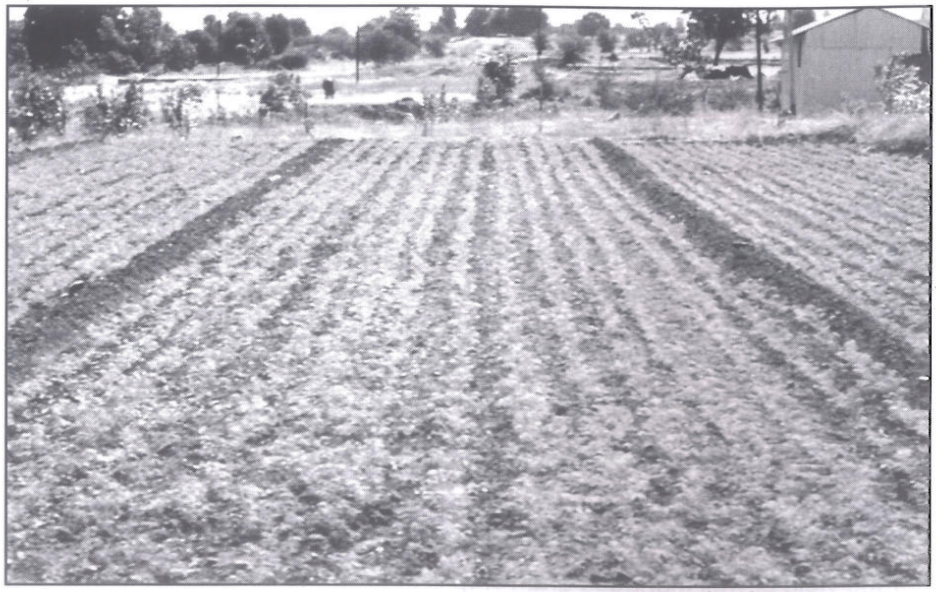

Fig.35 : Seeding Stage

Fig. 36 : Flowering Stage

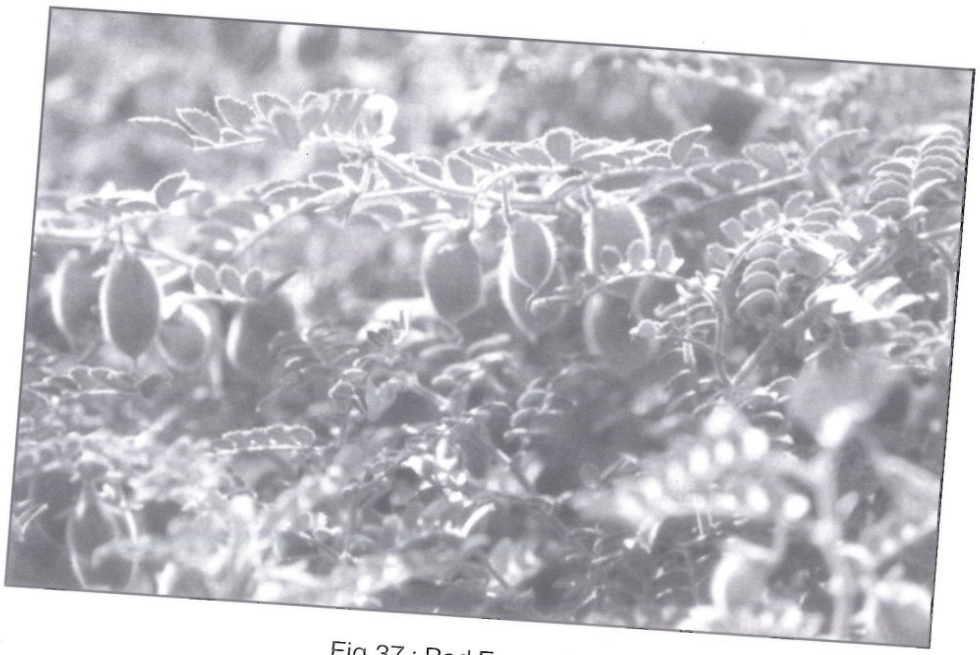

Fig.37 : Pod Formation

SUNFLOWER

Sunflower as an oilseed crop is a new introduction in India. It has got 46-50% good quality oil, and high amount of protein in cake. Sunflower holds great promise because of its short duration, photoinsensitive, wide adaptability and drought tolerant. It can be grown at anytime of the year and can serve as an ideal cash crop. Sunflower oil is a rich source (64%) of Linoleic acid which helps in washing out cholestrol deposition in the ceronery arteries of the heart and thus is good for heart patients. Oil is also used in the manufacture of soaps and cosmetics. The oilcake contains 44% protein and it is idealy suited for poultry and live stock rations.

Sunflower is cultivated on 12.0 million ha area in the world and its production is 5.2 million tons. In Maharashtra it is cultivated on 3.5 lakh ha.

Climate :

It requires warm weather from the seedling stage upto flowering stage and sunny days during flowering to maturity.

High humidity, cloudy weather and rainfall at flowering time results in poor seed set. It is photo and thermo insensitive crop. Therefore it can be grown successfully in any season viz. kharif, rabi and summer in India.

Soil :

Suflower can tolerate wide range of soil but maximum yield can be harvested on deep loam soils with good drainage and irrigation facilities. The optimum range of pH is 6.5 to 8.5.

Varieties /Hybrids :

SS - 2038 (Bhanu)	Morden	LDMRSH-1
EC 68414	Sunrise	LDMRSH-3
EC 69874	MSFH-1	SS-56
EC 68415	PKV 72-37	BSS-11
KBSH - 44	BSH-1	APSH-11
Phule raviraj	MSFH-7	

Preference should be given to hybrid Varieties.

Rotation :

This crop can be rotated with maize, paddy, jowar, potato, wheat, groundnut, cotton, arhar etc.

Field Preparation :

One deep ploughing and two to three harrowings, are required. Land should be levelled for irrigation, borders or ridges and furrows should be prepared. There should be sufficient moisture at the time of sowing because seed absorb moisture slowly.

Seed and Sowing :

A) **Sowing time :** This crop can be sown in any month but the experimental results show, that sunflower should be sown in first fortnight of July in kharif, second fortnight of October in rabi and first fortnight of February in summer.

B) **Spacing :** 60 cm x 15 -20 cm.

C) **Seedrate :** 10-12 kg/ha.

D) **Sowing depth :** 3-4 cm,

E) **Method of sowing :** Drilling or Dibbling.

F) **Plant population :** 60,000 to 80,000 plants /ha.

Manures and Fertilizers :

10 tonnes of FYM/ha	:	N	60-80 kg/ha
P_2O_5 40 kg/ha	:	K_2O	40 kg/ha.

The nitrogen should be splited into two doses. Fifty per cent N, full quantity of P_2O_5 and K_2O should be applied at the time of sowing by drilling method. The remaining quantity of N should be applied after 30 days from sowing. In sulphur deficient soils, 20 kg sulphur should be applied at the time of sowing.

Weed Control :

Weed control in sunflower upto 60 days is essential. Therefore, 1 to 2 hoeings and 1 or 2 hand weedings are essential. Artificial pollination is suggested at flowering.

Water Requirement :

Water requirement of sunflower depends on climate, season and duration of variety. The crop coefficient values, consumptive use of water, total irrigation requirement of sunflower are given in Table 42 (Andhale and Kalbhor, 1978). Observed that the irrigation requirement of sunflower grown at Pune is 524 mm.

Table - 42 : Crop coefficient, consumptive use and irrigation requirement of sunflower.

(Andhale and Kalbhor, 1978)

Dates, Months, period of crop growth.		Crop coefficient.(kc)	Consumptive use mm/day	mm/month	Field Irrigation requirement (mm)
Nov.	8 - 30	0.60	3.02	66.34	94.96
Dec.	1 - 31	0.56	2.66	82.49	117.96
Jan.	1 - 31	0.77	3.78	117.17	167.55
Feb.	1 - 28	0.57	3.59	100.56	143.84
	Seasonal kc	0.62	Total cu	366.66	Total 524.21

Patel and Singh (1983) reported that the irrigation requirement of sunflower grown at Udaipur is 400 mm.

Water supply and plant growth :

In sunflower there are four critical stages (Jadhav and Jadhav 1978). The critical stages are 1. Initial seedling stage (15-20 days from sowing). 2. Capitulum initiation (35 days) 3. Flowering stage (50-60 days) and 4. Grain development stage (70-80 days). When soil moisture is very low at early seedling stage, this reduces the plant height. Moisture stress at capitulum initiation can reduce the size of bud/flower. Severe moisture stress at flowering will cause poor seed setting and low yield per plant. If moisture is low at grain development stage will cause small grains, reduces the yield and oil content. Mayee and shelke (1986) reported that three irrigations are required in rabi season (Table 43). Similar type of results are also reported by Rodge (1986) (Table 44).

Table - 43 : Irrigation requirement of sunflower in rabi season at Parbhani.

(Mayee and Shelke, 1986)

	Treatment	No. of irrigation	Yield (kg/ha)
1.	Irrigation at bud initiation (Fig. 38)	1	614
2.	Irrigation at flowering (Fig. 39)	1	464
3.	Irrigation at grain development (Fig. 40)	1	384
4.	Irrigation at bud development and flowering	2	681
5.	Irrigation at bud and grain development	2	715
6.	Irrigation at flowering and grain development	2	636
7.	Irrigation at bud, flowering and grain development	3	898
8.	No Irrigation	0	255

Total quantity of water and yield :

Dastane et. al. (1971) observed the increase in the yield of sunflower with increase in total quantity of water applied (upto 300 mm.) The dose of 300 mm. water was applied at different stage in various combinations. Further increase in water quantity resulted in yield reduction.

Table - 44 : Grain yield of sunflower as influenced by irrigation treatments.

(Rodge, 1986)

	Treatments	No. of Irrigations	Yield (kg/ha) 1983-84	1984-85	Mean
I1	Irrigation at bud formation (30 + 5 days)	1	459	758	608
I2	Irrigation at flowering (55 + 5 days)	1	356	509	432
I3	Irrigation at grain formation (70 + 5 days)	1	242	492	367
I4	Irrigation at I1 and I2	2	521	880	700
I5	Irrigation at I1 and I3	2	528	747	637
I6	Irrigation at I2 and I3	2	442	838	640
I7	Irrigation at I1, I2 and I3	3	690	1059	874
I8	Irrigation at 0.60 IW/CPE	4	709	1186	947
I9	No irrigation	--	225	255	240
	CD at 5%	--	124	173	--

Fig.38 : Seeding Stage

Fig. 39 : Bud formation stage

Fig. 40 : Flowering Stage

Fig. 41 : Grain formation Stage

Allowable soil moisture depletion :

The results of the experiment conducted by Reddy et. al. (1980) shows (Table 45) that the allowable soil moisture depletion for sunflower should be 60% (p=0.6).

Table - 45 : Allowable soil moisture depletion in sunflower.

Allowable soil moisture depletion [ASMD (%)]	Yield (q/ha)
40	20.1
60	20.1
80	10.0

Irrigation scheduling :

Jadhav and Jadhav (1978) scheduled the irrigation by critical stage approach and reported that highest yield was obtained by giving irrigation at initial stage, flowering stage and grain filling stage.

Andhale and Kalbhor (1980, irrigated the sunflower by IW/CPE ration basis. They observed that the irrigation at 0.6 IW/CPE ratio produced maximum yield among all treatment at Pune.

Table - 46 : Irrigation scheduling on the basis of critical stages of rabi sunflower on medium textured soils of Pune.

Irrigation at critical stages	Grain yield q/ha			
	1973-74	1974-75	1075-76	Pooled Mean
1. Initial stage (15-20 days)	10.96	13.04	15.48	13.16
2. Capitulum initiation (30-35days)	11.88	15.07	15.89	14.28
3. Flowering (50-60 days)	12.41	14.75	16.88	14.88
4. Grain development (70-80 days)	10.42	14.27	15.16	13.28
5. Capitulum initiation + Grain development.	14.58	16.76	17.29	16.21

6.	Capitulum initiation + Flowering	12.86	16.28	17.77	15.64
7.	Initial stage + Flowering	14.63	17.43	18.15	16.74
8.	Capitulum initiation + Flowering + Grain development.	15.42	18.11	19.43	17.65
9.	Initial stage + Flowering + Grain development.	16.95	17.88	19.34	18.06

Table 47 : Irrigation scheduling based on IW/CPE ratio.

Irrigation treatment	Grain yield (q./ha)
No irrigation	9.79
Irrigation at 0.3 IW/CPE	14.95
Irrigation at 0.6 IW/CPE	15.99

Patel and Singh (1983) scheduled the irrigation based upon IW/CPE ratio basis, after his two years study they have reported that maximum yield was obtained when sunflower was irrigated at 0.7 IW/CPE ratio, The depth of irrigation at each time was 50 mm clayey soils of Udaipur (Table 48).

Suraj Bhan (1977) suggested that the depth of irrigation should be 50 mm and IW/CPE ratio should be 0.75 for highest yield of sunflower.

Table 48 : Irrigation scheduling based on IW/CPE ratio; on clay loam soil.

IW/PCE ratio	Grain yield (q/ha)		
	1976	1977	Mean
0.5	19.7	19.6	19.2
0.7	22.9	22.1	22.5
0.9	22.4	21.9	22.2
1.1	22.6	21.5	22.2

Rooting depth :

As per the results of experiment conducted by Musande et.al. (1987), the rooting depth is upto 165 cm in sandy loam soils of Aurangabad. Sunflower is catagoried as deep rooted crop. Sunflower can penetrate deep into the soil and can extract moisture and nutrients from deeper soil layer. Effective root depth is 1.2 m (D=1.2m)

Table - 49 : Effect of frequency and depth of irrigation on sunflower yield on sandy loam soils.

Treatments				Grain yield q/ha (Mean for two years)
Depth (mm)	IW/CPE ratio	CPE (mm)	No.of irrigation	
50	0.5	100	3	20.59
	0.75	67	4	20.77
	1.0	50	6	18.50
75	0.5	150	2	17.24
	0.75	100	3	16.63
	1.0	75	4	18.97

Irrigation methods :

Border strip is most common method of irrigation. Suraj Bhan and Khan (1980) reported that among all treatments (Table 50) irrigation in every furrow was produced highest yield in two years study at Udaipur.

Table - 50 : Effect of irrigation method on yield of sunflower on sandy loam soils.

Irrigation	Yield q/ha		
	1973-74	1974-75	Mean
1. Irrigation in flat beds	12.0	15.0	13.8
2. Irrigation in every furrow	12.6	15.9	14.2
3. Irrigation in alternator furrow	11.0	15.1	13.1
4. Irrigation in Alternate furrow (alternate at each successive irrigation).	12.0	14.6	13.3

Pest Control :

Pest	Control
1. Seed rot	– Seed treatment of captan or Bavistin @ 3 g/kg seed.
2. Alternaria blight	– Spray 3 kg Dithane M-45/1000 l water ha
3. Cater pillers	– Quinolphos 25 EC @ 1000 ml/500 liters water or Nuvan 76EC @ 1000 ml/500 liters water.

Yield :

In irrigated condition with improved cultural practices, it is possible to harvest 25 q/ha.

SAFFLOWER

This crop is mainly cultivated for its seed which yields a good quality oil. The seeds contain 24 to 36 per cent oil. The oil is largely used for cooking purpose or making soap. This is also used in manufacture of paints, varnishes etc. The cake is used as cattle feed or as a manure. Its cultivation is mainly confined to Maharashtra, Karnataka, Andhra Pradesh, Orissa and Madhya Pradesh.

Climate :

Safflower is a rabi crop. Temperature for germination should be about 15°C and at flowering 24-32°C for higher yield. Frost is harmful to the crop. At all stages, excessive rainfall or more humidity damages the crop by fungal diseases. This crop is not fit for tracts of heavy rainfall.

Soil :

Being drought resistant, it is cultivated on all types of soil but the crop is best suited to deep, well drained fertile soil with a high water holding capacity. This crop is tolerant to salinity but oil content is reduced.

Varieties :

For Maharashtra region Sharda, Girna, JLSF-414 Nari-6, Parbhani Kusuma, Phule Kusuma and Bhima varieties are recommended. On fine textured deep soil Bhima gives more yield. Tara variety is a early maturing variety can be grown on medium type of soil. Besides above varities, Nari NH - 1, DSH - 129 and MKH - 11 are hybrid varieties recommended for cultivaton.

Rotation and Mixed Cropping :

Safflower is mostly grown as a mixed crop with wheat, jowar, gram etc. Three rows of safflower being planted after every nine or twelve or more rows of main crop. It is also cultivated as a sole crop. A pure crop is rotated with soybean, greengram blackgram, groundnut, cotton, jowar etc.

Field Preparation :

Safflower is grown as mixed as well as pure crop. When cultivated as mixed crop the land is prepared according to the need of main crop. For a sole crop one deep ploughing and 2-3 harrowings followed by planking is sufficient. Suitable border strips can be prepared for irrigation.

Seed and Sowing :

Healthy seeds of improved varieties should be selected for sowing. The seed should be treated with Captan or Agresan G.N. at the rate of 3 gm per kg of seed before sowing. Last week of September to 15th October is the normal planting time for the crop. A spacing of 45 cm should be maintained between two rows. Plant to plant spacing should be 15-20 cm. About 15 kg seed will be required per hectare.

Manures and Fertilizers :

Apply 5 to 10 tonnes of farm yard manure or compost per hectare at the time of last harrowing. Application of fertilizers is essential for higher yield. For irrigated crop, use 75 kg N, 50 kg P2 O5 and 20 kg K2 O per hectare, Fertilizer should be placed 8-10 cm deep in soil and 4-5 cm away from seed at the time of sowing.

Weed Control :

The growth habit of safflower makes it extremely susceptible to weed competition following emergence. After emergence plants remain in a rosette stage for some time, before stem elongation. During this period control of weed is most important. Two weedings combined with hoeings with 15 days interval helps in better weed control.

Water Requirement :

ET crop	:	400 to 450 mm
Irrigation requirement	:	250 to 350 mm.

Water supply and crop yield :

To obtain maximum yield of safflower, adequate moisture is required during the growth period. The duration of safflower is ranging from 120 to 140 days depending on variety and climatic condition. In Maharashtra duration is about 120 days. Growth stages of safflower :

1. Early vegetative stage (Rosette development, 25-30 days)
2. Late vegetative stage (Branching and capitulum, 65-70 days)
3. Flowering (70-80) (Fig. 42)
4. Yield formation (grain filling, 80-100 days)

Fig. 42 : Flowering Stage in safflower

Table 51 : Irrigation requirement of safflower at various locations:

Location	Soil type	Total water applied for maximum yield mm	Reference
Jabalpur	Clay loam	300	Raghu and Sharma (1978)
New Delhi	Sandy loam	350	Dastane et. al. (1971)
Parbhani	Clay loam	360	Phulari et. al. (1986)
Sirguppa (Karnataka)	clay	300	Yadav (1975)
Karnal (Haryana)	Sandy loam	120	ICAR |(1973)

Magar et.al. (1984) reported that branching and 50 per cent flowering stages are more sensitive (Critical) for shortage of water. If the moisture is low in soil at branching to capitulum development, it will reduce the number of branches and capsules per plant and when there is sever moisture deficit at flowering, it will reduce the number of grains. This crop is also susceptible to excess water because of its reaction to diseases under wet condition, Excessive soil water causes root rot.

In safflower about 60 per cent of the total available soil water can be depleted without reducing its evapotranspiration and growth (Doorenbos and Pruitt, 1977) P= 0.60.

Water uptake :

The plant has well defined strong tap root, and normally produces thin horizontal laterals. The tap root commonly penetrates to a depth of 3.5 m in deep medium textured soil and this deep rooting characteristics allows the plant to draw moisture and nutrients from a considerable volume of soil. About 100 per cent water uptake of a full grown crop takes place from first 2 m depth (D= 1.5 m)

Irrigation scheduling ;

In safflower, irrigation scheduling by critical stage is suggested by Raghu and Sharma (1978). Results indicated that, three irrigations are sufficient for maximum yield. More than three irrigations (excess water) reduced the yield.

They suggested three irrigations, first at branching, second at flowering and third at grain formation stage. If two irrigations are available, first at branching and second at grain formation stage should be given if only one irrigation is available, it should be given at branching stage. Depth of irrigation should be 75 mm.

Magar et. al. (1984) suggested three irrigation one each at pre sowing, branching and 50 per cent flowering, which was found better under optimum irrigation resource conditions. Under the irrigation constraint, two irrigations, one at pre-sowing and other at branching would be sufficient for better yield. If only one irrigation is available it should be applied at branching stage only. Dhonde et. al. (1984) suggested only one irrigation at rosette development stage on deep medium black soils of Rahuri (Table 52). Dastane et. al.(1971) obtained highest yield by appling four irrigations on sandy loam soils of New Delhi. (Table 53).

Irrigation methods :

The crop is most commonly irrigated by border irrigation method. We have to take two important point in to consideration, one is its susceptibility to root diseases. More frequent irrigation or excess moisture for longer time in the root zone is harmful to the crop. Excess soil water causes root rot and reduces plant population per unit area. Secondly we have to consider the soil water reservoir. In deep soil this crop requires, long interval between two irrigations and each time depth of irrigation should be more. Safflower can take water from deeper layer and

there will be more efficient utilization of water. Soil should be well drained. Border irrigation method with 3 to 5 m width and 50-80 m length on levelled soil will be more suitable. Sub soil irrigation system is also suggested for higher yield.

Pest Control :

Rust	:	This fungal disease can be avoided by seed treatment with Thirum at the rate of 2.5 gm/kg seed.
Safflower aphids	:	The aphids suck the sap from the leaves, twings, flowers and capsules. This can be controlled by spraying of Acephate (75%SP) 1000 ml or Rogar (30 EC) 1000 ml dissolved in 1000 litre water on one hectare cropped area.

Yield :

A well managed irrigated crop may yield 20-25 quintals per hectare.

Table - 52 : Effect of irrigation frequency on yield of safflower on medium black soils of Rahuri.

Irri. treatments (Critical stage)		No. of Irrigation	Total depth applied (mm)	ER (mm)	Consumptive use (mm)	Grain yield (q/ha)
Io	--	0	100	31.7	245	22.71
I1	R	1	203	31.7	333	25.62
I2	CI	1	248	31.7	346	22.35
I3	F	1	248	31.7	293	20.06
I4	GD	1	253	31.7	355	23.08
I5	R,CI	2	304	31.7	381	22.14
I6	R,F	2	304	31.7	360	21.08
I7	R,CI, F	3	316	31.7	387	24.18
I8	R,CI, F,GD	4	366	31.7	413	19.79

R = Rosette, CI = Initiation of capitulum development

F = Flowering and GD = Grain Development.

Table - 53 : Yield of safflower as influenced by quantity of Irrigation water.

No.of irrigation	Water delta (mm)	Yield obtained (q/ha)
0	100	27.5
1	175	37.0
1	175	32.2
1	175	31.4
1	175	27.5
2	240	41.4
3	240	35.3
2	240	30.0
3	300	41.4
3	300	39.2
3	300	38.9
3	300	33.6
4	350	48.1

PIGEON PEA (TUR)

Pigeon pea (commonly known as red gram or arhar) is the second most important pulse crop in the country. It is mainly consumed in the form of 'dal'. The husk of pods and leaves obtained during threshing constitute a valuable cattle feed. Woody parts of the plant are used as fuel. It is a legume crop and consequently possesses valuable properties as restorer of nitrogen to the soil. This crop is very well suited for intercropping. This crop is extensively grown in Maharashtra, Uttar Pradesh, Madhya Pradesh, Karnataka, Andhra Pradesh and Gujrat.

Climatic requirements

Arhar grows well in warm tropical and sub tropical climate. The crop prefers a fairly moist and warm climate during the period of its vegetative growth. During flowering and fruiting it requires bright sunny weather. Cloudly weather, frost and excessive rainfall at flowering damages the crop to a great extent.

Soil :

Arhar may be grown well on a wide range of soils varying from sandy loam to clay loams, fertile and well drained loamy soils. Saline, alkaline and water logged soils are unfit for its cultivation

Varieties :

Table - 54 : Following varieties are recommended for Maharashtra.

Variety	Duration (days)	Yield (q/ha)
C-11	170-180	15-20
Type-21	160-165	20-22
No.148	160-170	12-15
BDN-2	150-170	15-20
Prabhat	120	12
ICPL-87	130	10-15
ICPL- 4	130	10-15
ICPL-87-119	180	15-16
BSMR-736	185	15-16
BSMR-853	175	15-16
AKT-8811	140	15-16

Vipula	145-160	
BDN - 708	160-165	24-26
(Amol)		20-22
Konkan Tur - 1	130-135	10-12

Field Preparation :

Arhar responds well to properly tilled seed bed. A deep ploughing followed by two to three cross harrowings and proper levelling should be given to ensure uniform irrigation.

Seed and sowing :

Treat the seed with Captan or Thirum at the rate of 3 g per kg of seed. After 15 - 20 minutes, seed should be treated with suitable strain of Rhizobium culture @ 25 gm/Kg of seed. Arhar should be sown before first fortnight of July. Row to row spacing should be 60 to 75 cm and plant to plant spacing should be 15 to 20 cm . A seed rate of 12-15 kg per hectare is sufficient for sole crop whereas in intercropping, seed rate is adjusted according to the proportion of main crop and intercrop Sowing should be done by seed cum fertilizer drill.

Weed control :

During rainy season weeds pose a serious problem. These weeds absorb the nutrients and moisture and also gives shelter to insect pests. The period of first 60 days is very critical. Two mechanical weedings, one at 25-30 days and another at 45-60 days after sowing give excellent weed control. The pre-emergence application of Lasso @ 3 liters or Basalin 1 kg a.i. per hectare as per-sowing spray.

Rotation and Intercropping :

This crop can be rotated with wheat, jowar, potato, maize etc. The practice of intercropping with other crops like jowar, cotton, groundnut is common. This crop is grown with wide row spacings. However, the initial growth is quite slow and grand growth period starts after 65 days of sowing. A lot of inter-row spaces therefore remain vacant during the early stages. This space can be utilized by growing other crops which will increase total monetary return.

Manures and Fertilizers :

One of the important reasons for poor yield is its nutrient requirement, which is generally neglected. This crop gives good response to manures and fertilizers.

This crop need following doses of manures and fertilizers and should be applied at the time of sowing.

F.Y.M.	10	T/ha
Nitrogen	20 - 30	kg/ha
Phosphate	50	kg/ha.
Potassium	30	kg/ha.

In zinc deficient soils, zinc sulphate @ 20 kg/ha should be applied at the time of sowing.

Water Requirement :

Water requirement of arhar is ranging from 500 to 750 mm depending upon the duration of variety. Being a deep rooted crop. It can tolerate drought. This crop is generally taken as rainfed crop. But arhar gives good response to irrigation.

kc Vaues :

	Stage of Crop	Duration of Stage (days)	kc Values
1.	Initial Stage	30	0.3 to 0.4
2.	Crop development stage	45	0.7 to 0.8
3.	Mid season stage	60	1.05 to 1.2
4.	Late season stage	35	0.65 to 0.75
5.	At harvest.	–	0.3 to 0.4

Fig. 43 : TUR

Critical stages :

There are three critical stages in pigeon pea.

1. Vegetative Stage : This stage comes after 25-30 days from sowing. If moisture is low in this stage, it reduces number of branches.

2. Flower initiation stage : This stage cames after 70 days. If moisture is low in soil at flowering, it will reduce the number of flowers. (fig. 43)

3. Early Pod formation stage : After 95 to 100 days from sowing pod formation will start and if there is severe moisture deficit, it will cause small grains.

Irrigation scheduling :

This crop is a deep rooted crop, can penetrate its roots upto 1.5 m deep in soil (D=1.2 m) therefore more depth (125 to 150 mm) with more interval between two irrigation (20-25 days) can be given to this crop. During rabi season (15th Oct. to 30th Nov.)

Irrigation scheduling can be done by critical stage approach , Three to four irrigations are sufficient.

Allowable depletion is 60 percent (P=0.60). This crop should be irrigated by border method.

Pest control :

	Pest		Control
1.	Wilt	:	1. Use resistant varieties like C-11 BDN-2, BSMR-736 and BSMR - 853 2. Crop rotation should be followed.
2.	Pod borer	:	Spray Quinolphos (25 EC) @ 800ml/500 Lit of water or 5% Neemark on the crop.

Yield :

Under irrigated condition yield is 15 to 25 q/ha.

SOYBEAN

Soybean is one of the most promising oilseed and pulse crops. It contains about 20% oil and 38 to 40% proteins. In Maharashtra it is grown in Vidarbha region on large scale. Similarly it is also grown in parts of Western Maharashtra and Marathwada.

Climate :

Optimum temperature requirement for soybean is 25°C to 35°C with 500 to 800 mm. well distributed rainfall.

Soil :

Silty clay, medium deep to deep, PH 6.5-8.5, rich in organic matter content, well drained.

Varieties :

MACS - 13	MACS - 450
MACS - 58	PKV - 1
PACS - 124	Phule Kalyani (DS - 228)
JS - 335	MAUS - 71
PK - 1029	JS - 80-21
MAUS - 158	MAUS - 32

Soil Preparation :

One deep ploughing followed by 2-3 harrowings.
Mix organic manures (FYM/Compost) @ 10t/ha.
and phorate 10 G (granules) @ 10 Kg/ha with soil.

Sowing :

(i) Sowing period : Kharif : 10 June to 15 July
Hot weather : 25 January to 10 February

(ii) Method of sowing : Drilling

(iii) Seed rate : 75 to 80 Kg/ha.

(iv) Depth of sowing : 3 cm.

Crop Geometry (Spacing) :

30 x 10 cm.
45 x 7.5 cm.

Intercultural Operations :

One weeding followed by 2 hoeings. Use of chemical weedicides like Basalin 2.5 liters or Lasso 4 liters in 800 liters of water is effective in controlling weeds.

Spray weedicides on the soil at the time of sowing to control the weeds.

Manures and fertilizers :

(i) F. Y. M./ Compost @ 10 t /ha before sowing.

(ii) 40 Kg N + 80 kg P_2O_5 + 20 kg K_2O/ha at the time of sowing.

Water Managemant :

a) Consumptive use of water & Irrigation requirent :

Sr. No.	Season	ETc (mm)	NIR (mm)
(i)	Kharif season	350-400	0-150
(ii)	Hot weather season	600-650	650-750

b) Managent Allowable Depletion : 50% (P-0.50)

c) Effective root depth : 1.0 to 1.2 m.

d) Method of irrigation : Border, Sprinkler

e) **Critical Growth Stages :**

Sr. No.	Growth Stages	Days after sowing
1.	Seeding	15-20
2.	Branching	20-40
3.	Flowering	45-60
4.	Pod formation	65-80
5.	Grain filling	80-95

Pest Management :

Sr. No.	Pest/Disease	Control Measures
1.	Aphids / Jassids	(i) Methyl Demeton (25 EC), 600 ml Or Dimethoate (30 EC). 500 ml. + 500 liters water/ha.
2.	Leaf Roller	(i) Quinalphos (25 EC), 1000 ml. Or Monocrotophos (36 EC), 700 ml. + 500 lit. water/ha.
3.	Leaf eating cater pillar	(i) Carbaryl powder 50 WP @ 2 kg. + 500 lit. water/ha.

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